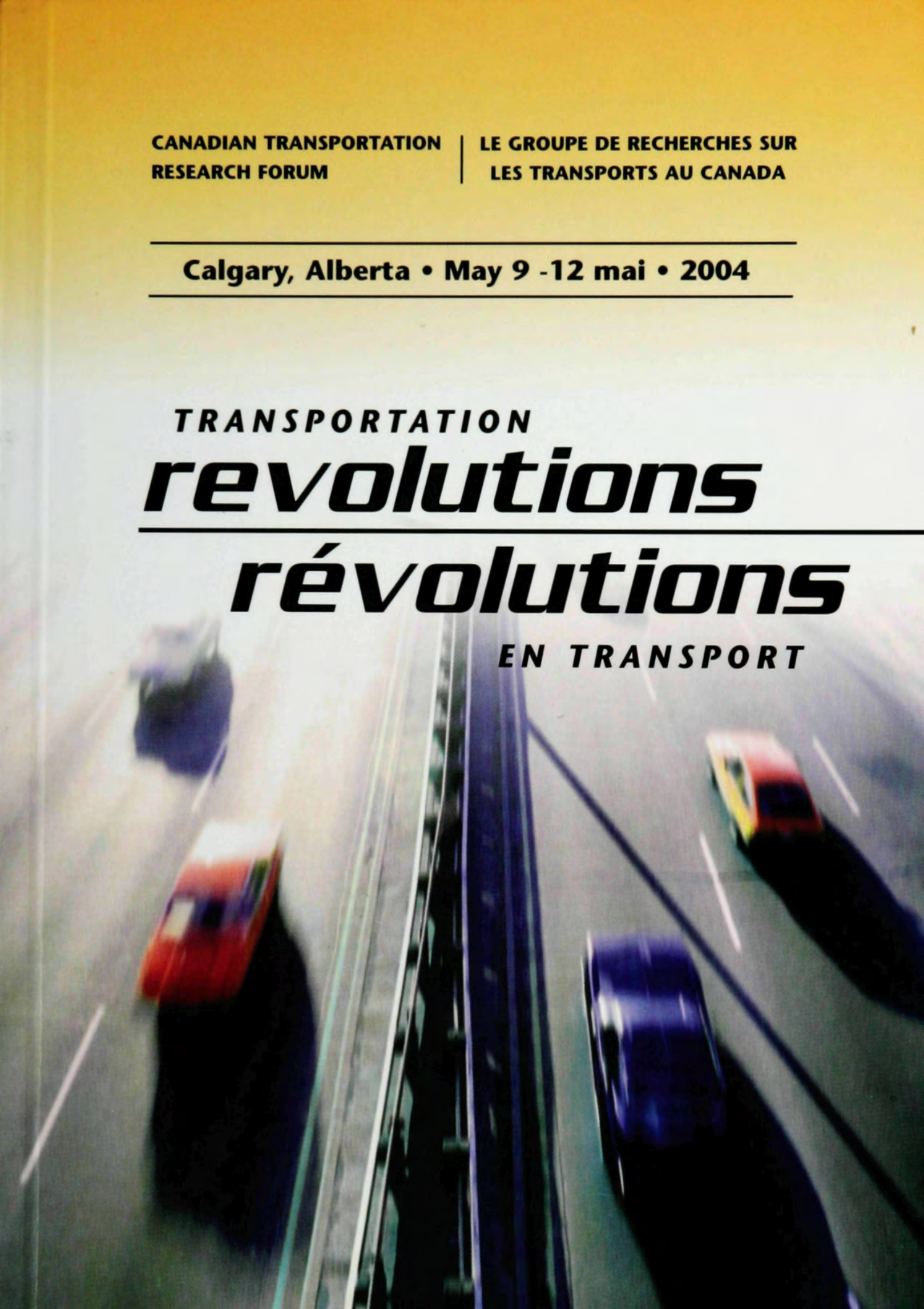
CANADIAN TRANSPORTATION RESEARCH FORUM | LE GROUPE DE RECHERCHES SUR LES TRANSPORTS AU CANADA

Calgary, Alberta • May 9 -12 mai • 2004

TRANSPORTATION revolutions

révolutions EN TRANSPORT



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

PROCEEDINGS
of the 39th Annual Conference

ACTES
de la 39è Conférence annuelle

Transportation Revolutions
Révolutions en transport

Calgary, Alberta
May 9-12 mai
2004

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President's Message

I would like to personally welcome those of you attending the 39th Annual CTRF Conference in Calgary. The organizers have worked hard behind the scenes to bring this event to you and we hope that you get as much out of the event, as they've put in to making it a reality.

This proceedings contains the collective efforts of the participants and reflects not only the diversity of transportation research in Canada, but also the impressive research abilities of the contributors. Our theme this year, "Transportation Revolutions" is drawn from a reference to the major revolutions associated with rail and highway developments in the last century. But, in a more forward vein, posing the question, are we on the verge of yet another revolution in transportation? A number of papers in this volume reflect on that question and we hope you are intrigued and perhaps inspired.

An event like this comes about through the unselfish efforts of volunteer organizers and I would like to recognize their valued contribution on behalf of the CTRF community. Lloyd Ash took the lead as VP program, responsible for organizing the sessions, dealing with submissions, and many other aspects of the conference. Peter Wallis, as VP meetings oversaw the entire conference and received

valuable support from his colleagues Nancy Stirling and Sarah Bolton. Our local organizing committee, Keir Packer, Kevin Doyle, Kim Royal, Jan Bowland, and myself, also provided key local insights and assistance. Lastly, Gail Sparks at the CTRF head office provided invaluable guidance and help throughout the organizational process. Thanks to all of our organizers for their many hours of hard work.

I would also like to recognize the extensive list of sponsors, financial and otherwise who help to make this event a success. The firms and organizations that sponsor our conference provide an incredibly important service to the transportation community and I thank them for their commitment. Finally, I would like to thank you, the CTRF member for your continued support of the organization. Our membership is our strength and the source of what keeps this organization at the forefront of Canadian transportation research.

Enjoy the conference and these proceedings and make plans next year to attend our 40th annual conference. See you in Hamilton!

Je voudrais, à titre personnel, souhaiter la bienvenue à ceux d'entre vous qui assistent à la 39è conférence annuelle du GRTC à Calgary. Les organisateurs ont travaillé dur, derrière la scène, pour vous offrir cet évènement; nous espérons que vous en retirerez beaucoup d'autant plus qu'ils ont tout fait pour traduire ce projet en une réalité.

Les Actes contiennent les efforts collectifs des participants et reflètent non seulement la diversité de la recherche en transport au Canada, mais aussi les capacités impressionnantes de ceux qui y contribuent. Notre thème de cette année, *Révolutions dans les transports*, est tiré de références relatives aux révolutions majeures qui ont marqué le développement des modes ferroviaire et routier durant le siècle passé. Mais, en poussant la réflexion plus loin, posons-nous la question : sommes-nous à la veille d'une autre révolution en transport? Un certain nombre d'articles dans ce volume reflètent cette question et nous espérons que cela vous intrigue et peut-être vous inspire.

Un évènement comme celui-ci résulte des efforts considérables d'organisateurs volontaires et dévoués dont je voudrais souligner, au nom de la communauté du GRTC, l'inestimable contribution. Lloyd Ash en a assumé la direction en sa qualité de vice-président - Programme, responsable de l'organisation des séances, des soumissions d'articles et de beaucoup d'autres aspects de la conférence. Peter Wallis, en tant que vice-président – Conférences, s'est occupé de toute la conférence et a reçu un soutien de choix de la part de ses collègues Nancy Stirling et Sarah Bolton. Notre comité d'organisation local, Keir Packer, Kevin Doyle, Kim Royal, Jan Bowland et moi-même, a apporté les contributions locales et son appui. Enfin, Gail Sparks, au siège social du GRTC, a été une guide de grande valeur et a accordé son aide au processus d'organisation. Merci à tous nos organisateurs pour leurs nombreuses heures de dur labeur.

Je voudrais également mettre en lumière la liste des commanditaires financiers et autres qui ont contribué à faire de cet évènement un succès. Les entreprises et organisations qui commanditent notre conférence fournissent un service d'une importance capitale à la communauté des transports; je tiens à leur exprimer ma reconnaissance pour leur engagement. Finalement, je voudrais vous remercier, vous le membre du GRTC pour votre support constant à l'organisation. Notre membership est notre force et la source de ce qui maintient celle-ci à la pointe de la recherche en transport au Canada.

Appréciez donc la conférence et ces Actes, et prévoyez déjà votre présence à notre 40è conférence annuelle. Au plaisir de vous voir à Hamilton!



Clarence Woudsma, CTRF President

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At Calgary, Alberta Canada
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Prediction of Freeway Crash Potential for Real-Time Crash Prevention
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The Transportation Sector: Federal Revenues and Expenditures Balance 1991/92-2001/02 and Five Year Forecast

J. Jurgens Bekker, Senior Research Associate
Barry E. Prentice, Director Transport Institute
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Introduction

Transportation services are provided as a mix of public and private investments. Private companies provide and maintain equipment, like trucks and airplanes, while the public sector provides the long lived infrastructure assets, like roads and airports.[1] Private investment in transportation is determined on the basis of competition. Public investment is determined politically.

The responsibility for public transportation infrastructure is shared between federal, provincial and municipal levels of government. Over the last decade, the federal government adopted policies of divestiture and reduced subsidies to transportation infrastructure investment and operations. The impetus for this fiscal policy change was pressure to control a rapidly growing national debt. In general, privatization of Air Canada, CN Rail and Nav Canada was positively received, as was the commercialization of the ports and airports. As the burden for providing infrastructure has fallen heavier on transport users and the secondary levels of government, however, calls have been made for a greater federal contribution.

The objectives of this paper are to provide an account of aggregate net federal spending on transportation since 1991 and to provide a five year forecast of the revenue/expenditure balance. Gross federal spending on all modes, and total revenues from both tax and non-tax sources are reported in 2000 constant dollars.[ii]

Trends in Federal Transportation Revenues and Expenditures

Figure 1 presents the balance of federal revenues and expenditures related to the transportation sector. Real federal transportation spending decreased 57.3% from $5,392 million in 1991/92 to $2,302 million in 2001/02. Total revenues from transport kept pace with, or exceeded inflation. As a result, the financial impact on the federal treasury went from an annual deficit of $547 million in support of transport, to a surplus of $2.4 billion taken out of the transportation sector. This policy helped curb the growing public debt, but it would appear that transportation bore a disproportionate share of cutbacks. Federal transportation expenditures as a percentage of total federal expenditures fell from 2.8% in 1991/92 to 1.3% in 2001/02.[iii]

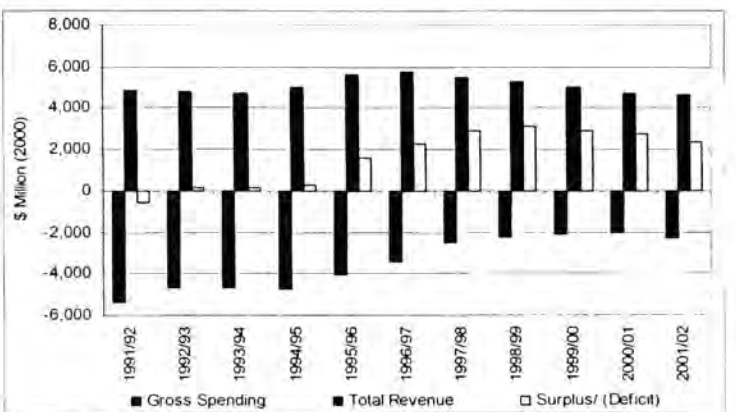


Figure 1: Federal Government Transportation Gross Spending, Total Revenue and Surplus/(Deficit), 1991/92 to 2001/02.

The impacts of fiscal restraint are uneven. All provinces complain that they cannot maintain the highway infrastructure, but the deterioration of the roads is particularly visible in the more sparsely populated provinces, like Saskatchewan and Manitoba. The cities complain that they are unable to maintain their streets and mass

transit systems, and they want a "new deal" from the senior levels of government.

Methodology

The collection and public dissemination of transportation data has changed significantly in the last few years. Prior to 1996, transportation information was not compiled in a single source. Transport Canada now provides quantitative information to the public through its Annual Report, *Transportation in Canada*, and through *T-Facts* information system via the Internet.

T-Facts were more comprehensive than the Annual Report in terms of coverage, but for many elements does not provide analogous and up to date time series. Consequently, other sources were required to complete the time series. Financial management and economic policy analysis directorates and branches of Transport Canada were consulted for the purposes of clarifying and/or augmenting the *T-Facts* data. Government of Canada Estimates Part III and Public Accounts were consulted for additional information.

Notwithstanding substantial consideration of appropriate definitions and methodology, some aspects remain open to debate. For instance, the federal government made one-time payments in the cases of Labrador Ferry Services Buy-out and Nav Canada and received one-time incomes from the sale of CN Rail and Nav Canada. Inclusion of these transactions would distort underlying trends, but exclusion of these events does not provide a full accounting of federal transportation dealings. The analysis notes one-time amounts, but excludes it from spending and revenue streams from which general trends are established.

Another case is the allocation of fuel tax revenues. Federal fuel tax figures were calculated using fuel consumption as recorded by Transport Canada and multiplied by the excise tax rate (Transport Canada, 2003b). However, this approach does not adjust for the exemption from excise tax of air fuel that is consumed for international flights. As a result, the contribution by the air mode to

federal fuel taxes will be overestimated, while contributions from other modes are correspondingly underestimated. Even though modal allocation of excise fuel taxes may be affected to some extent, total fuel taxes remain unaltered.

Government Sales Tax (GST) is not accounted for in reported federal transportation revenues. Adjustment of federal transportation revenues for GST generated from the transportation sector involves the complex fuel tax rate structure as well as modal exemptions that may apply from time to time, such as the case is for the air mode.

Direct subsidies are generally viewed as of two primary types. The first type represents payments from government directly to producers or consumers. The second type is tax expenditures. Tax expenditures are provisions in the tax law that reduce tax liability to qualifying firms or persons (Energy Information Administration, 1999). Only the first type of direct subsidy is quantified in this analysis.

Indirect subsidies include provision of transportation services or transportation infrastructure below market prices. In the pure sense, even government funded transportation research and development could be considered an indirect subsidy, if it substitutes for private research and development, and affects future transportation prices.

Indirect (modal) subsidies, direct (modal) subsidies and non-allocated overhead costs jointly constitute total federal transportation spending. This analysis does not apportion non-allocated expenditure or overhead costs to indirect modal subsidies. Safety, security and policy expenditures (except Canadian Air Transport Security Authority expenditures) and corporate services of Transport Canada cannot be accurately apportioned for the review period due to limited availability of data. Partial allocation to modes may imply underestimation of indirect modal subsidies, depending on the specific definition of indirect subsidies. The extent of underestimation is contingent on the significance of excluded overhead costs to total indirect subsidies. Indirect modal subsidies are not expressly reported due to limited allocation of total indirect costs to modes.

Consequently, the total indirect subsidy implied through modal net effect calculations should be interpreted with caution.

Results

The gap between federal transportation revenue and spending increased for the greater part of the review period. The annual deficit was eliminated in 1992/93 and since then a surplus has been recorded in every year. In the period from 1992/93 to 2001/02, real federal government transportation revenues have cumulatively exceeded real gross expenditures by $18.5 billion.

While less than the total net fiscal balance for transportation, the modal surpluses and deficits reveal the impact of changing priorities and user pay policies. Recall however, that one-time payments for specific modes are excluded to preserve the trend.

The modal surplus/deficit situation is presented in Table 1. In 1991/92, all modes except for roads were net beneficiaries of federal support. The railways received the greatest support until 1995/96 when payments under the Western Grain Transportation Act (WGTA) were phased out. Since then, the subsidies have been used mainly to support rail passenger service. It can be argued that WGTA subsidies are really used to assist rail users (i.e. farmers) rather than the railways, but this distinction is irrelevant to this analysis.

The ferries and marine mode is now the largest recipient of federal support at $616 million in 2001/02. In real terms this is still one third less than 10 years earlier. Aviation has experienced the most dramatic change. In the early 1990's, the air mode received between $200 and $300 million annually. By the end of the decade, an equivalent amount was being extracted from the air mode each year. Scheduled increases in airport rents will continue to drive this higher.

Table 1: Federal Surplus/(Deficit) by Mode, 1991/92 to 2001/02.					
Year	Rail[1,2]	Roads[3,4]	Ferries & Marine[5,6]	Airports/ Aviation[7,8,9]	Total Surplus/ (Deficit)[10]
	$ Millions (2000)				
1991/92	(1,704)	3,075	(964)	(234)	173
1992/93	(1,216)	3,068	(823)	(248)	781
1993/94	(1,075)	3,019	(845)	(319)	779
1994/95	(1,026)	3,136	(787)	(189)	1,134
1995/96	(520)	3,423	(723)	57	2,237
1996/97	(202)	3,332	(724)	475	2,882
1997/98	(171)	3,479	(665)	899	3,542
1998/99	(156)	3,790	(550)	608	3,692
1999/00	(114)	3,882	(652)	348	3,464
2000/01	(170)	3,814	(639)	317	3,322
2001/02	(247)	3,683	(616)	208	3,027

Source: Transport Canada, 2003. *Transportation in Canada 2002 Annual Report*, Addendum, Chapter 3: Government Spending on Transportation, Tables A3-2, A3-3 and A3-4, pp. A36-38 (1994/95-2001/02); Transport Canada, 1999. *Transportation in Canada 1998 Annual Report*, Chapter 3: Government Spending on Transportation, Tables 3-2, 3-3 and 3-5, pp. 23, 24 and 27 (1991/92-1993/94); Transport Canada, 2004. *Statistics from T-FACTS, Energy*, http://www.tc.gc.ca/pol/en/T-Facts3/Statmenu_e.asp?type=pu&file=energy&Lang=; Derkson, W. and Shurvell, S., 1999. *Transportation Spending and Revenues*, University of Manitoba Transport Institute, Appendix D, p 14 (1991/92-1995/96).

Notes:

[1] Includes WGTA payments as well as subsidies toward branch lines, grade crossings and hopper cars.

[2] Includes leases of hopper cars.

[3] Includes federal highway agreement contributions, strategic investment initiatives, infrastructure program, Atlantic Region Freight Assistance (ARFA) transition payments (excluding Labrador Ferry Services Buy-out) and Montreal bridges.

[4] Includes road safety fees and sale of assets.

[5] Includes Canadian Coast Guard (Coast Guard was transferred to the Department of Fisheries and Oceans in February 1995).

[6] Includes user fees, other service fees.

[7] Includes operating, maintenance and capital expenditures to the Air Navigation System until 1996/97.

[8] Includes excise tax revenue and Air Transportation Tax (ATT) to 1999/00; ATT transferred to Consolidated Revenue Fund (CRF) in 1996.

[9] Includes user fees, other service fees.

[10] Totals may not add due to rounding.

The changing fortunes of rail, marine and aviation pale when compared with the experience of highway users. The road network has been the great cash cow of the federal government. The annual surplus of revenues over expenditures has varied between $3.0 and $3.9 billion annually throughout the decade. The gap is explained by increasing fuel taxes while expenditures on roads never exceed 15 percent of the revenues collected.

According to the Canada Transportation Act Review Panel (CTAR) (2001) the distortions caused by current charging policies are widely recognized. However, the impasse in the national roads policy is exacerbated by the absence of reform to the funding of roads. It is clear that the growth of traffic has outpaced the maintenance of the highway system. Traffic is expected to continue to grow as vehicle purchases are forecast to increase by 3% annually and truck traffic is forecast to rise by 1.9% each year (CTAR, 2001). Regional transportation stakeholders are demanding a greater federal commitment to transportation infrastructure in Canada because of the accumulated "infrastructure deficit." In 1996 the municipal infrastructure deficit was put in the range of $12 to $44 billion, depending on how infrastructure is defined, and in 1997 the national highways system deficit was estimated at $17.4 billion.[iv]

Table 2 presents the record of federal fuel tax rates and revenues. The relative contribution by fuel taxes to total revenues increased over most of the review period. Total cumulative real fuel taxes from 1991/92 to 2001/02 were $45.6 billion. This includes revenues from road gasoline, aviation gasoline and other fuels. In 2001/02, fuel taxes contributed $4,278 million to federal revenues, which were 2.25% of total federal revenues and 91.2% of federal transportation revenues. As with other measures to counter the growing budget deficit, fuel taxes on road and aviation gasoline were increased in 1995/96.

Table 2: Federal Fuel Tax Rates and Revenues, 1991/92 to 2001/02.						
Year	Road Gasoline	Aviation Gasoline	Other Fuels[1]	Revenues[2]	Percent of Total Federal Revenues	Percent of Total Federal Transport Revenues
	(Nominal cents/litre)			$ Millions (2000)		
1991/92	8.5	9.5	4.0	3,638	2.43	75.1
1992/93	8.5	9.5	4.0	3,668	2.46	76.6
1993/94	8.5	9.5	4.0	3,714	2.56	78.1
1994/95	8.6	9.6	4.0	3,845	2.54	77.2
1995/96	10.0	11.0	4.0	4,333	2.80	76.5
1996/97	10.0	11.0	4.0	4,274	2.63	74.2
1997/98	10.0	11.0	4.0	4,395	2.52	80.2
1998/99	10.0	11.0	4.0	4,563	2.55	85.9
1999/00	10.0	11.0	4.0	4,524	2.41	91.0
2000/01	10.0	11.0	4.0	4,360	2.25	91.7
2001/02	10.0	11.0	4.0	4,278	2.25	91.2

Source: Transport Canada, 2003. *Transportation in Canada 2002 Annual Report*, Addendum, Chapter 3: Government Spending on Transportation, Table A3-4, p A38 (1994/95-2001/02); Transport Canada, 1999. *Transportation in Canada 1998 Annual Report*, Chapter 3: Government Spending on Transportation, Table 3-3 p 24 (1991/92-1993/94); Statistics Canada, 2004. Canadian Socio-economic Information Management System, Federal and Provincial General Government Revenue and Expenditure, Dollars, Canada, Federal Government, Total Revenue, CANSIM II V156113, Transport Canada, 2004. *Statistics from T-FACTS, Energy*, http://www.tc.gc.ca/pol/en/T-Facts3/Statmenu_e.asp?type=pu&file=energy&Lang=.

Notes:

[1] Others include diesel in all modes and aviation and marine turbo fuels.

[2] 1991/92 include fuels used outside transportation

Forecasts

In the 2004 Speech From the Throne, the federal government announced that they were immediately returning the GST paid by municipalities, and that they would be providing some share of fuel tax revenues to support transportation infrastructure of the cities. GST is not included in the analysis of this paper, but a shift in fuel tax allocation would be a significant change in policy.

Two forecasts are provided in Table 3. The first forecast is based on trends that have persisted during the 1990's, adjusted for announced changes. The second forecast examines the impact of returning to the cities some share of federal fuel taxes collected in urban centres.

Existing Trends Forecast

If current trends continue, the five year forecast projects an approximate $4.7 billion federal transportation surplus in 2006/07. This forecast is derived from Transport Canada estimates of planned spending and from Transport Canada Annual Reports.[v] Where official federal forecasts were not available, spending and revenue trends for the period under review were projected over the forecast period. Forecasted values were calculated by applying simple linear regression to time series data.

No causal relationship between variables in the simple regression model is postulated, but fiscal years are selected as independent variables. Under these conditions, the predictive benefit is by implication limited to a continuation of average past trends over the time series.

New taxes may be introduced during the forecast period that are not foreseeable. For example, an airport security tax was introduced in 2002, which will yield large revenues to the federal government. Similarly, revenues from airport rents are rising. According to *Straight Ahead*, eight of 22 airport authorities pay rents to the federal government and others were scheduled to begin rent payments in the next five years (Transport Canada, 2003a). Forecasts include estimated revenue from the Air Travellers Security Charge (ATSC) and estimated expenditures by the Canadian Air Transport Security Authority, but no forecasts were made of potential changes to the existing airport rents structure.

Table 3: Federal Government Transportation Gross Spending, Total Revenue and Surplus/(Deficit), with Alternative Forecasts to 2006/07.					
Year	Gross Spending[1]	Tax Revenue [2]	Non-Tax Revenue [3]	Total Revenue [4]	Surplus/ (Deficit)[4]
	[trend/new deal]	$ Millions (2000)			[trend/new deal]
1991/92	5,392	4,198	647	4,845	(547)
1992/93	4,653	4,234	551	4,786	133
1993/94	4,644	4,308	447	4,755	111
1994/95	4,726	4,497	483	4,981	255
1995/96	4,039	5,073	589	5,663	1,623
1996/97	3,438	5,060	696	5,756	2,319
1997/98	2,544	5,177	306	5,483	2,939
1998/99	2,213	4,875	434	5,309	3,096
1999/00	2,076	4,527	445	4,972	2,897
2000/01	2,007	4,360	397	4,757	2,750
2001/02	2,302	4,278	412	4,690	2,388
2002/03f	2,487	4,408	827	5,235	2,748
2003/04f	1,717	4,773	866	5,640	3,923
2004/05f	1,480/2,664	4,821	843	5,664	4,184/3,000
2005/06f	1,250/2,438	4,867	821	5,688	4,438/3,250
2006/07f	1,028/2,219	4,912	799	5,711	4,684/3,493

Source: Transport Canada, 2003. *Transportation in Canada 2002 Annual Report*, Addendum, Chapter 3: Government Spending on Transportation, Tables A3-1 and A3-4, pp. A35, A36 (1994/95-2002/03[F]); Transport Canada, 1999. *Transportation in Canada 1998 Annual Report*, Chapter 3: Government Spending on Transportation, Tables 3-2, 3-3 and 3-4, pp. 23, 24 and 25 (1991/92-1993/94; Transport Canada, 2003. *2003-2004 Estimates Report on Plans and Priorities* (2003/04f-2005/06f).

Notes:

[1] Excludes $999.8 million in CN debt forgiveness to the Public Accounts of Canada in 1995/96; Excludes payments of $292 million, $686 million and $216 million to Nav Canada during 1996/97 to 1998/99.

Excludes payments of $353 million for Labrador Ferry Service Buy-out in 1996/97 and 1997/98.

[2] Includes Air Transportation Tax (ATT) as of 1994/95 to 1999/00 (when rescinded); for prior years ATT is non-distinguishable from Non-Tax Revenue.

[3] User fees, leases, rents; does not include returns on investments or income from sales of assets.

[4] Totals may not add due to rounding.

Forecasts were made only of aggregate federal transportation revenues and spending respectively. Except for the newly introduced ATSC, no individual forecasts were made of the component parts that comprise aggregate federal revenues and aggregate federal spending respectively.

"New Deal For Cities" Forecast

Forecasts of revenue transfers on the fuel excise tax from urban fuel sales have been performed as follows: Volumes of (1) Total Road Gasoline and (2) Total Road Diesel were projected for the forecast period (only 4 years because actual numbers were available for the first year of the forecast period). The city/highway split of 55/45 was used to calculate annual fuel consumption (Office of Energy Efficiency: Transportation, 2004). The federal transfer to the cities as of 2004/05 was calculated as: (Total road gasoline fuel sales in litres x 0.55 x 5c per litre) + (Total road diesel fuel sales in litres x 0.55 x 2c per litre).

Figure 2 shows the projected federal government transportation gross spending, total revenues and resulting surpluses/(deficits) under conditions of the alternative forecasts. In both scenarios, federal transportation surpluses are projected to increase over the forecast period. The projected surplus by 2006/07 is $4.7 billion with continuation of existing trends, and $3.5 billion under assumptions of the "new deal".

According to these forecasts, the smallest surplus of $3 billion is projected in 2004/05 for the "new deal" scenario. This coincides with the introduction of the transfer. Except for this single year-on-year decline, increasing surpluses are projected for every year in each scenario. Subsequently, the federal government would still be gaining $3.0 to $3.5 billion annually from the transportation sector, notwithstanding a fuel tax transfer to the cities.

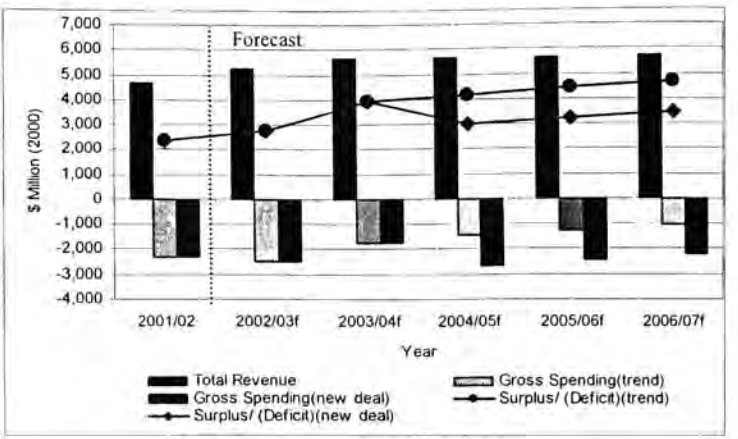


Figure 2: Alternative Forecasts of Federal Government Transportation Surplus/(Deficit), 2002/03 to 2006/07.

Conclusion

This paper reports on aggregate federal spending, revenues and the resulting surpluses/deficits from transportation, as well as modal net effects. The purpose is to document the path taken by the federal government toward a fiscal surplus from the transportation sector.

Information presented in this paper indicates that the disparity is increasing between the revenues that the federal government takes out of the system in the form of taxes, fees and rents, and what it puts back into the system (through the operations of Transport Canada, the Canadian Transportation Agency (CTA), other agencies and direct subsidies to individual modes).

The Martin Government has signalled that they are willing to share more of the burden of supporting urban transportation. While the details of any announcement will likely await an expected future

election, the federal government would appear to have adequate tax room to provide this support from the fuel taxes they collect. Even a generous 5 cents per litre rebate to the municipal governments would still leave the federal government with a growing surplus of transport revenues over expenditures.

In *Straight Ahead*, the federal government defends its transportation and fiscal policies. The federal government views federal fuel taxes as an instrument of fiscal, not transportation, policy and as an important source of general revenue (Transport Canada, 2003a).

The question of how and where government revenues derived from transportation services *should* be spent is beyond the scope of this paper. A case could be made for the diversion of funds away from the transportation sector on the basis of efficiency, if alternative non-transportation projects render greater benefits to society. Of course, if the provincial/municipal governments are simultaneously running a deficit, while the federal government enjoys a surplus, both cannot be right in their evaluation of benefits to society.

Inevitably, any net taxation of transportation finds its way into costs of goods and services. Consequently, the higher cost of transportation that results from the net taxation of this sector renders the Canadian economy less competitive in world markets. This stands in sharp contrast to other trading partners, such as the U.S., that appear to subsidize transportation as an instrument of economic development. The competitiveness aspect of the debate has not been adequately explored.

Acknowledgements

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Endnotes:

[i] The railways are an exception to this rule, but they did receive massive subsidies in their initial construction. The airports are also responsible for raising capital through Airport Improvement Fees (AIF) to fund their infrastructure needs. This is still a case of public funding because the assets return to the Crown at the end of the airport leases, and the taxing authority of the airports is devolved from the Crown under the Ground Leases of the airports.

[ii] Calculated from Statistics Canada, 2004. Canadian Socio-economic Information Management System, *Selected Economic Indicators, Canada; Gross Domestic Product (GDP), Implicit Price Index (1997=100)*, Cansim II Series V3839779.

[iii] Calculated from Statistics Canada, 2004. Canadian Socio-economic Information Management System, *Federal and Provincial General Government Revenue and Expenditure, for Fiscal Year Ending March 31, Dollars Canada; Federal Government; Total Expenditures*, CANSIM II Series V156163, Table Number 3850002.

[iv] Infrastructure deficit has been defined as "the gap between what we invest as compared to what we ought to invest in the nation's transportation infrastructure in order to optimize (...) productive capacity and economic efficiency." *National Infrastructure Policy: A Sustained Commitment*: A presentation by municipal and regional associations in Manitoba to the House of Commons Standing Committee on Transportation, November 1998.
Also see: A Submission by the Association of Manitoba Municipalities to the House of Commons Standing Committee on Finance, October 2003. Retrieved February 18, 2004, http://www.amm.mb.ca/images/FinCom03.doc.

[v] Calculated from Transport Canada, 2003. 2003-2004 *Estimates - Report on Plans and Priorities*, Table 2.7, p. 9;
Transport Canada, 2003. *Transportation in Canada 2002 Annual Report*, Addendum, Chapter 3: Government Spending on Transportation, Tables A3-1 and A3-4, pp. A35, A36.

DÉVELOPPEMENTS SUBSÉQUENTS À L'ADOPTION DES MODIFICATIONS À LA LOI SUR LA CONCURRENCE POUR L'INDUSTRIE AÉRIENNE AU CANADA

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I Introduction

Suite à l'approbation du ministre canadien des transports, l'acquisition de Canadien International par la Compagnie Air Canada résultait en une concentration dans les mains de cette dernière de 90% des revenus passagers du marché aérien canadien intérieur. Pour pallier les inconvénients d'une telle situation de faiblesse concurrentielle, le parlement fédéral adoptait le projet de Loi C-46, qui entrait en vigueur le 5 juillet 2000.
Depuis lors, la situation a évolué aussi bien sur le terrain qu'aux niveaux législatifs et juridiques.
C'est à ces deux derniers aspects que ce texte s'intéresse.

II Développements législatifs

Le 4 juin 2002 était sanctionné[1] le Projet de Loi C-23 intitulé "Loi modifiant la Loi sur la concurrence et la Loi sur le Tribunal de la concurrence". Il s'agissait là d'un ensemble de modifications à ces deux lois ayant pour objet leur modernisation. On y traite entre autre de la création d'une nouvelle infraction intitulée "documentation trompeuse"[2], d'un droit d'accès privé au Tribunal de la Concurrence, des mécanismes d'entraide juridique avec des états étrangers etc.. Deux dispositions cependant affectent plus particulièrement

[1] L.C. 2002, ch. 16 ci-après intitulée la Loi.
[2] Nouvel article 53 Loi sur la Concurrence, L.R.C. 1985 ch. C-34 (ci-après intitulée L.C.), prévu par l'Art. 6 de la Loi.

l'industrie du transport aérien qui avait déjà suscité des modifications à la Loi sur la Concurrence[3]. Il s'agit d'abord de l'article 11.4 de la Loi qui prévoit une modification de l'article 79 de la Loi sur la Concurrence, portant sur les possibilités d'ordonnances par le tribunal dans les cas d'abus de position dominante. En effet, l'article 11.4 de la Loi y prévoit l'ajout de paragraphes (3.1, 3.2, 3.3) à l'article 79 pour permettre l'imposition d'une sanction administrative pécuniaire de 15 millions de dollar, à une compagnie aérienne qui aurait fait l'objet d'une ordonnance en raison d'abus de position dominante.

Il s'agit là d'une disposition tout à fait exceptionnelle. D'abord parce que jusqu'à l'adoption de la Loi la notion de sanctions administrative pécuniaires n'avait été établi dans le cadre de la Loi sur la concurrence que pour le cas de pratiques commerciales trompeuses telles que prévues dans la partie VII.1 de cette Loi. De plus, la sanction pécuniaire maximale dans ces derniers cas ne dépasser 200 000 $. Souvenons-nous à cet égard que le législateur était déjà allé très en avant, en créant dans ce contexte civil une sanction qui rappelle sous bien des aspects le droit pénal, tout en insistant qu'il ne s'agit pas d'une punition mais plutôt d'un encouragement "à adopter un comportement compatible avec les objectifs de la présente partie"[4]. Le but du législateur, dans ce langage condescendant et antinomique est évident : posséder des moyens de coercition propres au droit pénal sans avoir pour autant à subir le lourd fardeau de preuve qui s'y attache.

Rappelons-nous également que deux ans auparavant l'article 78 de la Loi sur la Concurrence définissant les agissements anticoncurrentiels pouvant donner lieu à une ordonnance d'interdiction dans le cas d'abus de position dominante (article 79) avait été exceptionnellement modifié (ajout d'alinéas (j) et (k)), justement pour imposer des

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[3] Supra note 2. Voir : J. Picard "Importance des modifications à la Loi sur la concurrence portant sur les comportements d'éviction et les ordonnances provisoires relativement à un service aérien" Actes du Congrès annuel du Groupe de recherche sur le Transports au Canada (GRTC) 2001, Vol.2 p.630.
[4] Voir Art. 74.1 (4) L.C.

contraintes particulières aux exploitants de l'industrie aérienne[5]. Il ne s'agit donc certainement pas d'un comportement dont la nature intrinsèque suscite l'outrage associé à la commission d'infractions pénales. Le législateur a cependant jugé que l'imposition d'une sanction administrative pécuniaire pouvant atteindre 15 millions de dollars était un moyen justifié pour contrer les mesures employées par Air Canada afin d'empêcher l'entrée de concurrents nouveaux par le biais d'une coupure de prix[6].

La deuxième disposition de la Loi qui pourrait avoir des incidences sur du transport aérien est prévue à l'article 12 qui ajoute à la Loi sur la Concurrence l'article 103.3 qui tout en ne s'appliquant exclusivement ni au secteur du transport aérien ni aux abus de position dominante, octroie un nouveau pouvoir au Tribunal de la Concurrence. Il s'agit de la possibilité de rendre une ordonnance provisoire interdisant la poursuite d'un certain type de comportement nuisible à la concurrence (dont l'abus de position dominante) à la demande "ex parte"[7] du Commissaire. Il s'agit d'une sorte de pendant à l'article 100 qui prévoyait déjà une ordonnance provisoire dans certains cas de fusionnements. Elle s'ajoute à la disposition prévue à l'article 104.1 introduit par la Loi de modification de 2000[8], qui lui ne touche que l'industrie aérienne et qui donne au commissaire le pouvoir (dans certaines circonstances) de rendre une ordonnance provisoire, afin d'empêcher un exploitant d'accomplir un acte qui pourrait constituer un agissement anticoncurrentiel (selon l'article 78 de la Loi sur la concurrence).

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[5] Art. 13,
"Loi modifiant la Loi sur les transports du Canada, la Loi sur la concurrence, la Loi sur le tribunal de la concurrence et la Loi sur la participation publique au Capital d'Air Canada et modifiant une autre Loi en conséquence" L.C. 2000 ch. 15".

[6] C'est ainsi que se sont soldées par des échecs les tentatives par Canjet, Roots Air, Royal Aviation, Canada 3000 de constituer une concurrence viable à Air Canada.

[7] C'est-à-dire sans présence de la partie adverse.

[8] Supra note 5 art. 15

Nous verrons subséquemment que l'introduction du nouvel article 103.3 éliminera peut-être la nécessité de recourir à l'article 104.1 de la Loi sur la concurrence qui comporte l'inconvénient majeur d'octroyer à la personne qui effectue une enquête, le pouvoir d'émettre un jugement.

III Développements jurisprudentiels

A) Caractère inopérant de l'article 104.1 de la Loi sur la Concurrence

Le 16 janvier 2003 la Cour d'appel du Québec[9] infirmant un jugement de la Cour Supérieure du 12 juillet 2001, déclarait l'article 104.1 de la Loi sur la Concurrence inopérant en raison de son incompatibilité avec l'article 2(e) de la Déclaration canadienne des droits.

Il s'agit de la disposition permettant au Commissaire de la concurrence de rendre une ordonnance provisoire contre un transporteur aérien, lui interdisant (sous certaines conditions) "d'accomplir tout acte ou mener toute activité qui selon lui pourrait constituer des mesures qu'il estime nécessaires pour ne pas nuire à la concurrence ou pour éviter de causer des dommages à une autre personne"[10]. Une telle ordonnance peut être rendue sans préavis et "sans donner au préalable à qui que ce soit la possibilité de présenter des observations."[11] Cette ordonnance reste initialement en vigueur 20 jours. Une telle ordonnance avait en effet été rendue le 12 octobre 2000 par le Commissaire pour interdire à Air Canada d'offrir certains tarifs considérés comme anti-concurrentiels[12]. Tout en interjetant appel de cette décision devant le tribunal de la concurrence[13], Air

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[9] Air Canada c. Canada (Procureure générale) [2003] J.Q. no 21, 23 C.P.R. (4th) 129. Demande d'autorisation d'Appel à la Cour Suprême du Canada accordée le 14 août 2003.
[10] Art. 104.1 (1) L.C.
[11] Id.
[12] Voir J. Picard supra. note 3.
[13] Appel rejeté Air Canada c Canada (Commissaire de la Concurrence) [2000] D.T.C.C. no 24, 10 C.P.R. (4th) 195, puis rejeté à nouveau par la Cour d'Appel

Canada fait une requête pour jugement déclaratoire auprès de la Cour Supérieure du Québec afin de rendre inopérant l'article 104.1 pour des motifs d'ordre constitutionnel. La Cour Supérieure du Québec[14] rejette cette demande après avoir fait une analyse détaillée des arguments soulevés. En effet, Air Canada avait allégué que l'article 104.1 L.C. allait à l'encontre des principes de justice fondamentale, codifiés à l'article 2 (e) de la Déclaration Canadienne des Droits : les règles *audi alteram partem*[15] et "*nemo judex in sua causa*[16], signifiant le droit de chaque partie à une audition impartiale de sa cause. De plus, cet article porterait atteinte à l'article 96 de la Loi constitutionnelle de 1987, relatif aux pouvoirs judiciaires des Cours Supérieures. Le juge Downs disposera de ce dernier argument[17] en se basant sur un arrêt antérieur de la Cour d'Appel du Québec[18] qui avait statué sur la constitutionnalité du Tribunal de la Concurrence et qui avait soulevé des questions similaires. La Cour d'Appel confirmera d'ailleurs cet aspect de l'analyse[19]. Néanmoins la Cour Supérieure reconnaît que le paragraphe 2 de l'article 104.1 L.C. est clair quant à la non exigence de donner préalablement à l'ordonnance du Commissaire la possibilité de se faire entendre, et quant au fait que le Commissaire est à la fois juge et partie, puisqu'il agit comme enquêteur et devient par la suite le poursuivant devant le tribunal de la Concurrence[20]. Le juge Downs rejette cependant la demande d'Air Canada et se rend aux arguments de la Procureure générale du Canada à l'effet que selon les critères développés par la Cour Suprême dans les Arrêts Knight et Baker[21], "Les exigences de

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fédérale [2002] 4 F.C. 598, 18 C.P.R. (4th) 31. Autorisation d'appel refusée par la Cour Suprême du Canada [2002] C.S.C.R. no 212.

[14] Air Canada c Canada (Procureure générale) [2001] J.Q. no 3287 [2001] R.J.A. 185.

[15] "Toute partie à un jugement a le droit d'être entendue par le juge".

[16] "On ne peut pas être juge dans sa propre cause" ou règle d'impartialité.

[17] Air Canada c Canada supra note 14 par. 47

[18] Canada c Alex Couture [1991] R.J.Q. 2534 (C.A.), 38 C.P.R. (3d) 293 autorisation de pourvoir à la Cour Suprême refusée (1992) 141N.R. 396.

[19] Au Canada c Canada (Procureure générale) supra note 9 par 118

[20] Air Canada c Canada supra note 14 par. 11, 12.

[21] Knight c Indian Head School Division No. 19, [1990] 1 R.C.S. 653; Baker c Canada (Ministre de la citoyenneté et de l'immigration) [1999] 2 R.C.S. 817.

caractère procédural de l'article 104.1 sont minimales. Il s'agit de l'application d'une loi de nature réglementaire, d'une décision qui n'est pas finale et qui affectent les intérêts de droits économiques"[22]. Étant donné, donc qu'il ne s'agit pas d'une violation d'un droit tel que celui de Liberté ou sécurité et que l'ordonnance est susceptible de modification à très court terme, il faut privilégier l'intérêt de la collectivité et de la concurrence et tenir compte de contexte très particulier dons le cadre duquel cet article a été adopté.

La Cour d'Appel infirmera ce jugement.

Elle souligne d'abord que la Déclaration Canadienne des Droits est un "document quasi constitutionnel"[23], et les tribunaux n'ont pas hésité à l'invoquer pour déclarer inopérants une disposition d'une Loi adoptée par le parlement canadien [24]. Elle n'a pas perdu sa pertinence depuis l'avènement de la Charte Canadienne des Droits et Libertés [25], et constitue au contraire un rôle complémentaire pour certains droits non énumérés dans la Charte. De plus, le droit à une audition impartiale énuméré à l'article 2(e) de la Déclaration n'est pas limité à ce qu'il est convenu d'appeler les "Droits fondamentaux" mais s'applique dès qu'un droit ou une obligation, au sens large, est atteint. On doit donc invalider l'article 104.1 s'il prive une partie d'un droit exprimé dans la Déclaration à moins qu'il existe une justification. Le Juge Rochon note aussi [26] que le Parlement n'a pas choisi en l'espèce d'utiliser la clause «nonobstant» prévue dans l'article 2 de la Déclaration. L'ordonnance de Commissaire peut selon lui créer une situation «irrémédiable» pour la partie visée.[27] Quoique l'on ne retrouve pas dans la Déclaration Canadienne des Droits une disposition semblable à l'article 1 de la Charte des Droits et Libertés permettant de restreinte les droits énoncés "dans des limites qui soient

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[22] Air Canada c Canada supra note 14
[23] Air Canada c Canada supra note 9 par 42
[24] Par exemple Singh c Ministère de l'Emploi et de l'immigration |1985| I.R.C.S. 172
[25] Air Canada c Canada supra note 9 par 47, référant à la Loi Constitutionnelle de 1982
[26] Id. par 58
[27] Id. par 75

raisonnables et dont la justification presse de démontrer dans le cadre d'une société libre et démocratique"; la Cour d'Appel [28] considère que pour ne pas conférer un caractère absolu aux droits couverts par cette Déclaration, il est approprié d'utiliser les critères prévus dans le fameux arrêt Oakes [29] et qui ont depuis 1986 guidé l'interprétation qu'ont faite les tribunaux quant à l'article 1 de la Charte.

Le Juge Rochon reconnait que la première exigence pour justifier l'atteinte aux droits prévus par l'article 2(e) est satisfaite. En effet, "la réglementation de la concurrence constitue une préoccupation sociale urgente et réelle pour la société". Cependant, il considère que l'article 104.1 ne satisfait pas au critère de proportionnalité prévu par l'arrêt Oakes : "En premier lieu, l'intimée n'a pas démontré : (1) la nécessité d'accorder ce pouvoir exorbitant à l'enquêteur et au poursuivant en vertu de cette Loi et; (2) en quoi les tribunaux ordinaires ou spécialisés (tel le Tribunal de la concurrence) ne peuvent s'acquitter adéquatement de cette fonction? Il est à tout le moins curieux que le législateur ait, après l'adoption de l'article 104.1, conféré un pouvoir quasi similaire au Tribunal de la concurrence (art. 103.3). Cela démontre que, de l'avis même du législateur, un tribunal spécialisé peut s'acquitter adéquatement de cette tâche dans des situations urgente."[30] En conséquence, la Cour d'Appel déclare l'article 104.1 L.C. inopérant en raison de son incompatibilité avec l'article 2(e) de la Déclaration canadienne des droits[31].

B) Agissements anticoncurrentiels par Air Canada

Une autre décision judiciaire importante a été rendue le 22 juillet 2003, cette fois par le Tribunal de la Concurrence.[32]

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[28] Id. par 98
[29] R.c. Oakes, [1986] 1 R.C.S. 103
[30] Id. par 103
[31] Id. par 120
[32] Commissaire de la Concurrence c. Air Canada 2003 Trib. conc. 13, 26 C.P.R. (4th) 476.

Il s'agit là de la première phase seulement d'un jugement relatif à une demande d'ordonnance déposée le 5 mars 2001 par le Commissaire de la Concurrence, afin d'interdire à Air Canada de s'adonner à une pratique d'abus de position dominante.[33] La pratique ciblée dans ce cas était, entre autres le fait pour Air Canada d'avoir réagi à l'entrée de concurrents (tels que CanJet Airlines ou WestJet Air lines), en augmentant sa capacité de transport ou en diminuant ses tarifs sur certains trajet (exemple Montréal-Halifax, Toronto-Moncton) sans que les revenus additionnels ne couvrent les coûts "évitables" additionnels associés à ces changements.

La raison pour laquelle le Tribunal décide de procéder en deux phases est due à la complexité procédurale de la disposition traitant des ordonnances d'interdiction dans les cas d'abus de position dominante.[34] En effet, pour qu'une telle ordonnance soit émise, il faut d'abord prouver que le défendeur se livre ou s'est livré à une pratique d'agissements anti-concurrentiels.[35] Dans l'affirmative il faut encore que le commissaire établisse que le défendeur contrôle sensiblement ou complètement une catégorie ou espèce d'entreprises à la grandeur du Canada ou d'une de ses régions.[36] Il faut enfin que la pratique d'agissements anti-concurrentiels ait eu ou ait (dans le présent ou le futur), l'effet d'empêcher ou de diminuer sensiblement la concurrence dans le marché en question.[37] Il peut donc y avoir des cas où une personne s'est livrée à des agissements anti-concurrentiels sans qu'il y ait là abus de position dominante.[38] Ainsi le Tribunal statuera que même si dans certains cas[39], il est impossible de "tenir compte d'une justification commerciale légitime" pour déterminer si un agissement est anti-concurrentiel, une telle justification pourra être examinée ultérieurement, lorsque le tribunal décidera s'il y a eu "pratique"

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[33] Art. 79 (1) L.C.
[34] Art. 79 (1) b L.C.
[35] Art. 79 (1) b L.C.
[36] Art. 79 (1) a.
[37] Art. 79 (1) c.
[38] Commissaire de la Concurrence c. Air Canada supra note 32 paragraphe 55.
[39] prévus par les alinéas 78 (1) j et 78(1)k L.C.

d'agissement anti-concurrentiels, condition nécessaire (Art. 79 (1) b L.C.) à la preuve d'abus de position dominante.

Ce qui constitue un agissement anti-concurrentiel est prévu à l'article 78 de la Loi sur la concurrence. Dans la cause présente, le Commissaire invoque l'alinéa qui 78 (j) ne concerne que les transporteurs aériens domestiques. Cet alinéa a d'abord la particularité, comme nous venons de l'indiquer[40], de ne pas exiger d'intention ou début d'exclusion de concurrents existant ou potentiels. Par ailleurs, il ne peut être interprété qu'en faisant référence à un règlement d'application. En l'occurrence, il s'agit du "Règlement sur les agissements anti-concurrentiels des exploitants de service intérieur"[41] qui détermine que l'exploitation ou l'augmentation de la "capacité sur une ou plusieurs routes à des prix qui ne couvrent les coûts évitables de prestation de service en cause" constitue un agissement anti-concurrentiel prévu par l'alinéa 78(1)j L.C.

Le Tribunal de la concurrence devra donc, pour émettre une ordonnance d'interdiction pour abus de position dominante, commencer par déterminer s'il y a eu agissements anti-concurrentiels. Or, les agissements invoqués sont prévus par l'alinéa 78(1)j L.C. faisant lui-même référence par le biais du Règlement précité[42] à des routes dont les prix ne couvrent pas les coûts évitable de prestation. Il est donc compréhensible que le Tribunal ait décidé de procéder en deux phases dont la première aura pour objectif de répondre à la question : Air Canada a-t-elle effectivement exploité ou augmenté de la capacité sur une ou plusieurs routes à des prix qui ne couvrent pas les coûts évitables de prestation du service en cause ?

La tâche du Tribunal sera d'autant plus ardue que le règlement d'application parle de concepts tels que "capacité sur une ou plusieurs routes", "prix", "coûts évitables" sans en expliciter la teneur. Ce

40 Id

41 SOR/2000-324

42 Supra note 41

dernier s'attellera donc à répondre d'abord aux questions suivantes : 1. Quelle(s) unité(s) de capacité convient-il de prendre en considération ? Pour le Commissaire, il s'agirait d'un vol régulier; pour Air Canada, ce serait plutôt une route particulière dans son ensemble. 2. Quels types de coûts sont évitables et à quel moment le deviennent-ils ? Pour le Commissaire, presque tous les coûts d'Air Canada sont évitables (excepté les frais généraux). Pour la défenderesse, même certains coûts variables ne sont pas inévitables. 3. Quelle période doit-on considérer pour déterminer si des coûts son évitables ? En effet, des coûts inévitables à très court terme peuvent être évitables à plus long terme. 4. Doit-on tenir compte des revenus provenant du vols ? En effet, lorsqu'un voyageur utilise un vol "contesté" pour ensuite effectuer une correspondance sur le réseau d'Air Canada, doit-on considérer comme prix (pour les fins de calcul) ce qu'il paie pour le segment contesté ou pour le trajet tout entier ?

L'espace ne nous permet pas de détailler l'analyse du Tribunal de la concurrence. Cependant, il faut souligner un certain nombre de ses conclusions.

Tout d'abord, il définit de la manière suivante les coûts évitables dans le contexte de l'éviction : Il s'agit de "tous les coûts pouvant être évités en cessant d'offrir le bien ou le service en cause. En général, les coûts évitables de prestation d'un service seront constitués des coûts variables et du coûts fixes spécifiques récupérables"[43]. Aucune firme, selon le Tribunal, ayant pour objectif de maximiser ses profits ne fixera son prix au dessus de son coût évitable. Une pratique contraire pourrait indiquer une intention d'éviction de concurrents.[44]

En ce qui concerne la question relative à l'unité de capacité, le Tribunal est d'avis qu'il s'agit de l'exploitation d'un vol régulier, ceci conformément aux arguments du Commissaire de la concurrence.

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[43] Commissaire de la concurrence c. Air Canada supra note 38 par.76

[44] Ce n'est pas obligatoirement le cas, néanmoins. Les produits d'appât (Loss leaders) en sont un exemple.

Le Tribunal cependant refuse de statuer sur un lapse de temps maximal pour remedier à une situation où les prix demandés ne couvrent pas les coûts évitables. Selon lui, "l'obligation qu'a le transporteur dominant de faire en sorte que les coûts évitables demeurent inférieurs aux revenus est continue"[45]. Il n'y a donc pas de "période de grâce".

Quant à l'inclusion dans le prix (calculé aux fins de comparaison aux coûts évitables) des revenus provenant des vols de correspondance, le Tribunal considère qu'ils ne devraient pas être compris dans les fins du calcul, mais qu'ils pourraient constituer une justification commerciale légitime au moment où comme nous l'avons indiqué plus haut le Tribunal aura à juger de l'ensemble de la preuve d'abus de position dominante et non pas seulement d'agissement anti-concurrentiel.[46] Encore faudrait-il que les calculs de ces revenus soient bien étayés par le défendeur, ce qui n'avait pas été le cas lors de cette première phase de l'audience. Le Tribunal après avoir précisé que le critère des coûts évitables devait être appliqué par rapport aux prix pratiqués plutôt que ceux annoncés, procède à la détermination de ce qu'il juge être le caractère d'évitabilité de tous les coûts associés aux vols contestés.[47] Il conclut finalement que sur les routes Toronto-Moncton et Halifax-Montréal, Air Canada "a exploité ou augmenté sa capacité à des prix qui ne couvraient pas les coûts évitables de prestation de service".[48]

Il reste donc au Tribunal de la concurrence à déterminer dans la phase II de l'audience si tous les autres éléments nécessaires à l'application de l'article 79 L.C. prévoyant une ordonnance d'interdiction pour abus de position dominantes étaient présents lors de la période sur laquelle porte la demande du Commissaire à la concurrence.

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[45] Commissaire de la concurrence c. Air Canada Supra note 38 par196

[46] Id par 222

[47] Id. par 147

[48] Id. p. 339

Conclusion

Quoique l'attention du grand public se soit plutôt portée sur les difficultés financières d'Air Canada, cela n'a pas empêché les acteurs préoccupés dès le départ par l'acquisition de Canadian Airlines, de s'activer autour de la problématique liée à l'existence d'un transporteur dominant le marché aérien domestique canadien. Le législateur continue de tenter d'améliorer les mesures pouvant permettre l'essor d'une concurrence saine dans ce secteur. Le Bureau de la Concurrence a remporté un succès important en établissant qu'Air Canada avait agi de manière anti-concurrentielle dans certaines circonstances. De ce fait, il rassure ceux qui éprouvaient un certain scepticisme quant à sa capacité de discipliner un joueur d'un tel gabarit.

Le Tribunal de la concurrence a également éclairci un certain nombre de concepts un peu obscurs se trouvant dans la Loi, et qui risquaient de rendre hasardeuse une tentative d'application des dispositions placées précisément pour contrer les effets du fusionnement des deux grandes lignes aériennes du Canada.

Quant à la décision de la Cour d'appel du Québec de rendre inopérant l'article 104.1 de la Loi sur la concurrence, en raison de son incompatibilité avec la Déclaration Canadienne des droits, l'inclusion du nouvel article 103.3 dans cette même Loi devrait en atténuer la portée sur le plan pratique.

ANNEXE I

Déclaration Canadienne des Droits L.C. 1960 ch. 44 L.R.C. 195 App. III

Article 2
Toute loi du Canada, à moins qu'une loi du Parlement du Canada ne déclare expressément qu'elle s'appliquera nonobstant la Déclaration canadienne des droits doit s'interpréter et s'appliquer de manière à ne pas supprimer, restreindre ou enfreindre l'un quelconque des droits ou des libertés reconnus et déclarés aux présentes, ni à en autoriser la

suppression, la diminution ou la transgression, et en particulier nulle loi du Canada ne doit s'interpréter ni s'appliquer comme : . . .
e) privant une personne du droit à une audition impartiale de sa cause selon les principes de justice fondamentale, pour la définition de ses droits et obligations. . . .

ANNEXE II

Loi modifiant la Loi sur la Concurrence et la Loi sur le Tribunal de la Concurrence

Sanction administrative pécuniaire
(3.1) Si l'entité qui fait l'objet d'une ordonnance en vertu des paragraphes (1) ou (2) exploite un service intérieur, au sens du paragraphe 55(1) de la *Loi sur les transports au Canada*, le Tribunal peut aussi prononcer à son égard une sanction administrative pécuniaire maximale de 15 000 000 $, à payer selon les modalités qu'il peut préciser.

Facteurs à prendre en compte
(3.2) Pour la détermination du montant de la sanction administrative pécuniaire, il est tenu compte des éléments suivants :

a) la fréquence et la durée du comportement;
b) la vulnérabilité des catégories de personnes qui souffrent du comportement;
c) le tort causé à la concurrence sur le marché pertinent;
d) le comportement antérieur de l'entité, en ce qui a trait au respect de la présente loi;
e) toute autre circonstance pertinente.

But de la sanction
(3.3) La sanction prévue au paragraphe (3.1) vise à encourager l'entité à adopter un comportement compatible avec les objectifs du présent article et non à la punir.

12. La même loi est modifiée par adjonction, avant l'article 104, de ce qui suit :

Ordonnance provisoire

103.3 (1) Sous réserve du paragraphe (2), le Tribunal peut, sur demande *ex parte* du commissaire dans laquelle il atteste qu'une enquête est en cours en vertu de l'alinéa 10(1)*b*), rendre une ordonnance provisoire pour interdire :

a) soit la poursuite d'un comportement qui pourrait faire l'objet d'une ordonnance en vertu des articles 75 à 77, 79, 81 ou 84;

b) soit la prise de mesures visées aux articles 82 ou 83.

Restriction

(2) Le Tribunal peut rendre l'ordonnance s'il conclut que le comportement ou les mesures pourraient être du type visé aux alinéas (1) *a*) ou *b*) et qu'à défaut d'ordonnance, selon le cas :

a) la concurrence subira vraisemblablement un préjudice auquel le Tribunal ne pourra adéquatement remédier;

b) un compétiteur sera vraisemblablement éliminé;

c) une personne subira vraisemblablement une réduction importante de sa part de marché, une perte importante de revenu ou des dommages auxquels le Tribunal ne pourra adéquatement remédier. . . .

ANNEXE III

Loi sur la Concurrence

Définition de «agissement anti-concurrentiel»

78. (1) Pour l'application de l'article 79, «agissement anti-concurrentiel» s'entend notamment des agissements suivants :. . . .

. . . i) le fait de vendre des articles à un prix inférieur au coût d'acquisition de ces articles dans le but de discipliner ou d'éliminer un concurrent;

j) à l'égard des exploitants d'un service intérieur, au sens du paragraphe 55(1) de la Loi sur les transports au Canada, les agissements précisés à l'alinéa (2)a); . . .

Règlements

(2) Le gouverneur en conseil peut, par règlement pris sur recommandation du ministre et du ministre des Transports :
a) préciser des agissements pour l'application de l'alinéa (1)j); ...

Définition de «agissement anti-concurrentiel»
79. (1) Lorsque, à la suite d'une demande du commissaire, il conclut à l'existence de la situation suivante :
a) une ou plusieurs personnes contrôlent sensiblement ou complètement une catégorie ou espèce d'entreprises à la grandeur du Canada ou d'une de ses régions;
b) cette personne ou ces personnes se livrent ou se sont livrées à une pratique d'agissements anti-concurrentiels;
c) la pratique a, a eu ou aura vraisemblablement pour effet d'empêcher ou de diminuer sensiblement la concurrence dans un marché,
le Tribunal peut rendre une ordonnance interdisant à ces personnes ou à l'une ou l'autre d'entre elles de se livrer à une telle pratique...

104.1 (1) Le commissaire peut rendre une ordonnance provisoire interdisant à une personne exploitant un service intérieur, au sens du paragraphe 55(1) de la *Loi sur les transports au Canada*, d'accomplir tout acte, ou de mener toute activité, qui, selon lui, pourrait constituer des agissements anti-concurrentiels ou lui enjoignant de prendre les mesures qu'il estime nécessaires pour ne pas nuire à la concurrence ou pour éviter de causer des dommages à une autre personne lorsque, à la fois :
a) il a commencé une enquête en vertu du paragraphe 10(1) en vue de déterminer si les agissements de la personne ont donné lieu à une situation visée à l'article 79;
b) il estime qu'en cas de non-prononcé de l'ordonnance :
(i) soit la concurrence subira vraisemblablement un préjudice auquel le Tribunal ne pourra adéquatement remédier,
(ii) soit un compétiteur sera vraisemblablement éliminé ou une personne subira vraisemblablement une réduction importante de sa part de marché, une perte importante de revenu ou des dommages auxquels le Tribunal ne pourra adéquatement remédier.
Aucun préavis ni aucune observation
(2) Le commissaire peut rendre l'ordonnance sans préavis et sans donner au préalable à qui que ce soit la possibilité de présenter des observations....

CANADIAN TRANSPORTATION ALLIANCES UNDER THE *COMPETITION ACT*?

Joseph Monteiro, Gwillym Allen and David Krause*

Introduction

Alliances, partnerships, mergers and acquisitions have occurred across the transportation spectrum as in many other sectors. As one commentator in telecommunications indicated they define the key to success in today's dynamic marketplace. This is hardly surprising in a world where regulatory barriers, legal barriers, and international barriers have been and are being dismantled. The former Minister of Transport, the Hounourable David M. Collenette in a speech to the C.I.T.T. stated "one of the most important trends now developing - one that we should all encourage - is the growing number of partnerships..." "What is required ...is for all sectors of the transportation system to focus on expanding and building more strategic alliances between modes." Similarly, the US Department of Justice has affirmed that global airline alliances can "promote the public interest by creating consumer and pro-competitive benefits that airlines cannot provide on their own" and the Association of European Airlines has recognised that international airline alliances are "one of the most important developments in the international airline industry in recent years."

To deal with these evolving forms of organization and their behaviour, we shall examine the treatment of Canadian transportation alliances under the *Competition Act*. Part I reviews the meaning of an alliance and the various alliances in different transportation modes. In Part II, the economic rationale for alliances is reviewed and Part III briefly indicates the impact of alliances. Part IV to VI examines the treatment of alliances in transportation under the *Competition Act* and briefly touches on the treatment of such alliances in other jurisdictions.

I. Alliances in Transportation in Canada

a) Definition

There is no unique definition of the term 'alliances'. At one

extreme, an alliance is formed by a complete joining of companies through a merger or take-over (referred to as a strategic alliance). At the other extreme, it may simply embrace some forms of agreement pertaining to limited practices in a market (referred to as a marketing alliance).[1] However in some countries, it has a more specific meaning if defined in law. Similarly in Canada, for purposes of enforcement of the *Competition Act*, the Competition Bureau defines an alliance as "an agreement, be it contractual or otherwise, between firms which involves something other than an arrangement to restrict competition amongst themselves."[2]

b) Alliances in Transportation - Is it Widespread in Canada?

The development of alliances in transportation can be traced to the late 1980s and the early 1990s. It first developed within the rail transportation subsector though it received greater prominence in connection with air passenger transportation.

i) Air Transportation - *Air passenger*: In air passenger transportation, transborder air alliances were initially formed in 1992 between Air Canada and United Airlines, and between Canadian International Air Lines and American Airlines though discussion about forming an alliance between Air Canada and US Airlines began in 1991and ended in failure. Air alliances with other countries began in

Table 1 - Major Countries Served by Alliance Networks

Carriers	Countries Extensively Served
1. STAR (i.e., Air Canada, Air New Zealand, All Nippon Airways, Ansett Australia, Austrian Airlines, British Midland, Lufthansa, Mexicana Airlines, SAS Scandinavian Air System, Singapore Airlines, Thai Airways International, United Airlines, and VARIG)	Canada, New Zealand, Japan, Australia, Austria, U.K., Germany, Mexico, Sweden, Singapore, Thailand, United States, and Brazil
2. Oneworld (i.e., Aer Lingus, American Airlines, British Airways, Cathay Pacific, Finnair, Iberia, LanChile, Quantas, Swiss International. *Associated* - Air Pacific, and Japan Airlines)	Ireland, United States, U.K., Hong Kong, Finland, Iberia, Chile, New Zealand, Air Pacific, and Japan
3. Wings (i.e., Braathens, Continental Airlines, Kenya Airways, KLM Royal Dutch Airlines, KLM UK, Northwest Airlines *Associated* - Air China, Japan Air System, Malaysia Airlines)	Scandinavia, United States, Kenya, Netherlands, U.K., China, Japan, and Malaysia
4. Delta/Air France (i.e., AeroMexico, Air France, Delta Airlines, Korean Airlines)	United States, France, Mexico, and Korea

1993 and by 1996 the air passenger industry witnessed a consolidation of these alliances into four major global alliances.

These alliances today are: 1. STAR; 2. Oneworld; 3. Wings; and 4. Delta/Air France. The market share of the these four global alliances in terms of the share of world scheduled passenger kilometres as of July 2000 was: 21.3%; 16.4%; 9.8%; and 9.7%. The countries extensively served by these alliances are shown in table 1.

Air cargo: The first air cargo alliance was formed in 1990 between Northwest Airlines and KLM Royal Dutch Airlines, however it existed on paper for five years. Until recently, air cargo alliances have had limited success and though it was expected that its formation would follow the pattern of air passenger alliances, this expectation did not materialize due to wide differences in which air lines handle cargo. In 2004 the emergence of air cargo alliances is expected to be stronger.

The three major global alliances to emerge in air cargo to date are: 1. SkyTeam Cargo; 2. WOW or New Global Cargo; and 3. Oneworld. The global market share (international traffic - freight ton kilometres) of the above three in 2002 were:14.9%; 19.9%; and 13.9%. The countries extensively served by these alliances are shown in table 2.

Table 2 - Major Countries Served by Air Cargo Alliance Networks

Carriers	Countries Extensively Served
1. SkyTeam Cargo (i.e., Air France, Delta, Korean, Alitalia, Aeromexico, CSA)	United States, France, Italy and Korea
2. WOW or New Global Cargo (i.e., Lufthansa, Singapore Airlines, SAS, JAL)	Germany, Singapore, Sweden and NE Asia
3. Oneworld (i.e., British Airways, American Airlines, Cathay, Lan Chile, Iberia et al., Swiss International Airlines)	United States, U.K., Hong Kong, Chile and Iberia

ii) Water - The first global alliance in ocean shipping was formed in 1994 between American President Lines (APL), Orient Overseas Container Lines (OOCL), and Mitsui-OSK Lines (MOL). The initial alliances formed in 1995 have since evolved.

Today the five major alliances are: 1. Maersk and Sea-Land.; 2. Grand Alliance; 3. New World Alliance; 4. The K-Line/COSCO Group; and 5. United Alliance. The market shares in US trade lanes of Maersk and Sea-Land, Grand Alliance, New World Alliance, The K-

Line/COSCO Group, and United Alliance in 2000 were 14.38%,

Table 3 - Service Routes of the Global Alliances in Water

Carriers	Routes
Sea-Land/Maersk	Trans-Pacific, Asia-Europe, Transatlantic, Latin America
Grand Alliance (i.e., Hapag-Lloyd, MISC, Nippon Yusen Kaisha (NYK), OOCL, and P&O Nedlloyd)	Trans-Pacific, Asia-Europe, Asia-U.S. East Coast, Europe-Middle East, Asia-Middle East/Mediterranean
New World Alliance (i.e., Hyundai Merchant Marine (HMM), MOL and Neptune Orient Lines /APL)	Trans-Pacific, Asia-Europe
K Line/COSCO Group (i.e., COSCO, K-Line and Yangming)	Trans-Pacific, Asia-Europe, Transatlantic, Mideast
United Alliance (i.e., Hanjin/DSR Senator and UASC	Trans-Pacific, Asia-Europe

Source: "Will mega-alliances mean mega-benefits for shippers?" Logistics Management, May 1996, pp. 65A-69A and "Twisting Alliances," American Shipper, January 1998, pp. 8-11.

13.80%, 12.52%, 11.35%, and 8.98%. There has been a suggestion that the last two alliances might merge which would make it the largest of the four alliances. The major trade routes or lanes of the alliances are shown in table 3.

iii) Rail - The forging of north-south links either through alliances, agreements, mergers, or operating rights which gathered steam in the 1990s can be traced to the implementation of the Canada-United States Free Trade Agreement. For example, CP in 1989 increased its ownership in SOO Line to 100 percent and in 1991 it finalized its purchase of Delaware and Hudson Railway and entered into agreements with Conrail. Similarly, CN in 1991 entered into separate agreements with Union Pacific, Burlington Northern and Norfolk Southern. Further, CN in 1992 formed alliance agreements to provide service to Mexico through Burlington Northern Railroad, Ferrocarriles Nacionales de Mexico and Protexa Burlington International.

Today, there are two major alliances involving the two Class I carriers in Canada, CN and CP. These are: 1. CN-Illinois Central Corporation; CN-Wisconsin Central Transportation Corporation; CN-Haulage Rights (Superior to Chicago; and Toledo to Cincinnati); CN-Burlington Northern Santa Fe Corporation (proposed merger-disallowed); CN-Burlington Northern Railroad, Ferrocarriles Nacionales de Mexico and Protexa Burlington International, and 2. CP-Norfolk Southern and CSX Transportation; and CP-Delaware and Hudson Railway.

Other alliances include CN's 15-year marketing alliance with

Kansas City Southern; a marketing agreement in October 2000 with BNSF to move agricultural products out of Illinois and Iowa; a alliance in November 2000 with BNSF developing interline service between western Canada, western US and southern US; co-production agreements in July 2000 with CP; joint intermodal service agreement with CSX in May 2001; and a joint intermodal service with UP to handle NAFTA freight in and out of Mexico and South Texas.

Table 4 - Major Points on Rail Alliance Networks

Carriers	Routes
CN and Alliances	Prince Rupert, Vancouver, Edmonton, Calgary, Winnipeg, Saskatoon, Thunder Bay, Toronto, Montreal, Halifax, Superior, Chicago, Omaha, Detroit, Cincinnati Kansas City, St. Louis, Memphis, Jackson, New Orleans, Mobile and points in Mexico
CP and Alliances	Vancouver, Prince George, Edmonton, Calgary, Regina, Saskatoon, Winnipeg, Thunder Bay, Sudbury, Sault Ste. Marie, Toronto, Moutreal, Sherbrooke, Philadelphia, Washington, NY/NJ

The market shares of CN and CP in Canada, the two alliance railways in 1999 were: 52.8% and 37.8% in terms of tonne kilometres. The major points served by the rail alliances are shown in table 4.

iv) Trucking - In trucking, the industry witnessed rapid structural changes after the introduction of regulatory reforms in 1987. Entry, mergers and alliances occurred with rationalization,[3] only a brief mention will be made of the alliances that occurred among the largest trucking companies. Some of these were recorded as early as 1993.

Of the largest eleven for-hire trucking companies that existed in 2000 in Canada at least seven companies had some form of alliance with other trucking companies. These include: Cabano Kingsway Transport of TransForce; Trimac Transportation Services; Mill Creek Motor Freight of Mullen Transportation Inc.; Midland Transport of J.D. Irving Ltd.; Day and Ross of Day and Ross Transportation Group; Clarke Inc.; and TransX. Alliances among small trucking companies include: Erb Transportation/FEE Transportation; Overland Freight/ Courier of BC/McGilvary Transport System; Challenger Motor Freight Inc./Daily Motor Freight Inc.; etc. A recent development is the combination of various logistic operations, resulting in supply chain integration. Recently, 6 of the largest US truckload carriers combined

their logistics operations into a company called Transplace.com.

The market share of alliance carriers in terms of fleet size indicate that they have 29.4% of the fleet of the fifty largest for-hire companies in Canada or 64.2% of the largest eleven. This is an underestimate as the number of alliances among all the fifty carriers is not known.

v) Intermodal transportation - Forming alliances with other modes of transport provide alternative forms of competition. These alliances mostly between the rail/truck and rail/marine modes were formed after 1990 and have not attracted much attention. The major intermodal alliances are briefly indicated.

Rail/Truck Alliances: CN has formed trucking partnerships with J.B. Hunt, APL Land Transport Services, KLLM Transport (of Jackson Mississippi), Kleysen Transport (of Winnipeg), Maritimes-Ontario Freight Lines Ltd., TransX and Clarke Inc. CP has formed an intermodal alliance with N. Yanke Transfer Ltd. and Guildford Transportation.

Rail/Marine Alliances: A rail-marine alliance was signed by CP - OOCL providing shipping service from Pacific Rim countries to Vancouver and inland rail service from Vancouver to Toronto and Montreal. Traffic will also move between Asia and Europe via the land-bridge service.

vi) Pipelines - The formation of alliances has not spread to the pipeline transportation industry though Canadian pipelines deliver crude oil and natural gas to connecting US pipelines.

The above description indicates that 'together' the alliances in the major subsectors of transportation (excluding trucking and pipelines) have become *widespread* and that they account for a *large share* of the freight in trade lanes in which they operate. This does not mean that any 'single' alliance controls the market or trade lane as the specific route would have to be determined and examined in greater detail.

II. Alliances - Is There An Economic Rationale?

New forms of organizational structure such as alliances provide numerous benefits: The benefits cited by the Competition Bureau are: 1) developing products by spreading costs and risks that would not be

possible; 2) reducing costs through common distribution systems or marketing agency; 3) providing access by enabling firms to surmount barriers; and 4) enabling product compatibility and minimum quality standards. Rigas Doganis cites four factors that are driving the search for alliances: a search for the marketing benefits of large size (including networks) and scope; a desire to reduce costs; the need to reduce competition as the industry becomes more liberalized and competitive; and nationality rules which make cross-border acquisitions and mergers impossible. A few economic theories to support one or the other of the above rationale is described.

Network Theory: The network theory has been used to explain the formation of alliances and mergers. In network industries, efficiencies arise on the supply-side from the joint provision of service by members of the network and externalities arise on the demand side as the value to existing users increase as more individuals join the network.[4] Access to entry has an effect on the equilibrium prices of the owner of the network and the entrant.

The Cartel-Monopoly Theory: Under the cartel-monopoly theory, firms have an incentive to coordinate their production and pricing activities to increase their collective and individual profits by restricting market output and raising market price. This is because a firm's profit goes up when it forms a cartel even though competitive firms may be 'maximizing their profits'. It results because each firm in the competitive situation ignores the increase in profits to other firms from a reduction of its own output, which it believes to be insignificant as it cannot affect price. In contrast, a cartel is able to capture the gains from a reduction of members' output.[5]

The Theory of the Empty Core: The theory of the core can be used to explain the reason for alliances as it could solve the instability problem resulting in an equilibrium where none would otherwise exist or the core is empty (i.e., there is no optimal solution). To explain this empty core two basic reasons are used. First, if demand is not an exact integer multiple of the output produced at the minimum point on the average U shaped cost curve, there will not be room for all firms to produce at the minimum (assuming identical curves). Therefore, some

of the firms will have to exit. As output is less than the total demand, prices will rise and new firms will be attracted charging below the existing price, thereby driving out the existing firms. Thus, there will be no competitive equilibrium or the core will be empty. Second, an empty core can also exists, without all firms having identical minimum average costs, if the supply curve is represented by disconnected upward sloping segments (and the length of the gap between the segments is equal to capacity) with the demand curve passing through.

The Theory of Contestablity: The contestability theory can also be used be used to explain the formation of alliances. If markets are non-contestable, alliances are formed to overcome sunk costs or barriers to entry such as regulatory requirements or ownership requirements. There are three conditions necessary for perfect contestability: (i) the absence of sunk costs[6]; (ii) a symmetrical positioning of entrant and incumbent; and, (iii) price sustainability.[7] The evidence of entry and exit, its costlessness, and the absence of sunk costs in the formation of alliances will determine the relevance of this theory.

Conclusion: There has been very little econometric work to provide support for one economic theory in favour of the other as alliances are a relatively new form of organization. Given the varied characteristics of the major transportation sectors, it is unlikely that one theory will provide a justification for all types of alliances.

III. Impact of Transportation Alliances

An alliance has several effects.[8] The most prominent can be categorized into those related to: 1) transportation networks, 2) services and 3) information and communication technology systems.

1) Transportation networks: The effects related to hub-and-spoke networks (air, sea, rail or trucking) are: enhancement of efficiency; enhancement of demand for the network; and reduction of competition or potential competition. In the case of networks that do not overlap except on the hub-hub route and where there are no potential entrants into each others market (as in the case of international air alliances) the alliance can result in efficiency gains in the form of seamless operations and any efficiency that may arise on the hub-hub route

from rationalization, increased density, etc. There will also be reduction of competition on the hub-hub route and an anti-competitive effect of an enhancement of demand for the network. In the case of networks that do not overlap but share a common hub, the alliance can yield efficiency gains from seamless operation and a reduction of any duplicate resources from sharing of the hub. There will also be an anti-competitive effect of increased market power of the alliance at the hub. In the case of networks that do overlap the efficiency benefits can be significant to the extent that there is greater scope for rationalization of the hub spoke system. The alliance, however, can result in a significant reduction of competition on all overlapping routes. Of all the three cases, the third case could lead to the greatest competition concerns. In addition, if the network structure itself changes, there would be an effect on traffic patterns and on transport related services.

2) Transport Related Services: In transport, several related services such as -- a) airport take-off, landing slots and gates, ship berths, railway interchange facilities, railway and trucking terminals; b) air-traffic control services, ship to shore navigational facilities and pilotage services, and border highway customs clearance services; c) services related to: air passenger and air baggage handling facilities, gantry cranes, air cargo sorting and storing facilities, and shipping terminals; d) maintenance services; e) cleaning services; and f) catering services -- are involved in the provision of transport services. Alliances have two effects: one on these services directly; and two on the provision of transport services indirectly. To the extent that transport services are rationalized or reduced in the first and third case of networks indicated above, the need for most services will be reduced, particularly a) and b). However, since the alliance will now have a greater proportion of most of the services needed in a)-c), particularly a), under its control its potential to prevent or restrict the development of new competing transport services will increase. The impact will depend on the significance of the alliance at a air hub, seaport or central terminal.

3) Information and communication technology (ICT) systems: ICT

systems include electronic data exchange, internet services, logistics and intelligent transport systems. Alliances have two effects: one on ICT systems directly; and two in the provision of transport services indirectly. To the extent that the formation of an alliance leads to rationalization of transport services, it would be possible for the alliance to rationalize its ICT operations if they use different ICT systems and to a lesser extent if they use the same. Assuming there are economies of scale in ICT operations (eg. computer reservation systems in air) a shift to one system would not only lower its costs but could lead to increased dominance of the ICT depending on the specific ICT involved. Increased dominance of an ICT could have an effect on competition in the provision of these ICT services and on competition in transport services, especially if the specific ICT is owned by the carriers forming the alliance.

IV. Transportation Alliances Under the *Competition Act*

Alliances are not specially referred to in any provision of the *Competition Act*. However, the Competition Bureau is of the view that most alliances do not raise an issue under the Act, in certain situations however, it can have several anti-competitive effects. Examples include: 1) price-fixing, market allocation, or bid rigging; 2) restricting output and raising prices; 3) deterring entry by potential competitors; and 4) reducing product innovation by discouraging independent research and development.

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.[9] According to the Bureau "Economic integration requires cooperation and coordination of the firms' assets that allow output and/or cost configurations that would not be feasible without the alliance. This implies that an agreement with no economic integration involves only changes in business decisions, such as pricing and output, and no essential recombination of assets."[10]

Abuse of Dominance Provisions: An abuse of dominant position occurs when an alliance creates a dominant entity in a market which engages in conduct that is intended to eliminate or discipline a competitor with the result that competition is prevented or lessened substantially. The three elements that must be satisfied under these provisions are: 1) the alliance substantially controls, throughout Canada or any area thereof, a class or species of business; 2) the alliance has engaged in a practice of anti-competitive acts; and 3) the practice has prevented or lessened competition substantially in a market.[11]

Merger Provisions: Where the effect of the alliance is to give one party the ability to materially influence the economic decisions of another, then the definition of a merger is likely satisfied as it implies the existence of a significant interest. The merger is then analyzed under the framework of the *Merger Enforcement Guidelines*. There are three basic analytic steps used: First, the relevant markets must be determined together with any changes in concentration that will occur. Second, the competitive concerns must be assessed to determine if the merger prevents or lessens competition substantially or is likely to do so. In determining the matter, a number of factors should be considered.[12] If concerns over substantial prevention or lessening of competition do not arise due to competition among members of the alliance or from non-alliance members, the alliance will not be challenged. Third, the efficiencies from the formation of the alliance and the balancing of it against the lessening of competition have to be addressed. If gains from the former are greater than the latter the alliance may still be allowed to proceed.

Conspiracy Provision and Related Provisions: There are two basic steps used in the economic analysis of a conspiracy once it has been established that the alliance entered into an agreement to lessen competition. First, one begins by determining if the parties to the agreement possess market power (in the relevant product and geographic market) or are they likely to obtain market power by virtue of the agreement. In other words, do the accused have the power to enable them to behave relatively independent of the market, in a

passive way. It is not necessary for the accused to have a monopoly, possession of a moderate degree of market power may be sufficient to support a finding of undueness. In determining this matter, market share alone is not sufficient to demonstrate market power. It is also important to determine if barriers to entry exist as it enables one to identify whether the alliance has market power. Second, the agreement must be or must have been likely to injure competition. Some agreements that merely involve exchange of product standards, or define trade terminology, etc. may not injure competition.

There are two other provisions of the *Competition Act* under which alliances may be considered: the joint venture provision and the specialization agreement provisions. The former is generally considered to have limited applicability as the definition of joint venture is unlikely to be satisfied given that an alliance does not refer to a specific program of research and development or a specific project. The later is also expected to have limited applicability as it involves an agreement between alliance members to reciprocally discontinue providing services among them. The specialization agreement must be registered with the Competition Tribunal if it is to obtain an exemption from the conspiracy provision.

Given the nature of an alliance, the interpretation of the above provisions of the *Competition Act* may raise certain issues: 1. The calculation and weight to be given to market share; 2. The treatment of information sharing; and 3. The treatment of access. Regarding the first, the calculation of the market share depends on the alliance agreement. Further, the calculation of the market share and the weight to be given to any market share depends on: the ability of the alliance members to take independent action to compete, the effect of control on incentives to compete, the duration of the alliance, the potential of the alliance to exercise market power by eliminating competition, and the exchange of information among members of the alliance. Regarding the second, the sharing of information among members of an alliance is generally unlikely to raise an issue under the Act, however, where members of an alliance possess market power and the exchange or sharing or information is likely to affect competition

unduly, the exchange will raise concern, as even under the conspiracy section such a defence is not applicable. Regarding the third, exclusion of non-members will not raise any competition issues in general as it could have pro-competitive effects. However, in situations where access is critical and its denial by the alliance will have anti-competitive effects, the Bureau will consider the matter on a case by case basis.

In sum, the Competition Bureau is of the view that most alliances do not raise an issue under the *Competition Act* and that most alliances will be looked upon favourably because of their positive impact on innovation and efficiency.

V. Treatment of Alliances by U.S. and EEC Antitrust Authorities?

Since alliances are a form of global organization they are also dealt with by other antitrust authorities. In the US, the statutes that are most applicable to alliances are section 2 of the *Sherman Act* concerning monopoly (i.e., actual monopoly, attempts to monopolize, and combinations and conspiracies to monopolize), section 7 of the *Clayton Act* pertaining to a merger (i.e., a acquisition that may substantially lessen competition, or tend to create a monopoly) and the *Hart-Scott Rodino Antitrust Improvement Act of 1976* dealing with pre-merger notification. Regarding mergers, the US has issued Horizontal Merger Guidelines and sectoral specific guidelines e.g., rail mergers. In the EEC, the most relevant regulations that are applicable are Article 86 of the EEC Treaty concerning abuse of a dominant position and Article 2 of Council Regulation 4064/89 of 21 December 1989 on the control of concentration between undertakings pertaining to merger (i.e., whereby effective competition would be significantly impeded in the common market).

So far, the treatment of alliances in the US and EEC, though limited basically to air transportation, reveals that these antitrust authorities have taken different approaches to dealing with perceived threats to competition (i.e., barriers to entry resulting from slot dominance and elimination of competition on short to medium haul routes). This is largely a result of their different policy approaches. The US anti-trust

authorities believe that if international alliances are operating under 'open skies', then free market forces should guard against anti-competitive behaviour.[13] The more interventionist policy of the EEC requires the alliances to give up runway slots to rivals to deal with hub dominance and route dominance. This is not surprising giving their different philosophies underlying competition laws. Perhaps, in due course of time these two jurisdictions may harmonize their approaches since the alliances have often to be approved by both.

VI. Are Alliances Exempt Under Other Laws?

In Canada, alliances in transportation are not provided any exemption under any other laws, such as the *Canada Transportation Act*, the *Railway Act*, the *Motor Vehicle Transport Act*, *Shipping Conferences Exemption Act* or other provincial motor carrier acts.

It should be noted that ocean liner shipping alliances, which may be exempt under statutes in other countries, do not receive any specific exemption under the *Shipping Conferences Exemption Act* (SCEA). SCEA applies to shipping conferences and the definition of a shipping conference does not include an alliance. This holds even though members of an alliance may be from different shipping conferences that receive an exemption (since the exemption applies to a conference and not to individual members). Similarly in the EEC, shipping alliances are not provided any exemption under regulation 4056/86. In contrast to Canada and the EEC, US provides an exemption to ocean liner shipping alliances if the alliance members file their agreements pursuant to the requirements of the *Ocean Shipping Reform Act*, 1998 (OSRA). However, it should be noted that shipping alliances are not specifically defined or mentioned under OSRA.

Concluding Remarks

Alliances are relatively new forms of organization that have grown in popularity with the fall in trade barriers and the increasing move to globalization. In air, water, and rail transportation, alliances have become *widespread* and *together* these alliances account for a *large share* of the market in each of these sub-sectors.

To explain this development, competing economic theories have emerged to provide a rationale for alliances. However, there is little econometric work to *generally* support one theory in favour of the other. Notwithstanding this, alliances have a *beneficial impact* on *efficiency* and *innovation* which appears to be corroborated by the limited empirical work in various transport sectors.

Since alliances may have anti-competitive effects they can be considered under the conspiracy, abuse of dominance, merger, joint ventures and specialization agreement provisions of the *Competition Act*, though alliances are not specifically mentioned in the *Act*. However, given that alliances can have a beneficial effect, an *individual* alliance generally *will not raise an issue under this Act* in Canada. The treatment of alliances by the US and EEC antitrust authorities is different based on the perceived threats to competition.

It has been suggested that alliances are transitional devices that have sprung up in the short run in response to the international regulatory environment that has hindered international mergers. Nevertheless, alliances are preferable to mergers from the competition perspective being looser forms of organization. In the long run, with the growing move to freer trade, once the ownership and nationality restrictions are removed this organizational form may become less important.

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

Endnotes

1. Button, Kenneth, "Shipping Alliances: Are they at the 'core' of solving instability problems in shipping?", in *Liner Shipping What's Next?*, Proceedings of the 1999 Halifax Conference, p. 60.

2. An agreement will be considered to involve something 'other than' a restriction of competition whenever it requires the firms to carry out a joint business function that requires some degree of economic integration. Firms jointly deciding how their respective businesses should be conducted to achieve a common purpose will not be considered an alliance. An agreement between firms to adopt a common approach to advertising, or to setting common price margins on their respective products would not qualify as an alliance. While, an agreement that involves firms jointly carrying out marketing research and developing and implementing a joint marketing plan to better determine and meet consumer needs would be considered an alliance since the agreement involves a joint business function that requires some degree of economic integration.

3. See *Annual Reviews of the National Transportation Agency*: 1991, p. 111; 1992, pp. 105-106; 1993, p. 61; and 1994, pp. 88-89. *Transport Canada, Annual Reports*: 1997, p. 169; 1998, pp. 213-214; 1999, pp. 114-115; and 2000, pp. 113-118.

4. The customer can realize benefits that go beyond the reach of an airline such as: smoother transfers, e-ticket interlining, greater rewards and services for frequent fliers, cost savings from joint procurements and sharing, provision of enhanced services through its scale of operations and the possibility of earning and redeeming awards across the entire network.

5. To visualize how the nature of this collective gain, is achieved see Monteiro, Joseph and Robertson, Gerald, "Shipping conference legislation in Canada, EEC, and the U.S.A: Background, emerging developments, trends and a few major issues", *Transportation Law Journal*, Volume 26, No. 2, Spring 1999, pp. 196-197.

6. A sunk cost is an outlay that cannot be recouped without substantial delay.

7. This can be achieved by preventing the incumbent firms from taking price action that will lead to zero expected profits. This condition has been referred to as the "price sustainability" condition. Price sustainability is likely to be achieved if the firms existing in the market cannot change their prices as fast as the new entrant or if the entrant can secure a contract with customers that guarantee him fixed prices and positive profits. This theory specifically emphasizes the significance of multiproduct firms and the problems arising from such cost structures. It also emphasizes the cost of joint production. Contestability theory permits no inefficient method of production to exist in the long run. If a market is contestable, a stable industry configuration has to be the most efficient configuration. Concerning natural monopoly, in a multiproduct context, conditions of natural monopoly will occur if and only if the costs of joint production are less than the costs of separate production for any scale or combination of outputs.

8. OECD, "Airline Mergers and Alliances," *OECD Journal of Competition Law and Policy*, Volume 2/No. 2, 2000, pp. 127- 224.

9. 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 one of 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.

10. In determining the extent of economic integration, the Bureau will consider such factors as the combination, by contract or otherwise, of significant capital, technology or other complimentary assets necessary to achieve such business functions as: production, product development, product distribution, or marketing such that firms involved are viably able to reduce costs or new products.

11. Substantial control is synonymous with market power (indicators of it are market shares, barriers to entry and other qualitative and quantitative factors); throughout Canada or any area thereof is synonymous with the relevant geographic market; and class or species or business is synonymous with the relevant product market. A practice under existing jurisprudence can encompass one occurrence that is sustained or systematic over a period of time or a number of different acts which when taken together have the prohibited effect. An anti-competitive act is one whose intended effect is either 'predatory, exclusionary or disciplinary', and in making this determination anti-competitive purpose is necessary. Substantial lessening of competition is assessed by reference to the level of competition in the relevant market namely do the anti-competitive acts preserve or add to market power which has an effect on the former.

12. Such as the extent of foreign competition, the likelihood that the merging firms would fail, acceptable substitutes, barriers to entry, the extent to which effective competition remains, the extent to which the merger would remove an effective competitor, the extent of innovation in the market or any other factor relevant to competition in the market.

13. Regulators in the US and Europe have expressed concern about the competitive effect of alliances in closed-entry markets - i.e., where restrictive bilateral or practical operational limits imposed by slots and gate space constrain potential new market entry.

Patents and R&D Expenditures as Indicators of Innovations in the Canadian Transportation Sector

Dimitri Sanga*

This paper provides a perspective on the innovation performance of the Canadian transportation sector using two indicators: Research and Development (R&D) and Patents. These indicators have been developed based on information obtained from the Canadian Intellectual Property Office patent database, the US Patent and Trademark Office database as well as OECD database on R-D.

Canadian inventors are responsible for 11.4 % of the patents delivered for transportation products in Canada. The analysis shows that US inventors have received from Canada nearly five times more patents for transportation products than Canadian inventors. For patents delivered by the US, this ratio is even greater at nearly 21 to one. Interestingly, Canadians received more patents in the US (3 662) than in their own country (2 058).

As compared to OECD leaders for the year 1999, the R-D effort for the transportation and warehousing sector (measured as total intra-mural R&D expenditures as a percentage of GDP) in Canada is low. France leads the pack with almost $ 50 of R&D in transportation and warehousing per $ 100 000 US of GDP. The US is third with $5 per $100 000 US of GDP while Canada is fourth with only $ 2.6. The G7 average is $13.

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* Senior Economist, Policy Research Group, Transport Canada. The opinions expressed in this paper do not represent the views of Transport Canada. I would like to thank David Kowalski for his help in collecting data on U.S. patents from the US Patent and Trademark Office database.

1 Introduction

While there is no unanimity on the meaning of '*innovation*', most definitions include the notion of applying new technologies and ideas for commercial or public policy purposes[1]. In *Straight Ahead: A Vision for Transportation in Canada*, Transport Canada reaffirmed that it would work to create an efficient transportation system in order to promote economic prosperity and a sustainable quality of life, in part through competition. To make the transportation sector more competitive, and pursue public policy objectives related to safety, security, the environment, accessibility and urban congestion, one of the Department's strategies is to rely on innovation.

Innovations in the transportation sector, as indeed in other sectors, are of interest to the government because they are publicly available: potential spin-offs from an innovation do not only benefit the owner (inventor or innovator) but may also be used by other producers. Thus the market, left completely to itself, offers little incentive for a given producer to invest in innovation. The government may therefore want to intervene to stimulate innovation through measures that will give private companies or individuals an incentive to innovate or to find innovative ways of supplying public goods and services.

If the government wants to act wisely in this regard, the public sector must have an adequate understanding of the extent of innovations in the various sectors of the economy. The present study contributes to such understanding by providing a comparative analysis of innovation in the transportation sector through two indicators: R&D expenditures and patents. These will be examined and compared to indicators for other sectors of the Canadian economy and for the economies of other OECD countries.

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[1] The Oslo Manual defines innovation as including any new concept, product or process, whether major or minor, and any new market. It also includes inputs other than research activities as such, including intramural activities related to design and market studies, and outside acquisitions of technology.

The first part of the article defines the concept of innovation and looks at its various aspects, ways of measuring it, and certain related indicators. It then proceeds to take a close look at innovation indicators for the Canadian transportation sector and at international comparisons, in terms of patents and R&D.

2 Measures of innovation

Innovation is a complex, multidimensional phenomenon, involving everything from the ability to innovate, to new products and processes, to the impact of innovation on the lives of consumers. Innovation may be recognized through patents, trade secrets or copyright.

2.1 Indicators of innovation

In view of the multidimensional nature of innovation, several indicators are needed to obtain a comprehensive picture of it. These indicators focus on one or another facet of the innovation process, such as inputs or outputs.

2.1.1 Indicators of inputs to innovation

Input indicators are those, which refer to financial investment in R&D, human resources assigned to R&D, and the equipment used to generate new or improved products or processes. The most commonly used indicators are:

- For financial investment, the GERD (**gross domestic expenditure on R&D**). This is the amount invested by a nation in R&D projects within that country. It can take the form of an absolute number, a percentage of gross domestic product (GDP) or a percentage of spending by an industry.
- For human resources, an **inventory of researchers, administrators, professionals and technicians assigned to R&D** in terms of either physical persons or Full Time Equivalents.

- For equipment, an **inventory of capital expenditures for R&D**.

2.1.2 Indicators of outputs of innovation

Output indicators point to marketable processes, products or ideas resulting from innovation. They include:

- **Patents**, which is an indicator of the volume of outputs by firms. Patents are indirect indicators.[2]
- **Sales of products or imitations**, which are new to a firm or new to an industry. When a product is new to a firm, it is considered an imitation; when it is new to an industry, it is considered a 'real' innovation.
- **Announcements of new products**: an inventory of new product announcements in technical and trade magazines.

2.1.3 Macroeconomic indicators of innovation

Certain macroeconomic variables may capture one or another aspect of innovation. Here are some of the macroeconomic indicators most used for this purpose:

- **Productivity**: Economic theory states that productivity arises in large measure from innovation. Data on the rate of growth of labour productivity in a sector may be used to measure innovation, though it is better to use total productivity because this takes account of all factors, not just labour.
- **Costs**: innovative industries provide high quality goods and services at a relatively low price.
- **World market share**: competitive advantage and truly innovative solutions manifest themselves internationally in the form of an increase in market share.
- **Intensity of R&D**: expenditures on R&D by source of funding and by number of people involved in R&D.

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[2] Not all innovations are patentable and not all are in fact patented. Also, not all patented innovations actually go to market.

While several indicators are available, the ones selected for analytical purposes will depend on availability of data. This study focuses on two indicators which are widely used and for which data are easily available: expenditures on R&D and patents[3].

3 Patents as indicators of innovation in the transportation sector

Patents are temporary monopolies granted to inventors for the commercial use of a newly invented device. The inventor may benefit from his invention by selling it, licensing it, or using it as an asset in negotiating a loan.

The advantages of using patents as indicators of innovation include: the fact that they measure those ideas which have taken material form in new products or processes; the availability of data on patents; the existence of an international classification system for patents in almost all countries, thus allowing for international comparisons; and finally the fact that patents reflect most areas of technology and a large number of industrial sectors.

There are also some disadvantages: not all inventions are patented or patentable; patents are not all of equal value and do not have the same impact; small and medium-sized firms are less likely to seek patents than large firms; patents are more effective in protecting inventions related to products than inventions related to services (which are often reflected in trade secrets); patents are not necessarily translated into marketable processes or products; the classification of patents does not always match the classification of industries; and finally, the technology sectors of the economy tend to seek patents more than other sectors.

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[3] Transport Canada is participating in the Statistics Canada 2003 Survey of Innovation, which is part of an effort by OECD countries to produce more advanced indicators of innovation than the traditional ones (R&D, patents). The Survey covers several aspects of innovation, from inputs to finished products or processes. The Survey is also gathering information on success and failure factors. The transportation sector will be covered, as will some of its subsectors.

3.1 Patents granted in the Canadian transportation sector

All Canadian patents can be found in a database maintained by the Canadian Intellectual Property Office (CIPO), which is part of Industry Canada. This database can be used to create tables of transportation-related inventions patented in Canada.

For purposes of this analysis, the International Patent Classification (IPC) was used because it allows for international comparisons. Note that the IPC does not always match the North American Industry Classification System (NAICS). To identify transportation-related patents, the entire IPC was scanned and certain relevant classes were identified (see Table 1).

Note that while these classes do cover innovations used in the transportation sector, these innovations come to a great extent from the transportation equipment manufacturing industries. As in the rest of the service sector, the services provided by the transportation industry, being non-material in nature, are not suited to patenting. For that reason, our analysis will refer to patents for *products related to* the transportation sector.

Table 1: Transportation-related classes of the International Patent Classification

Description	IPC class
Vehicles in general	B60
Railways	B61
Land vehicles for travelling otherwise than on rails	B62
Ships or other waterborne vessels; related equipment	B63
Aircraft; aviation; cosmonautics	B64
Construction of roads, railways or bridges	E01
Signalling	G08

Unless otherwise stated, all patent statistics are for the year 2002, the most recent year for which complete data are available in Canada and the United States[4].

3.1.1 Patents granted in Canada to Canadian inventors for products related to the transportation sector

If we restrict ourselves to patents granted in Canada to Canadian inventors, transportation-related products[5] represent 6-10% of all patents. This figure has changed little since 1980.

Canadian inventors received 11.4% of all patents related to the transportation sector that were granted during the period 1980-2002. Thus the great majority of transportation-related patents granted in Canada went to foreigners. This situation is not peculiar to the transportation sector: foreigners received 92.6% of Canadian patents in all sectors combined.

Within the transportation sector, the largest number of patents granted to Canadians were in the class 'Vehicles in general' (36.9%), followed by 'Land vehicles for travelling otherwise than on rails' (19.7%), 'Construction of roads, railways and bridges' (14.8%), 'Signalling' (12.3%) and finally 'Aircraft; aviation; cosmonautics' (2.5%).

3.2 Patents granted in Canada and the United States for products related to the transportation sector

In addition to the CIPO database, the database of the US Patent and Trademark Office (USPTO) was consulted to identify patents granted in the United States.

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[4] Analysis of patent data for the period 1980-2002 showed that results are similar to those based on the year 2002. One reason this period was selected for analysis is that it can represent by current activity.

[5] For present purposes, the transportation sector is represented by the set of classes on Table 1.

Patents obtained by Canadians in the United States were essentially of the same types obtained in Canada: the above-mentioned order of the classes is the same. It is worth noting that Canadians obtained more transportation-related patents in the United States than they did in Canada: 256 in the United States as compared to 122 in Canada in 2002. Also, Americans received more patents than Canadians in both countries: 5,210 in the United States and 389 in Canada. Two factors may in part explain the very great propensity to obtain U.S. rather than Canadian patents. First, patents can be assigned to others against financial consideration, and the expected payback for U.S. patents is more attractive. Second, U.S. patents are probably more visible because of the greater size of the American economy.

Transportation sector-related products accounted for 9.6% of Canadian patents granted to Canadians in all sectors of the economy, as compared to 5.9% of U.S. patents granted to Canadians in all sectors. It seems that in the transportation sector, Canadian inventors have a greater propensity than they do in other sectors to seek patents in Canada rather than in the U.S. Also, American inventors are somewhat less inclined than Canadians to seek patents in the transportation sector. Patents for transportation sector-related products accounted for only 5.8% of Canadian patents granted to Americans in all sectors, and only 4.6% of U.S. patents granted to Americans.

In 2002, patents granted to Canadian inventors represented 9.9% of all patents granted in Canada, whereas American inventors received half (51.9%) of all patents granted in Canada. American inventors also held 61.9% of all patents granted by the USPTO.

The transportation sector compares favourably to other sectors of the economy in terms of patents. For example, the class representing transportation sector products comes third, just after 'Medical or veterinary sciences' (A61) and 'Agriculture; forestry; animal husbandry; hunting; trapping; fishing' (A01). This is true in both Canada and the United States.

In absolute terms, Americans get more patents than Canadians in both countries. The difference is especially great for patents granted by the United States. In the class 'Vehicles in general' (B60), Americans get 4.4 times as many Canadian patents as Canadians, but they get 27.7 times as many American patents.

3.3 Patents granted in Canada and the United States to G7 inventors for products related to the transportation sector

Among the G7 countries, Canada received the highest proportion of transportation-related Canadian patents (9.6% of all Canadian patents), followed by Germany (6.3%) and the United States (5.8%). Italy came last, at 2.2%. Thus no country's share of Canadian patents for inventions in the transportation sector exceeded 10%.

For transportation-related American patents, Germany led the field (8.3%), followed by France (6.1%), Canada (5.9%), and Italy and the United States (both 4.6%).

Patents obtained by Canadian inventors of transportation-related products in Canada represented 0.95% of all Canadian patents, while the patents they obtained in the United States represented just 0.14% of all U.S. patents.

Looking at all 2002 patents, Canadians obtained fewer Canadian patents than Americans (6665) or Japanese (1618), and they obtained fewer American patents than any G7 country except Italy. Canada is second last among the G7 countries when it comes to patents.

All G7 inventors together received 94.2% of the patents for transportation-related products granted in Canada in 2002. For patents granted in the United States, the figure is 98.6%. In both Canada and the United States, about 5% of all patents granted were in the transportation sector.

4 R&D as an indicator of innovation in transportation

According to the Frascati Manual[6], research and development comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. R&D is the most popular indicator of innovation.

The advantages of R&D as an indicator of innovation are that all countries have regularly collected R&D data since 1950 and that they cover all sectors of the economy. The disadvantages are that R&D is an *input* to the innovation process, but in any given case there may not be any output. Also, R&D is just one input among many. For these reasons R&D may not be a good indicator of the outcome of the innovation process.

More particularly, R&D data tend to overestimate innovation in the manufacturing sector as compared to the services sectors. They bias the measurement of innovation because they leave out of account non-R&D inputs. As a result, the extent of innovation in the services sectors has long been underestimated.

4.1 State of R&D in the Canadian transportation sector[7]

For the Canadian economy as a whole, gross domestic expenditure on R&D in the business sector (BERD) is some 60% of total R&D expenditure[8]. BERD is about 1% of gross domestic product (GDP).

Our analysis of R&D concerns the transportation and warehousing sector (NAICS 2001 code 48-49). This sector spent some $34 million intramurally on industrial R&D in 2000, which is 0.05% of the value

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[6] OECD manual (6th edition 2002) for the measurement of resources devoted to R&D.
[7] The transportation industry falls into the category "transportation and warehousing" (NAICS code 48-49).
[8] This present analysis does not take into account R&D expenditures by governments and postsecondary institutions. BERD is more closely connected to the creation of new products and production techniques.

of production in the sector, and 0.3% of intramural R&D spending in the economy as a whole. Thus R&D in this sector represents only a tiny percentage of spending in the sector or of total Canadian R&D spending.

A total of 351 people were assigned to R&D in the transportation and warehousing sector, or 0.38% of all personnel assigned to R&D in the economy as a whole.

As a proportion of the value of production in a sector, the transportation and warehousing industry was one of those, which invested the least in R&D. For every $10,000 of production, the industry invested only $3.2 in R&D, as compared to $143.7 invested by the manufacturing sector and $33.4 by the service sector as a whole. Note however that this is the picture, which emerges when only R&D related to transportation services is considered. The picture would improve if account were taken of all the other sectors of the economy, which directly provide inputs to the transportation sector (transport equipment manufacturing; transport-related information technologies).

4.2 State of R&D in the Canadian transportation sector as compared to the other G7 countries

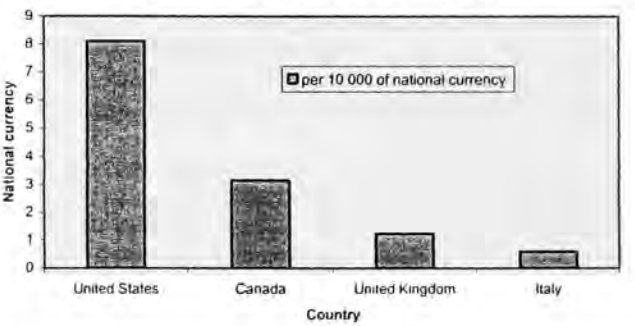
Data on R&D expenditures in the G7 countries have been taken from the OECD. The amounts given here may differ from other sources because they reflect the OECD's Analytical BERD database rather than the Official BERD data that appear in the publications of the various member countries. The figure for Analytical BERD is calculated from estimates based on the official data provided by member countries. It takes into account problems of international comparability and consistency. Coverage of the transportation sector is based on the transportation and warehousing services industry as

described by classes 60 and 63 of the International Standard Industrial Classification (ISIC, revision 3)[9].

Analysis of the OECD data for 1999 as can be observed in figure 1, shows that, within the business sector, the United States devotes a very large portion of its R&D expenditures to the transportation and warehousing industries: $2.5 out of every $1000 spent on R&D in the business sector. Canada is close behind at $2.1. Japan follows with $1.6, and Italy is last at $1.2.

The R&D effort in relation to the size of the transportation and warehousing industry varies greatly from country to country, being highest in the United States ($8.1 per $10,000 of production) and lowest in Italy ($0.6). Canada ranks second, at $3.2.

Figure 1: R&D Expenditures in the Transportation and Warehousing Sector per 10 000 of GDP in the sector, 1999



[9] BERD data for transportation and warehousing in France and Germany include the postal and telecommunications sector (ISIC 64), which means that they are not comparable to the other G7 countries. Data for the United Kingdom are not available for the period under study, for reasons of confidentiality.

5 Conclusions

The picture of innovation in the transportation sector, which we obtain from the two indicators, considered here has certain deficiencies. Patents focus solely on innovations affecting products, while R&D is just one of the inputs stimulating innovation, and as is well known, R&D underestimates the extent of innovative effort, particularly in the service sector. Still, patents and R&D are the only indicators for which reliable data are available.

Analysis of the data on patents granted in Canada and the United States to inventors from the various countries reveals that the great majority of Canadian patents have been granted to foreign inventors, and in particular inventors from the United States and other G7 countries; that Canadian inventors have more American than Canadian patents for transportation-related products; and finally that Americans have more patents than Canadians in both countries.

Analysis of the data on R&D in the transportation and warehousing sector in Canada and the other G7 countries reveals that R&D in this sector in Canada represents a tiny percentage of total Canadian R&D (0.3%) and of spending in the sector (0.05%); that only 0.38% of people assigned to R&D in the economy as a whole are working in the transportation and warehousing sector; that the sector is one of those which invests the least in R&D; that the United States devoted a significant share of R&D expenditure to the sector and that its R&D effort in relation to the size of the sector was high in 1999, at $8.1 per $10,000 of production, as compared to Canada with $3.2 per $10,000.

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Design and Demonstration of a GPS/EGNOS-based Railway User Navigation Equipment (RUNE)

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INTRODUCTION

The use of satellites has grown over the past decades increasing, improving and optimizing technologies related to telecommunications. The use has also been extended over the past decade to other applications, more notably, as complement or replacement of navigation tools. The airline and shipping industries have efficiently tapped into the advantages of global positioning systems. As a transportation industry, railway operations can be significantly improved by the use of global positioning systems with respect to amenities, to safety, to assistance to the operations, to protection of goods and people, and to productivity.

The use of satellite based navigation systems by the railways will undoubtedly represent a technical, industrial and operational challenge. The railways have a consolidated experience using other means of navigation, which may not always be ideal, but are well known and familiar to the operators. On the other hand, railways, like other modes, have to cope with a number of new challenges.

Alternative and more flexible train and freight tracking systems, in combination with existing techniques, are expected to prove attractive, if not indispensable, to be able to meet the new challenges (increased capacity and productivity, higher operating speeds,

increased safety requirements, environmental protection), and to cope with the tremendous pressure to improve and optimize the economy and profitability of their operations. Competition from other modes is fierce; satellite navigation is one of the options available to railway operators and users, to significantly improve track occupancy, safety of operations, productivity and customer satisfaction.

As demonstrated by various projects in Europe (e.g. RUNE), or in North America (e.g. Positive Train Control) for increased and enhanced train control, the use of GPS in conjunction with the appropriate systems and conventional navigation sensors, will permit a significant and dramatic increase in the safety, security and flexibility of the operations, increases in capacity and productivity, in the operating speeds, in customer satisfaction.

Traditional rail operation is based on defined and fixed blocks (length of track of defined limits, the use of which is governed by block signals, cab signals or both). Train movement is constrained by the fixed nature of the block, which impacts the speed and track occupancy. A GPS based system such as RUNE, will provide an accurate position over time, which permits an accurate calculation of train speed, and provide this information to the Operations Control Centre and to the on-board personnel. With all of the location and trajectory of each train in the system, a RUNE based operation complemented by conventional practices to overcome obstacles (e.g. loss of signals, weather conditions), will provide the flexibility needed to have a "block" move with the train, as opposed to the train moving within a block, thus increasing speed of operations, track capacity while preserving or enhancing safety.

THE EUROPEAN ENVIRONMENT

Although RUNE is being developed with the long term objectives of: **enhancing customer service** (passengers, freight, public at large), **providing better assistance to the locomotive engineer** for safer and productive operations, **providing more precise information to the Operations Control Centre** for increased safety in train

movement control, and increased productivity, and **increasing safety** of human life and better protection of goods and assets, in the immediate term it will demonstrate that it could be facilitating the implementation of ERTMS/ETCS in Europe.

The control and management of rail traffic in Europe is about to experience a major change. The common, interoperable European Train Control System (ETCS), which is a fundamental component of the European Rail Traffic Management System (ERTMS), is soon becoming reality, with lines and fleets of trains due to start commercial services in several countries within the next few years. Global Navigation Satellite System (GNSS) based position determination is expected to constitute an attractive complement to, or even a replacement for, some existing techniques, though it has received little attention so far. However, the emergence of reliable GNSS services, initially with the European Geo-stationary Navigation Overlay System (EGNOS) and eventually with Galileo, is expected to influence the practical implementation of ERTMS/ECTS. The emphasis is increasingly on safety-critical services for introducing GNSS in safety-critical rail operations, while safeguarding the investments made already in ERTMS/ECTS. The European Commission, the European Space Agency (ESA) and others already support the development of GNSS-based rail applications and more are planned. In particular On December 6, 2000, the ESA issued an invitation to submit a tender for the development and demonstration of a novel application in the field of railway transportation involving the use of the GNSS-1 signals GPS/GLONASS and their European SBAS EGNOS.

The railway application presented by the group led by Laben S.p.A. (which comprises Canada's national passenger railway operator VIA Rail Canada, the railway equipment and systems manufacturer ANSALDO Segnalamento Ferroviario, and the software developer Intecs) is called Rail User Navigation Equipment (RUNE). It explores the possible improvements resulting from an enhanced capability of the train to determine its own position by fusing the on board train

sensor currently used (odometer) with the Satellite Navigation technology (based on EGNOS).

The project is being implemented in two phases. During Phase 1, completed in September 2002, the group developed and assessed the requirements and defined the demonstrator (hardware, software, rail operating set-up). The demonstrator is assembled during Phase 2 and tested in laboratory. Its evaluation will be completed with a demonstration of its performance in the rail environment and of its functionality in two rail applications. The test will take place later on this year on a Trenitalia's test train, operating on the test track between Olcenengo and Settimo on the Torino-Milano line, in Northern Italy.

ERTMS REFERENCE ARCHITECTURE

Due to the nature of the required functions, the European ERTMS/ETCS system is subdivided into two sub-systems, the on-board sub-system and the trackside sub-system, in an environment composed of the train, the driver, the external trackside systems (interlocking, control centres, etc.), for which no interoperability requirement has been established.

The train computes its position through its odometer unit. This position is communicated via a GSM link to the nearest Radio Block Centre (RBC) (ERTMS level 2 and 3). The position consists of the computed distance (and the related integrity information) from the last relevant balise group (LRBG) whose position is known by the control centre and is identified by its ID. The Control Centre is constantly aware of the position of each train (ERTMS level 3) and can easily manage the traffic returning to the train the movement authority (free ahead track) and the track description via Euro Radio relating to a balise. The train monitors train integrity (using an external train integrity proving device which is not part of ERTMS/ETCS), selects the most restrictive value of the different speeds permitted at each location ahead. It calculates the dynamic speed profile, taking into account the train running/braking

characteristics that are known on-board and the track description data. Moreover it compares the actual train speed with the permitted speed and commands a braking if necessary.

The ERTMS defines 4 application levels. At level 0, ERTMS / ETCS is not used. Train management is committed to the driver and to the trackside visual signals. Application level 1 ERTMS/ETCS Level 1 is a spot transmission based train control system to be used as an overlay on an underlying signalling system: movement authorities are generated trackside and are transmitted to the train via Eurobalises. ERTMS/ETCS Level 1 provides a continuous speed supervision system, which also protects against overrun of the authority. Train detection and train integrity supervision are performed by the trackside equipment of the underlying signalling system (interlocking, track circuits etc.) and are outside the scope of ERTMS/ETCS. In Level 2 movement authorities are still generated trackside but the information are managed by the control centre and dispatched via GSM-R. Application level 3 requires only trackside balise only for train location purposes. The traffic management is based on train position information and the communication between the control centre and the train via the GSM link.

RUNE ARCHITECTURE OVERVIEW

Train navigation is somewhat different from all the other type of navigation (aerial, naval, car pedestrian): train position has only one degree of freedom. This fact has many consequences:

- for rail users (traffic control centres), the position along the track and not the geographical position is the required information;
- the odometer is the best-suited sensor for such type of measurement while a GPS sensor without aiding information (railway map) is almost useless.

Though, odometers performances are compromised by slip & slide and creep phenomena, this causes the position error to increase with time and the difficulty to have an accurate velocity profile during

brakes (in case of slips). ERTMS foresees the balise as navigation aiding for odometer error reset, and track ambiguity re-solution. Balises cannot improve the velocity profile and their installation is particularly expensive, however, the information is extremely affordable.

The RUNE objectives are to introduce an autonomous positioning system into the ERTMS/ETCS architecture (mainly based on GNSS) in order to:

- integrate the odometer function, enhancing its accuracy, robustness and integrity estimation function,
- saving costs on trackside signalling, substituting the physical balise with the *virtual balise* where the reference position is based on the GNSS and a digitalized railway map,
- providing real time accurate track information to the train kernel for speed profile supervision, breaking profile computation (speed, acceleration and adhesion factor estimate).

The RUNE system integrates data in a Navigation Kalman Filter from 3 main on-board sensors: GPS/EGNOS Receiver, 3-axis Inertial Measurement Unit, Train Odometer unit, and a database *virtual balise map* containing balise identifications, their geographical and along track position.

In the ERTMS/ETCS application perspective RUNE substitutes the two modules (Odometer and Balise Transmission Module BTM) keeping the same interface to limit the impact on the existing architectures safeguarding the investments.

The developed prototype implements the functionalities of the final application together with facilities and functionalities for a real time performance evaluation: balise and Doppler radar data are acquired in order to provide position and velocity references. The prototype is also able to perform off-train tests using the data collected on-board. This capability helps in simulating visibility gaps or other

environmental conditions that cannot be gaps or other environmental conditions that cannot be easily reproduced during a test in a real railway environment.

The Recording and Evaluation System (RES) software is the heart of the RUNE Demonstrator; it acquires the Navigation Data, stores them and performs the Real Time Verification. More in details, RES:

- Acquires the Navigation Data generated by Navigation Sensors (GNSS receiver, odometer, IMU) and reference sensors (balises, Doppler radar),
- Timestamps the collected data with respect to the GPS Time reference system and store them for post processing,
- Implements the Real Time Data Fusion (Navigation Filter),
- Supports the Real Time Verification comparing the computed Train position with the marker provided by the wayside balises,
- Provides the Environment for Data Post Processing (off line evaluation),
- Verifies the overall RUNE Demonstrator functionality and maintain a fault log,
- Provides the MMI to the Test Engineer,
- Generates virtual balise telegrams and sends them to the train Kernel through PROFIBUS.

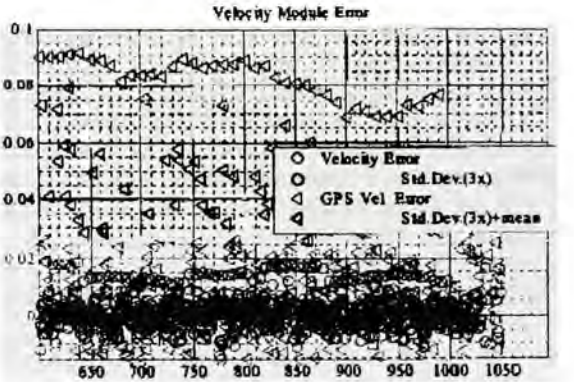
RUNE is interfaced trough a PROFIBUS to the ANSALDO on board navigation system ATC (Automatic Train Control System) developed in conformance to the ERTMS\ETCS requirements. RUNE integrates seamlessly into the ANSALDO ATC by substituting the odometer and BTM PROFIBUS IF with its own. In particular it will be demonstrated the capability to travel using virtual balises.

Moreover RUNE MMI provides an in-cab signalling functionality (based on a database of the track virtual signals) together with a speed monitoring (based on a database of the velocity profiles along the track).

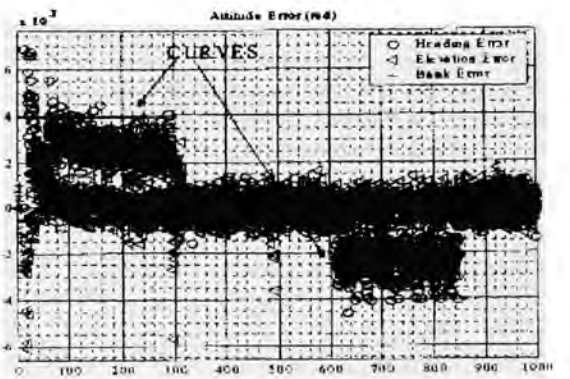
SUMMARY OF PRELIMINARY RESULTS

RUNE has passed functional laboratory tests whose results are briefly summarized in the plots below.

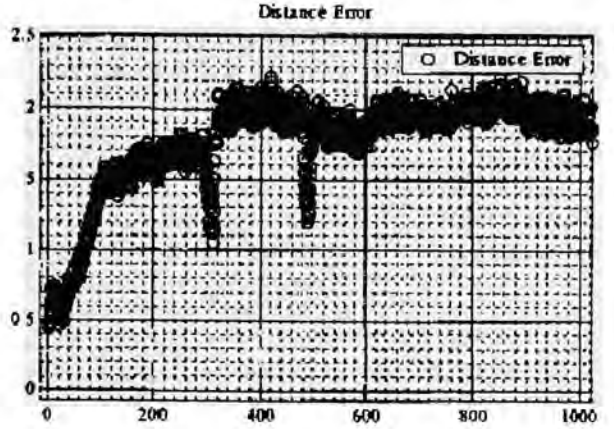
Along Track Velocity Error



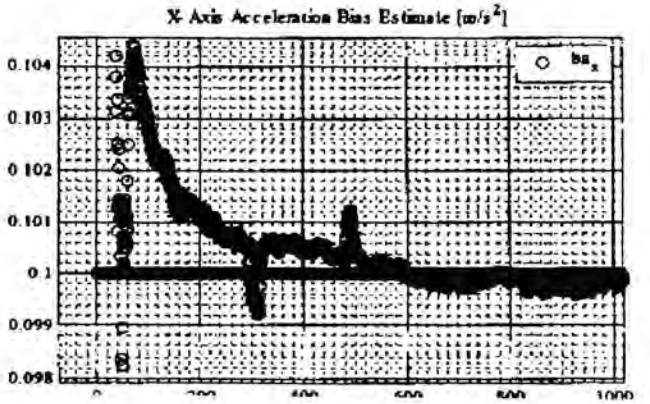
Attitude Error



Along Track Distance Error



Bias Estimate Error



VALIDATION TEST CAMPAIGN

The on train demonstration will compare en-route the **performance** of the RUNE Demonstrator with respect to accurate train positioning capabilities and train velocity information, with that obtainable with traditional navigation sensors. It will also demonstrate its **functionality** in two applications: in-cab signalling and virtual balise detection.

The target for position accuracy is to improve the train capability to self-determine its own position with an accuracy of ± **3 m** (nominal dynamic condition) and better in nominal static condition in order to improve ERTMS Level 1, 2 and 3 Position Accuracy Requirements to reduce the frequency of the Odometric Balises, and to comply with Level 3 (nominal dynamic condition) and Level 2 (nominal static condition) safety application requirements.

The possibility of supporting the awakening train assignment to track will also be investigated.

The Target for speed accuracy is to improve the train capability to self-determine its own speed with an accuracy of ± **2Km/h** in order to detect slip and slide phenomena, and to improve overall safety.

The following figure summarizes the on train set up for the test.

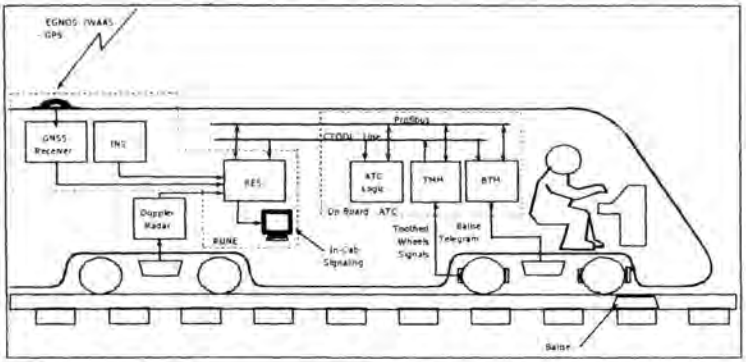


Figure 1 – Demonstration Set Up

- **Train Positioning**

The RUNE Demonstrator will receive navigation data from the GNSS receiver, including latitude, longitude, time and alarm limit, required to determine and record the train position on the Digital Train Route Map.

The train position accuracy will be tested and verified by setting into the Digital Balise Map a virtual balise for each physical one, and located at the exact same position.

The On-Board ATC will detect the train crossing over a physical balise. The information is then provided to the RUNE RES through the Profibus, and recorded.

Similarly, the train crossing over the corresponding virtual balise will be detected by RUNE through the GNSS receiver. The RES records the information.
The RUNE RES compares the two positions recorded, and reports any discrepancy.

- **Velocity Monitoring**

Train velocity will be calculated by RUNE based on train position signals from the GNSS receiver.

Train velocity will also be provided by the Train Odometer Unit (TOU) and by the Doppler Radar.

Accuracy will be verified by comparing the values obtained by the RUNE RES and by the On-Board ATC.

- **In-Cab Signalling**

Once the performance of RUNE has been evaluated and established, it will be possible to demonstrate its behaviour in a rail application. The demonstration will consist of displaying on the PC monitor installed on the test train all information relevant to train movement and operation (In-Cab Signalling). The information is intended for the locomotive engineer or for the rail traffic controller in the operations centre, and is needed for the safe and secure monitoring of train movement and operation.

The information displayed on the on-board monitor will include **travel information**, such as train position, current speed, maximum allowed speed, traveled distance, estimated time to the next lateral signal; **warnings** to the locomotive engineer, such as exceeding maximum speed and approaching lateral signal; the **travel log**, comparing the actual train speed to the maximum allowed speed over the complete trip

During the process, the accuracy and correctness of the displayed information will also be established.

- **Virtual Balise Detection Capability**

This other demonstration will consist in the detection of the Virtual Balise by RUNE and the transmission of the relevant message to the

On-Board ATC. The verification of the correctness of the transmitted information will be performed using the diagnostic functionality provided by the On-Board ATC. The RES will collect the data and present the results of the comparison (time and position of the physical balise versus time and position of the virtual one).

During on-board demonstration, the RUNE navigation output will be compared to measurements taken from a Doppler Radar installed on the train, and physical balises installed along the test track used as high accuracy position reference.

OFF-TRAIN TESTING

The tests taking place in the real environment are mainly functional, since, due to the limited length of the track, the environmental conditions are not representative. However, because of the RES capability, laboratory tests will be performed where typical environmental effects like GPS visibility gaps, creep, gross slip & slide phenomena will be reproduced through real time collected data conditioning.

In particular the following items will be measured:

- along track position and velocity performance in a nominal environment,
- sensitivity to visibility gap duration / frequency,
- sensitivity to creep,
- sensitivity to gross-slip & slide phenomena,
- protection level (availability / effective confidence level in case of EGNOS visibility),
- computation of the missing detection / false alarm probability for the integrity function through laboratory failure simulation.

A specific safety analysis will end this work with the objective of using the test results in order to provide a ROM estimate of the safety integrity level of the RUNE prototype.

CONCLUSIONS AND FUTURE WORK

Availability and integrity requirements are the most challenging obstacles towards an ERTMS/ETCS compliant GNSS aided railway navigation equipment. Future Galileo local augmentation services (local elements) could fill the gap. RUNE is designed to take advantage of the current EGNOS integrity and wide area differential correction service and extend its availability through a hybridized navigation system. Functional tests have validated the proposed architecture. Future performance tests in a real railway environment, integrated by laboratory tests (based on real time collected data) will asses about the possibility to use RUNE like architecture in low cost low speed lines or in railway lines characterized by favourable environments.

The proposed architecture has still margin for further improvements. Map matching techniques for example could enhance the position accuracy and the reliability of the integrity function (larger number of redundant measurements) with small architecture modifications: the trajectory for train model linearization is provided by the map (no integration on gyro measurements for attitude computation is required). Moreover, being a digitalized railway map, a one-dimensional space, (two pseudo-range measurements are required for position determination) continuity could take advantage of a tight coupling architecture that relies on receiver pseudo-range measurements.

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The Economics of Commuter Rail Alternatives: A Comparative Cost Perspective

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Abstract

In the North American commuter rail environment, authorities planning to commence or expand service have a number of rolling stock options to evaluate. In the non-electrified mixed traffic operating environments that are prevalent outside of the North-eastern United States, locomotive hauled vehicles have traditionally been the equipment of choice. This has involved diesel-electric locomotives with head-end power units used in push-pull operation with either single-level or multiple-level coaches. With the imminent re-emergence of a diesel-multiple unit (DMU) vehicle compliant with Federal Railroad Administration (FRA) standards for mixed traffic operation, the available equipment options have expanded. Authorities must be provided with the required information to evaluate the cost and benefits of this newly available option in a comparative perspective. This study evaluates the true direct costs associated with the life cycle of rail vehicles, in order to provide transit authorities with the information required to make informed procurement decisions.[1][2]

[1] For the uses of this study 'True Direct Cost' excludes track access fees and insurance. Justification for the exclusion of these issues is included on pg. 13 of this paper.

This study determined the following costs for typical operational configurations.

- A 1-5-1 consist (669 seats) of one F40PH locomotive operating in push-pull configuration with five single level coaches and one cab car based on the design of the New Jersey Transit Comet IV vehicle was found to incur operational costs of $37.70 per mile over a 30 year life-cycle operating 50,000 miles per year.
- A 1-5-1 consist (880 seats) of one F40PH locomotive operating in push-pull configuration with five bi-level coaches and one cab car based on the design of the Bombardier BiLevel commuter car was found to incur operational costs of $42.12 per mile over a 30 year life-cycle operating 50,000 miles per year.
- A consist of 2 married pairs (374 seats) of DMU vehicles based on the operating costs of existing Bombardier built EMU and DMU vehicles was found to incur operational costs of $27.89 per mile over a 30 year life-cycle operating 50,000 annual miles.

Introduction

The feasibility of developing and deploying modern diesel multiple unit (DMU) technology in the North American operating environment has been evaluated by transit authorities, consultants, and car builders over the past 20 years.[3] The traditional industry opinion has held that DMU, due to its operational characteristics, is the best technology choice for low density lines with variable ridership demand. Despite the appeal of this logic, seldom in the literature have the tangible benefits of this assumption been quantified. In order to justify the re-deployment of this technology, authorities must answer a number of

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[2] All dollar amounts not specifically labelled are quoted in unadjusted 2003 US dollars. When source information was only available in Canadian dollars, a 1.45 US/CAD cross rate was used.

[3] See Sislak (1996), Jacobs & Galbraith (1997), Rader (2003).

questions. Specifically, what are the quantifiable benefits attainable from the operation of DMUs and how does the operating cost of this technology compare to traditional push-pull technology.

Research Methodology

The research approach used for this study involved the collection, analysis, and review of multiple data sources. Source data collected included:

- 30 year life-cycle material maintenance costs for the Bombardier BiLevel commuter car based on actual operational experience at a major North American commuter rail property
- 30 year life-cycle material maintenance costs for a single-level commuter rail coach based on a system-by-system analysis
- 30 year life-cycle material maintenance costs for an EMD F40PH locomotive from operational experience at a major North American commuter rail property
- 30 year life-cycle material maintenance costs for an FRA-compliant DMU vehicle based on the M-7 Electric Multiple Unit (EMU) design
- A survey of maintenance costs for a cross section of North American commuter rail properties that include material & labor costs and administrative overheads
- A survey of maintenance and labor costs for DMU vehicles at a major European rail operator for a 10 year operational cycle
- Numerous internal interviews and discussions with knowledgeable vehicle maintenance staff within Bombardier Transportation

The research methodology involved the following steps

- Evaluation of maintenance (material and labor) costs for all vehicles selected for the study

- Determination of the maintenance costs on a per mile basis for each operational example
- Utilization of alternate experiences and cases to justify a common-size approach to vehicle mileage across the different vehicles (normalizing the data for mileage effects)
- Evaluation of known and predicted market prices for vehicles considered in the study
- Determination of other direct costs associated with operations including; fuel, crews, and cleaning
- Choice of the operational context (annual miles and hours of service) to be used for a comparative view of total direct cost
- Analysis of the results and determination of total cost conclusions

Description of Rolling Stock

Single Level Coaches

Single level commuter rail coaches are in service at a number of authorities across North America. Such coaches are prevalent among operators such as New Jersey Transit, Metro North Railroad, and the Connecticut Department of Transportation. The vehicle chosen for this evaluation was the New Jersey Transit Comet IV vehicle of which 99 cars were produced by Bombardier Transportation between 1995 and 1997. These vehicles were produced with a 3x2 theatre seating configuration. The seating capacities are 113 for the coach and 104 for the cab car. These vehicles were built to specification with both high and low level boarding.

Bi-Level Coaches

For the purposes of this study, the bi-level vehicle evaluated was that of the Bombardier BiLevel commuter car. This vehicle has been produced for more than 25 years in various configurations and is currently in operation at ten North American transit agencies. It is an aluminum car shell construction with low-level boarding. The configuration chosen was that of pod seating in a 2x2 configuration. Seating capacity of the coach car is 147 while that of the cab car is

145. Operation and maintenance costs were surveyed for this vehicle. As Bombardier Transportation currently maintains two fleets of these vehicles (GO Transit in Toronto, Canada & SCRRA in Los Angeles, California) extensive operational information was available for the uses of this study.

Locomotive

For the purposes of this study, the most comprehensive locomotive life-cycle cost information was available for the GM Electro-Motive Division F40PH. With extensive service history and parts availability, the information available for the maintenance of the F40PH model was more complete than data available for the F59 series locomotive. The prime source for locomotive maintenance information was the *Massachusetts Bay Commuter Railroad Inc (MBCR)*. which provides operation and maintenance services to the Massachusetts Bay Transportation Authority in Boston, Massachusetts. *MBCR* is responsible for the operations and maintenance of 55 F40PH locomotives.

Diesel-Multiple Unit

Without a modern operational unit with revenue service experience in North America to evaluate, the primary task has been to determine the operation costs of a DMU vehicle for comparative purposes. While available Budd Rail Diesel Car (RDC) vehicles were a potential choice, this was disregarded as a significant number of vehicle systems would be substantially different in a modernized DMU. A potential DMU configuration was determined by a survey of the industry and the Bombardier Transportation product portfolio to determine the best product configuration. A number of European products were evaluated as potentials for conversion to North American specifications. This evaluation included vehicles currently in revenue service in Great Britain, Germany, France, and Denmark and included an evaluation of double deck (bi-level) powered vehicle designs. It was determined that significant technical issues remain to be solved before any such vehicles could be adapted to FRA requirements. Thus the ideal DMU product configuration would be

based on the M-7 vehicle that is currently in revenue service as an Electric Multiple-Unit (EMU) for the Long Island Railroad. This vehicle would operate in a married pair configuration with consists up to 12 cars or 6 married pairs. Seating would be in a 3x2 configuration for a commuter application yielding 187 seats per married pair. The vehicle is to have capacity to serve both high and low boarding environments.

Description of Terms

Scheduled maintenance

Scheduled maintenance for the purposes of this study refers to any regular scheduled maintenance that is required to maintain a rail vehicle in good working order. Dependent upon the maintenance regime, this includes 92 day, 84 day, or 168 day inspections with the FRA required safety evaluations. Regular scheduled maintenance will address the predictable effects of wear and the more variable failures that may affect vehicle systems. These systems include; brakes, wheels, trucks, heating ventilation & air conditioning (HVAC), doors, train line electrical, couplers, cab system components, and interiors. For locomotive and DMU units, the prime mover engines are included in the regular scheduled maintenance regime. Scheduled maintenance is alternatively referred to as preventive maintenance.

Unscheduled maintenance

From our maintenance experience, a significant amount of unexpected wear is incurred on rail vehicles dependent upon the operating environment. While it is difficult to predict with accuracy the extent of damage due to the variable aspects of operations, it is foreseeable what types of systems would be the subject to unscheduled maintenance. These often include operational failures of mechanical and electrical systems. Unscheduled maintenance is a significant component of cost for locomotive units as a number of systems (electrical, hydraulics, traction motors, and main driver) are often subject to unforeseen technical difficulties that are resolved on an as required basis. Unscheduled maintenance is alternately

referred to as corrective maintenance.

Overhaul

Overhauls include both component overhaul and vehicle overhaul. Component re-engineering and overhaul is often performed on a number of sub-systems during the useful life of the vehicle. These include; trucks, HVAC, and door operators & controls. For locomotives, component overhauls are done on engines (both head-end power and main driver units), traction motors, and other significant vehicle sub-systems. General vehicle overhauls are assumed to be complete overhaul of rail vehicles. General vehicle overhauls include; seats, wall panels, interiors, wiring, door panels, and windows. While vehicle overhauls are often referred to as mid-life overhauls, experience suggests that such programs are actually conducted after 20 years of revenue service. For the uses of this study, vehicle overhauls are assumed to take place after 20 years of service. Locomotives and the motive power systems on DMUs are expected to be overhauled after 8 years of service.

The major overhaul assumptions for this study are;

- Locomotives undergo major overhauls every 400,000 miles, including complete engine and traction motor overhauls. Overhauls of head end power (HEP) units every 200,000 miles.
- Push-pull coaches and cabs undergo major overhauls every 1,000,000 miles which includes a complete rebuild.
- DMU vehicles require both motive power and interior overhauls over the life cycle. Engine (prime mover) and propulsion system overhauls are assumed at 500,000 miles. The vehicle interior overhaul is assumed at 1,000,000 miles

Acquisition Costs

For the purposes of this study, acquisition costs are considered on a variable cost basis. While this is not aligned with the funding reality of most authorities, classifying capital costs along side variable factors will provide a total life cycle basis of comparison for the different vehicle types. We have considered the original acquisition cost would be financed over 30 payment periods (yearly) at an interest rate of 6%. This straight-line, fixed rate method of recognizing capital costs is a hypothetical scenario to allow for the evaluation of total costs of different vehicle types. Capital costs are evaluated as a depreciation charge contributing to total yearly costs of operations which provides a more complete view of the true cost of vehicle operations. The acquisition cost assumptions include:

- A locomotive price of $2.5M. While neither the F40 or F59 series locomotive is currently in production, this was considered a fair market price for a new locomotive of this type and function.
- A single-level commuter coach price of $1.6M. An additional 15% is added for the price of a cab car. This was based on market trends and recent contract awards.
- A Bi-Level price of $1.9M per coach plus 15% for a cab car, based on recent publicly disclosed procurement prices.
- A price for the DMU married pair of $6M, from an evaluation of the market price for such a vehicle based on Bombardier Transportation internal analysis.

Table 1 **Acquisition cost and capital charge for evaluated vehicles**

Vehicle Type	Acquisition Cost	Yearly Capital Charge
Locomotive	$2,500,000	$181,622
Single-Level Coach	$1,600,000	$116,238
Single-Level Cab	$1,840,000	$133,674
Bi-Level Coach	$1,900,000	$138,033
Bi-Level Cab	$2,185,000	$158,738
DMU (married pair)	$6,000,000	$435,893

In order to facilitate a comparison of total cost (operating and capital), a breakdown of cost elements is presented in the conclusion of this paper.

Materials

A significant cost driver associated with vehicle maintenance is the material cost of various rail car systems. Materials can be separated into generic materials, and materials specific to a rail vehicle. Generic materials include all disposables, hardware, solvents, and oils. Procured materials include the replacement cost of every major component on the rail vehicle. Substantial portions of numerous vehicle sub-systems are replaced at regular intervals. It is assumed for scheduled maintenance, unscheduled maintenance, and overhauls that supplier non-recurring costs and labor are blended into the unit cost per component. Wherever possible we have used the market price for components.

Bi-Level Coach and Cab Material Costs

An evaluation of the 30 year cost for vehicles as they currently operate at GO Transit was used as the basis of the life cycle material costs for BiLevel vehicles. The total material life-cycle costs are based on a yearly operating mileage of 47,500 miles and annual hours of operation of 2,850. This yields a per mile cost for the material component of life-cycle cost.

Single-Level Coach and Cab Material Costs

Little direct maintenance information was available concerning the single level coaches of the type chosen for this study. As such, in order to evaluate the material costs, a sub-system level analysis of the entire vehicle was conducted. When costs were unknown or unavailable, comparable components were substituted. It was found that material costs are extremely similar between single-level and bi-level vehicles. However a number of costs are lower for a single-level coach, recognizing the reduced vehicle interior space, and certain different sub-systems. The material maintenance costs used are based

on the same operating assumptions as the Bi-Level vehicles to facilitate comparison; 47,500 annual miles and 2,850 annual hours. This yields a per mile cost for the material component of life cycle cost.

Locomotive

While many diesel-electric locomotives are available for commuter rail applications, this study utilized the GM Electro-Motive F40PH. While this locomotive is currently out of production, a 'standard' commuter rail locomotive is expected to have attributes similar to those of an F40PH. These include 4 axles, DC traction, and 3000 hp. The material costs used were based on an operating environment of 51,100 annual miles and 3,110 annual hours of operation. This yields a per mile cost for the material component of life cycle cost.

DMU

Based on the M-7 design, the baseline material costs were derived for those of the M-7 EMU with a number of needed modifications to account for different propulsion and motive power system designs. As 70% of the vehicle sub-systems are materially identical to those on the M-7, a significant portion of the material costs are known. Two significant challenges were created via this choice of material costs; the higher duty cycle of the M-7 vehicle, and the material costs for as yet un-integrated components such as the power pack including cooling system and propulsion unit.

The M-7 vehicle has been designed for significantly higher in-service miles and annual hours than other rail vehicles. Annual miles are approximately 125,000 and service hours are potentially in excess of 7,000 annually. This is not comparable to the duty cycle of other commuter rail equipment in use in North America. However, the M-7 example provided a concise understanding of the DMU maintenance costs associated with an extremely rigorous duty cycle and a per mile cost for the material component of life cycle cost.

An additional exercise was undertaken to further clarify the total material costs associated with the proposed DMU vehicle. First, a survey was undertaken across Bombardier Transportation to evaluate existing DMU technologies worldwide and to validate the material costs for a North American version of the product. This was done through a close evaluation of the diesel propulsion package utilized for the *Virgin Voyager* DMU in Great Britain and for a product currently in production for the SNCF in France, the *Automotrice Grande Capacité (AGC)*. The material costs and planned maintenance regimes for the respective propulsion systems were considered for these products. This experience with the life-cycle cost patterns of this technology in revenue service operation provided a needed level of detail and validation of the material cost assumptions.

The next task was to determine the best method by which the material costs for a high mileage scenario (125,000 annual miles) could be adapted to the required scenario of 50,000 annual miles to provide a comparative perspective. The method used was to clearly segment each material cost element. First overhauls were segmented from scheduled and unscheduled maintenance in the high mileage scenario. As total mileage over the first 12 years of revenue service for the high mileage scenario (1.5M miles) equals the total 30 year mileage for the lower mileage scenario, it was assumed that the vehicle overhaul costs should be capped at the 12 year point. Scheduled and unscheduled maintenance costs were assumed to be time of service sensitive and as such were not changed between different mileage assumptions. The total overhaul cost for 1.5M service miles in the high mileage scenario (12 years of revenue service) was summed and then attributed in equal portions over a 30 year useful life for a lower mileage assumption. While this method does not give an the'peaks and troughs' profile of vehicle overhaul costs over the 30 year useful life, it does however recognize that overhauls are largely mileage based activities and that these costs will be incurred over the useful life. The affect of allocating overhaul costs as a constant function may not be accurate in an operational or capital budgeting perspective, but

when considered on a per mile basis for comparison, this method was deemed to work effectively.

Labor Costs

A number of factors influence labor costs for maintenance operations. Unfortunately many of these factors hinder comparability across different vehicle types and authorities. First, using budgeted labor amounts for existing maintenance operations was not an acceptable approach as this budgeted amount often includes assumptions concerning labor productivity. Labor productivity can lead to divergent labor costs across substantially similar operating environments. A significant amount of economies of scale are prevalent in rail car maintenance, whereby a larger fleet will enjoy a per unit labor cost significantly lower than those for small fleets. Labor costs are also significantly impacted by both unionized and non-unionized labor agreements that serve to restrict shift schedules and may serve to limit potential productivity.

In light of the difficulties reconciling all of the factors affecting labor costs, it was determined that another approach to labor cost would be required for this study. From a survey across a number of maintenance facilities and existing maintenance agreements, it was determined that labor hours were incurred at the same rate as material consumption on an aggregate basis. Materials are consumed as labor hours are incurred on a rail vehicle. By capturing this ratio of material to labor costs, it was possible to isolate the exact labor costs attributable to each maintenance activity. This co-efficient was determined by calculating the ratio of material costs incurred by hour of labor attributed for different vehicle types.

Table 2 **Material $ to Labor Hours Ratio for Vehicles Surveyed**

Vehicle Type	Material $/Labor Hours Ratio
Locomotive	39
Single-Level Coach	48
Bi-Level Coach	46
DMU (married pair)	50

This methodology has logical appeal as it captures some of the known differences in the labor intensity associated with different rail vehicles. In this case, a locomotive is the most labor intensive vehicle type as more labor hours are required in relation to material consumption when compared to the passenger rolling stock. The other vehicles, although slightly different, all exhibit a comparable level of labor intensity. The ratio for the DMU is an indication of the ease of maintainability with lower labor intensity, while material costs would be higher reflecting the costs associated with a self-powered unit.

Once the labor hours were determined by vehicle type, wages provided by the US Department of Labor were applied. The bureau of labor statistics estimated in 2000 that the median hourly wage for railcar maintenance was $16.19 in the United States.[4] This number was increased by 50% to consider fringe benefits and an additional 15% to recognize the costs of variable shifts for overtime wages incurred for unscheduled maintenance. It was determined that wage increases have not been significant on an aggregate basis to justify escalating the wages to 2003 rates. While wage increases may have been a localized experience, significant increases would be necessary to increase the median wage across the industry. Thus, the labor cost used was $27.93 per hour.

A note of caution to those wishing to reconcile labor costs to existing maintenance operations. This is an effort to determine only the direct labor hours incurred; as such the alignment of shifts will need to be considered to determine the total labor cost of maintenance. While this process may have drawbacks, it was chosen because it provides the best basis of comparison between different vehicle types.

Total Maintenance & Labor Costs

The methodology outlined above was used to determine the yearly total materials and labor cost of each vehicle type considered. The result of this analysis is presented graphically below.

[4] Bureau of Labour Statistics. (http://www.bls.gov/oco/ocos197.htm)

Fig. 1

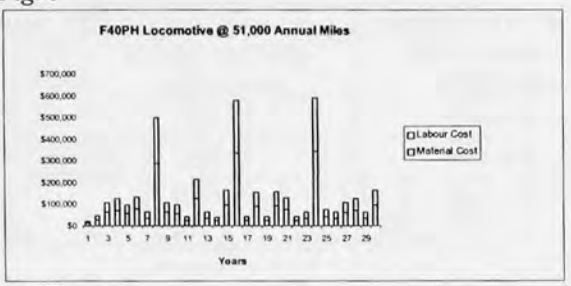


Fig. 2

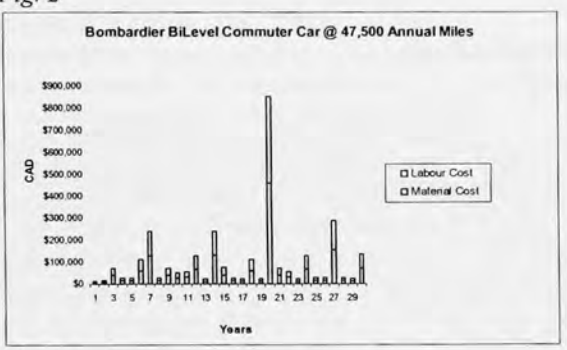


Fig. 3

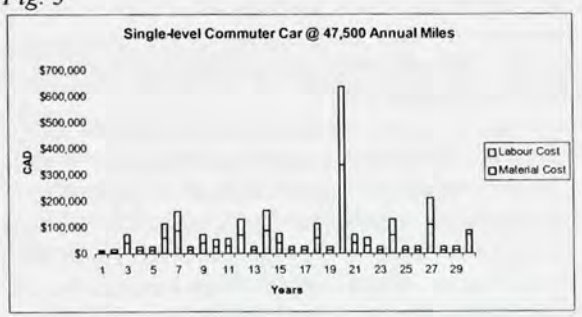
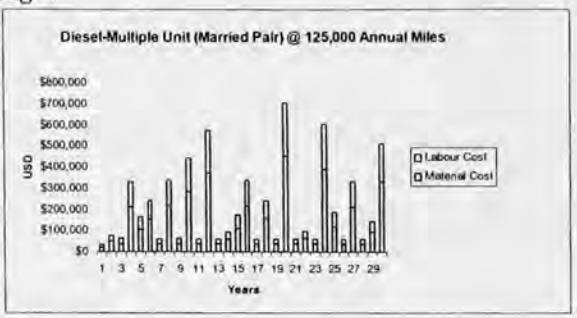


Fig. 4



Other Direct Costs

Crewing

For the purpose of this study it was assumed that three crew positions would be used. These include: engineer (driver), conductor, and assistant conductor. While crewing requirements will vary significantly between operations particularly in light of labor agreements, it was determined that only the required crew for operations would be used. For locomotive hauled equipment it was assumed that from a 1-2-1 consist up to and including a 1-8-1 consist required one engineer, one conductor, and one assistant conductor. For DMU equipment, it was determined that only an engineer and a conductor were required for operations up to 4 married pairs. This assumes the standard product configuration with full walk-through capability from the end cars.

The wage rates used for crew costs were provided by the US Department of Labor. The bureau of labor statistics 2000 median hourly wage for engineers was $21.26 and for conductors and assistant conductors was $18.86. Again, wage inflation was not considered to be a factor on the aggregate level. These hourly wages were grossed up by 50% to consider fringe benefits. For 3,000 yearly operational hours, crew costs are listed below.

Table 3 **Crew wages and annual costs**

Crew type	Hourly Wage w/ Fringe and shift adjustment	Annual Crew Cost for 3,000 annual in-service miles
Engineer	$31.89	$95,670
Conductor	$28.29	$84,870
Assistant Conductor	$28.29	$84,870

Fuel

For the purpose of this study, fuel costs were considered as a significant input to the annual operating costs of the system. However, no idling was assumed for either the locomotive or for the DMU vehicle. It was determined that while idle time and the use of standby mode is prevalent among locomotive operators, the cost was not significant enough to warrant consideration here and would further hinder comparability. These considerations and the speed of operation have material impacts on fuel consumption, but remain dependent upon the operating regime. Despite the fact that these factors have been disregarded to facilitate better comparisons, operators must be aware that these issues entail a number of nominal costs that should be evaluated in specific cases.

- The assumed fuel efficiencies for operations were determined to be 0.50 miles per gallon for the F40PH locomotive and 2.0 miles per gallon for the DMU.
- Fuel costs used for this study were determined to include transportation and re-fuelling costs. A blended price of $1.25 per gallon of diesel fuel was determined fair based on the most recent market price fluctuations.

It should be noted that while fuel consumption is a crucial aspect of operational costs, actual fuel consumption is extremely sensitive to the operating environment. A preferable approach would be to operate a demonstration program to determine the actual consumption

profile of the proposed service. Without this demonstration program, a dynamic route analysis considering the environment, track layout, grades, and speed of operation may be undertaken in order to determine the true cost of fuel consumption. The approach used in this study serves to facilitate the best possible comparison between rolling stock technologies, and not to provide a concise picture of actual fuel consumption for commuter rail operators.

Cleaning

Cleaning is an additional variable cost associated with rail vehicle operation. For this study it was assumed that cleaning includes interiors (including toilets and water tanks) and exteriors. It was determined that a yearly cost per vehicle would be the most appropriate way to facilitate comparisons.

- For single-level coaches, yearly cleaning totals $15,000.
- For bi-level coaches, yearly cleaning totals $18,000.
- Recognizing the fact that a married pair would be similar in layout and size to two single-level coaches, a cost of $30,000 per year was assumed for cleaning.

Insurance

Insurance costs, while significant, were determined to be more sensitive to the operating environment than to the equipment type. For this reason it was omitted from this study.

Track access fees

Track access fees to railroads vary significantly between railroads and locations. These fees are largely based on an opportunity cost assessment by the railroad based on the lost freight revenues associated with not having a portion of track available for operations. This is clearly an exogenous factor to the choice of vehicle. Despite the difference in track forces for different commuter rail equipment, railroads only consider the cost of making tracks available for

commuter operations. These track access fees have been omitted from this study to facilitate better comparability.

Dispatch

The costs associated with dispatch and consist building in the rail yard have been purposely omitted from this analysis. While push-pull equipment requires additional labor hours to couple and un-couple cars as needed, it was decided that this cost was negligible and would constitute a small advantage favoring DMU equipment. Dispatch costs were considered to be same for each vehicle type, hence would not have added comparative depth to the study.

Total Cost Findings

The total cost was derived from the sum of all assumptions outlined above. This involved evaluating the per mile maintenance charges that included both materials and labor for each vehicle type. This includes the actual bi-level, single level and locomotive information in comparison to the adjusted DMU information. To this, the other required direct cost assumptions were added. This includes the capital charge, crew, fuel, and cleaning. The sum of this information for each potential consist of push-pull equipment and married pairs for DMU equipment were outputted by the cost model for a number of different annual mileage and operating hour assumptions desired. Based on annual mileage of 50,000 miles and 3,000 service hours, the findings are presented graphically below.

Fig. 5

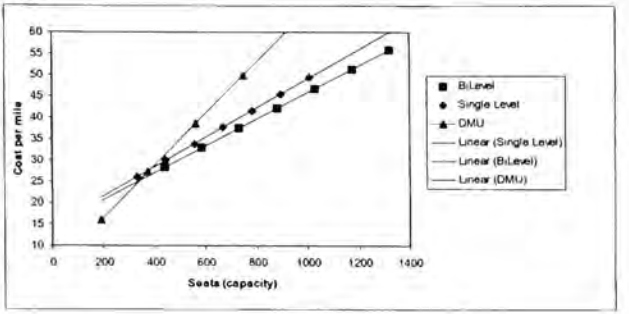
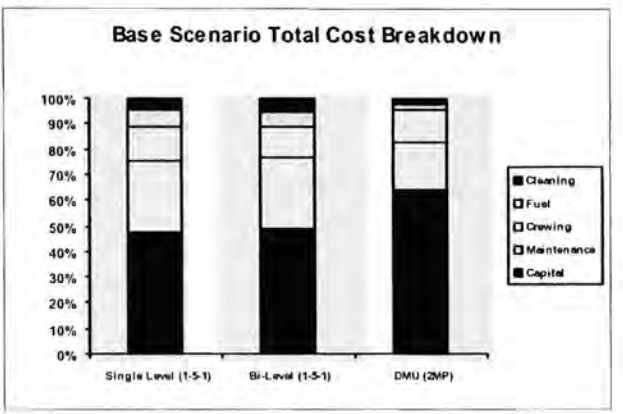

Cost per mile
60
55
50
45
40
35
30
25
20
15
10
0
200
400
600
800
1000
1200
1400
Seats (capacity)
BiLevel
Single Level
DMU
Linear (Single Level)
Linear (BiLevel)
Linear (DMU)

Fig. 6


Base Scenario Total Cost Breakdown
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Single Level (1-5-1)
Bi-Level (1-5-1)
DMU (2MP)
Cleaning
Fuel
Crewing
Maintenance
Capital

Conclusion

- DMU is the low cost option for seating requirements up to those provided by 2 Married Pairs[5]. DMU per mile costs under the 50,000 annual mileage assumption is between **39% and 44%** lower than the direct costs for locomotive-hauled equipment.
- After the crossover point of 400 seats, Bi-Level vehicles rapidly become the low cost option in the 50,000 annual mile scenario. At 700 seats, the Bi-Level option enjoys an **10%** per mile cost saving over the single level consist, and a **38%** cost saving over the comparable DMU consist.

This study has attempted to provide a brief understanding of the true direct costs of different commuter rail alternatives. However, a complete needs analysis should always begin with a rider ship analysis considering both time of day and day of week factors. While no single rail vehicle will provide the optimal operational efficiency for all projected demand levels, the evaluation process should consider the various trade-offs inherent to different vehicle costs and capacities. With the re-emergence of DMU technology in the North American operational environment, a technology ideally suited to lower density or off peak service is once again available to operators. This analysis clarifies a portion of the cost versus the benefit provided by this vehicle type in comparison to other available technologies. It is hoped that this analysis will provide a portion of the input required to allow authorities to make informed procurement decisions in the future.

[5] In a 3X3 seating (commuter) configuration, 2 married pairs provide 374 seats. In a 2X2 (intercity) configuration, 2 married pairs provide 306 seats.

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MEASURING WHAT YOU MANAGE: CHALLENGES FOR PROVINCIAL TRANSPORTATION POLICY

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1. INTRODUCTION

Macro data are available to determine the general state and direction of the national economy, but this level of aggregation can be insufficient for the micro policy analysis that is necessary in provincial jurisdictions. The problem varies, of course, with individual sectors of the economy. The transportation sector is one of the most difficult to monitor because of its magnitude and complexity. Accurate, timely and publicly available transportation data are relatively scarce. Data gaps limit the scope for regional, or provincial policy analysis, and the resultant quality of the economic development plans.

This paper examines the transportation data available for the Province of Manitoba, and its adequacy to address the challenges that face provincial transportation policy. The first section presents the implicit hypothesis that transportation data gaps unduly affect policy assessment. The subsequent sections set out the magnitude and causes of data gaps for highway, rail, air and urban modes and transportation equipment manufacturing and trade. The paper concludes with some thoughts on the implications for provincial jurisdictions of being unable to measure the transport issues that they are expected to manage.

2. The Necessity of Transportation Data

Transportation activity is a leading indicator of changes in the global economy. Consequently, better measurement of transportation activities can enable managers to prepare for economic growth and downturns.

Economic growth is measured by the increases in productivity and the output of goods and services traded. Efficient and reliable transportation is critical to economic growth. Transportation is the largest single logistics cost affecting domestic and international trade. Accordingly, economic growth can be helped, or hindered, by the competitiveness and sustainability of the transportation system.

Decision makers need comprehensive and timely transportation data to manage the economic health of this critical system. Accurate information is necessary for planning infrastructure investments to alleviate bottlenecks. Similarly accurate data are essential to the development of public policy strategies. The evaluation of new services, exploration of new market opportunities and examination of industry competition are all data rich activities.

Major shifts in the Canadian and global economies are changing supply chain relationships and trade flows. Companies consider transportation factors to be important when selecting a new location for manufacturing and distribution. Absence of data precludes measurement of location advantage.

Finally, data are needed to evaluate the impacts of endogenous and exogenous shocks. Internal forces of change that require assessment include environment protection policies, changes to industry structure and the application of advanced information technology. Some external forces are the impacts on provincial transportation related to NAFTA, the "Open Skies" agreement, new security procedures (following September 11, 2001) and the 20 percent rise in the value of the Canadian dollar in 2003.

3. Identification and Analysis of Data Gaps

The purpose of this paper is to highlight specific transportation sector data gaps identified for the Province of Manitoba. The implicit hypothesis of this paper is that the current state of transportation statistics hinders accurate policy making and assessment at the provincial level. Examples of data deficiencies are presented by transport modes and sectors.

Transport Canada's annual report *Transportation in Canada* provides a comprehensive overview of the industry. Some provincial data are reported; however, the scope of the annual report is insufficient for provincial analyses. In 1996, the Transport Institute recognized the absence of a complete Manitoba transportation data set and began developing a comprehensive provincial database. The purpose was to have one reference that contained all relevant statistics specific to Manitoba's transportation sector. Implementation of the National Transportation Act (1987) in 1988 was taken as the database origin.

The magnitude of undertaking this database quickly became apparent. Provincial transportation data are scattered amongst dozens of reports, and no central reference exists to document their location. The most recent report on this project is entitled *Transportation and Trade Statistics for Manitoba Edition 2: A Periodically Updated Database and Trend Analysis*[i]. The University of Manitoba Transport Institute's publication contains all relevant and available transportation and trade information at the provincial level for fifteen years from 1988 to 2003.

The provincial transportation data are derived from Statistics Canada, CANSIM II (the Canadian Socio-Economic Management Database), the Manitoba Bureau of Statistics, industry organizations (such as the Railway Association of Canada), and operators (such as the Winnipeg Airports Authority and Winnipeg Transit). During the annual updates of this database, significant gaps and data reporting inconsistencies have been observed. These gaps and inconsistencies are detailed further in this article by mode of transport and related industry.

3.1 Highway Transport: Importance and Data Gaps

The Manitoba truck transport industry contributed $561 million (at basic prices and in 1997 constant dollars)[ii], or 1.8 percent of the total Manitoba economy in 2002. The trucking industry is of greater importance to Manitoba (in terms of revenue or employment) than the national average[iii]. The trucking industry accounts for about 1.2 percent of Canada's economy[iv].

In 2002, truck transport in Manitoba employed 7,837 people[v], or 1.4 percent of all Manitoba employees. Over 500 truck transport firms are domiciled in Manitoba[vi]. Five of these firms are amongst the top 25 largest carriers in Canada.

The majority of information on highway transport for the Province of Manitoba is obtained from CANSIM, and the Statistics Canada publications *Trucking in Canada* (53-222) and *Surface and Marine Transport* (50-002).

Trucking data vary with the different classifications of operations. Small for-hire, medium to large for-hire, owner operators, and private carriers do not have the same data reported in each case. Specific examples include Manitoba carrier operating revenues, expenses, number of employees, and salaries (from the Motor Carriers of Freight Survey). This information is reported for small for-hire carriers and owner operators, but not for medium to large for-hire, or private carriers of Manitoba. Without comparable data, studies of economies of size, industry concentration and structure become very suspect.

The annual distance traveled by vehicle type, fuel consumption and costs are available for Manitoba owner operators and small for-hire carriers. These data are not reported for medium to large for-hire carriers. Similarly, average wages data are unavailable for Manitoba trucking.

Since 1997, no data are reported for solely Manitoba trucking operations. Manitoba, Saskatchewan and Alberta data are amalgamated in the reporting of estimated transport revenues, tonnages hauled, tonne-kilometers and number of shipments to and from other provinces by for-hire trucking. These data are essential to the estimation of demand elasticities, structural change and economic growth. The economies of the three provinces are very different, leading to individual transportation demand patterns[vii].

The significant growth of trade since the signing of CUSTA (1988) and NAFTA (1994) has stimulated for-hire south and northbound movement of goods to and from United States regions. By value, more than seventy percent of this trade moves by truck[viii]. The impact of north-south trade on emerging trade corridors deserves attention. The ability to promote economic development and industrial location, and the implications for policy development, depends on an understanding of changes to identify strategic opportunities.

Some data have never been collected, but could be very useful in assessing economic growth. For example, freight rates and vehicle utilization data could be used to estimate backhaul demand and competitive advantage for investment and plant location. Wage data could be helpful in the analysis of driver shortages. This data wish list could become more important given the recent appreciation of the Canadian dollar. If the U.S. trucking industry gains a cost advantage, as they did in 1989, such data could be invaluable in managing the market share adjustment of the cross-border transportation industry.

3.2 Railway Transport: Importance and Data Gaps

Canadian National Rail, Canadian Pacific Rail, Via Rail, the Hudson Bay Railway and other short-line railways serve Manitoba. The trucking industry may employ more workers in Manitoba than the railways, but the national share of railway employment to Manitoba is much larger[ix]. The rail transport industries employed 1.1 percent of all Manitoba workers in 2001 (6,091 people), versus 0.3 percent (50,376 people) in all of Canada[x].

To express this point another way, Manitoba accounts for 12.1 percent of national employment in the Canadian railways, while the population of Manitoba is only 3.3 percent of Canada. Consequently, the railways are almost four times more important to Manitoba than the average importance for other provinces in Canada.

The majority of data on railway transport in Manitoba is reported in the Statistics Canada publication *Rail in Canada* (52-216) and by the Railway Association of Canada. Statistics Canada's *Rail in Canada* has greatly diminished since the CTA 1995. In 1995 it had 151 pages. It has now shrunk to only 71 pages of material (in 2000) and several data series have been terminated.

The growth of intermodal containers is the most dynamic change occurring in the rail industry. Since 1998, Statistics Canada has discontinued reporting data on railway freight origin and destination (to and from Manitoba) with marine imports and exports separated. It seems ironic that when double-stacked trains and mega-Panamax container ships are creating a "renaissance" of rail, less is known about container traffic today than when it was far less important.

Meaningful economic and policy analysis needs accurate trade data series. The reporting of major commodity movements north and southbound between Manitoba and United States destinations by rail has changed due to a commodity reclassification after 1998. No historic information is available under the new commodity classification system. If rail rate levels and distance hauled by origin and destination were available, derived demand elasticities could be estimated[xi,xii] using gravity models.

Like the trucking sector, labour data for the Manitoba railway industry is underreported. Salary or wage information for Manitoba railway employees is unavailable. Given the relative importance of the rail industry to Manitoba, structural analysis of this labour sector justifies the collection of these data.

3.3 Air Transport: Importance and Data Gaps

In 2002, the Manitoba air transport industry employed 3,165 people[xiii]. The monetary impact of the GDP contribution at market prices is $584 million annually[xiv]. The economic activity is concentrated at the Winnipeg International Airport, which is one of the top Canadian cargo airports and operates on a 24-hour basis.

The majority of data on air transport in Manitoba are derived from the Statistics Canada publications *Canadian Civil Aviation* (51-206) and *Air Carrier Traffic at Canadian Airports* (51-203), CANSIM and the Winnipeg Airports Authority. Significantly greater amounts of aviation data are routinely available in the United States.

Statistics Canada air cargo data are available for Winnipeg International Airport, Manitoba, and Canadian levels. However, these data are deemed of limited use. The air cargo data of Statistics Canada excludes courier movements and specialized all-cargo airlines. Winnipeg International Airport moves the vast majority of their total cargo by these couriers. The Winnipeg Airport Authority collects the cargo data (since 2000) but only aggregate figures are publicly available.

Air cargo is one of the fastest growing areas of the freight industry, and one that is least known. No information is available on carrier market shares or average freight rates.

Typically, total air passengers and aircraft movement data are available for Winnipeg and northern Manitoba airports. Information on the number of flights, or passengers by origin/destination is unavailable.

Confidentiality specifications increased with the merger of Air Canada and Canadian Airlines. Access to air carrier data is more difficult during their transition. Five scheduled carriers now serve Winnipeg International Airport, so no such restrictions should exist. Data would be desirable for average airline fares and quality of

service measures. Quality can be measured by departure delays and mismanaged baggage.

3.4 Urban & Intercity Transport: Importance and Data Gaps

The role of urban transportation in reinventing our cities and in combating the reduction of greenhouse gas (GHG) emissions makes this sector of regional and national importance. The majority of data on urban and intercity transport in Manitoba is provided by the operating agencies (such as Winnipeg Transit and Brandon Transit), the Statistics Canada publication *Passenger Bus and Urban Transit Statistics* (53-215), and CANSIM.

The Canadian Urban Transit Association (CUTA) collects data from individual operating agencies. Ironically, these data that are paid for by "publicly owned" and accountable urban transit authorities are not freely available to the public. CUTA charges a considerable subscription fee to provide the information to the public. Moreover, they prohibit the reporting of any economic analysis and benchmarking with these data.

Data on the Manitoba intercity (e.g. interurban or rural) bus transport industry are not found. The needs of rural areas are unique and difficult to serve. Without data, no assessment of public needs is possible for these low-density markets.

3.5 Trade Service and Transportation Equipment Manufacturing: Importance and Data Gaps

Manitoba's trade with the United States has grown rapidly, via the mid-continent corridor, since the signing of NAFTA in 1994. In 2001, the dollar value of Manitoba's total exports was $9.3 billion ($7.4 billion of which went to the United States)[xv]. Also in 2001, the dollar value of Manitoba's total imports was $9.8 billion ($8.4 billion of which came from the United States)[xvi].

From 1991 to 2001, both imports to and exports from Manitoba tripled. In 2002, the Manitoba transportation and warehousing industry gross domestic product was $2,029.7 million[xvii], which is 4.5 percent of the total Manitoba economy. For Canada in 2002, transportation and warehousing was $44,623.9 million[xviii], or 4.6 percent of the total Canadian economy.

Trade data for Manitoba was primarily obtained from the Manitoba Bureau of Statistics. High-level data were available through the Manitoba Bureau of Statistics publications, while lower level and more detailed information had to be purchased.

Manitoba is the northern gateway of the Mid-Continent International Trade Corridor (MCC), a trade alliance between Canada, the United States and Mexico. The business communities, governments and economic development agencies of the cities located along the corridor have been working together to develop north-south trade opportunities and strategies. The advantages pursued by corridor development of the MCC include increased trade, peripheral industry expansion, cluster formation and employment growth.

The strategic development of a defined geographic passage or route requires a focused and controlled approach to achieving the benefits from trade. Data needs include all aspects associated with trade corridors such as inter and intra modal connectivity, border crossings, transportation and infrastructure. At the moment, such information is piecemeal, at best. Data requirements should be defined in cooperation with the United States and Mexican counterparts.

In addition to the employment created by the logistics services stimulated by trade, the export of transportation equipment accounts for approximately 10 percent of total exports. In 2002, Manitoba exported a total of $934 million in transportation equipment ($883 million to the United States)[xix]. Manufacturing businesses include intercity buses, transit buses, aerospace overhaul and components, and rail equipment. Transportation equipment manufacturing

employed 9,279 people[xx] in Manitoba in 2002, or 1.6 percent of all Manitoba employees.

The majority of data on the transportation equipment manufacturing industry is available online from Industry Canada (online trade database) and CANSIM. The total number of employees is provided by CANSIM; however, the number of employees by subsector cannot be located. Similarly, Manitoba data are unavailable for wages or average annual salary.

Data on Manitoba's transportation equipment manufacturing shipments would be desirable in terms of value-added and by subsector. Insufficient data exists to undertake a serious policy analysis of Manitoba's transportation equipment manufacturing industry at the provincial level.

4. General Data Deficiencies and Reporting Problems

Data problems and consistency concerns were revealed in the compilation of the comprehensive Transport Institute database. Both commodity and industry classification systems have changed in the past five reporting years. Prior years data are not reformatted in the new classification systems; therefore, no historical information is available. Without consistent data neither changes can be analyzed, nor can trends be determined, beyond the reporting breaks.

Some inconsistencies are explained by budget cuts. Statistics Canada has cut back its core program, introduced new technologies, and dropped a number of surveys (some of which were replaced with data from administrative records)[xxi]. In addition, both the amount of published material and the frequency of releases have been reduced.

Amalgamation of geographic boundaries makes it impossible to analyze emerging trends on a provincial basis. Trend analysis in Manitoba has been truncated by aggregation of data with Saskatchewan and Alberta. When transportation data are reported on a regional basis, but not provincially, it suggests that the sample is too

small. No doubt this can also be attributed to budget cuts. National data are of limited use in the smaller provinces, given the diversity of the Canadian regional economies and the wide array of transportation needs.

Inconsistent collection and reporting techniques are used by different collection agencies. Problems include data reported in constant dollars for different base years, or at factor versus market costs.

Excessive lag times in the distribution of new data frustrate the analysts of economic trends and policy. Currently, Statistics Canada has yet to release information past 2000 for the majority of its transportation related publications. Typical lag times reach two to three years. With changing policy and the competition environment, such wait times for data greatly affect the usefulness of analysis.

Confidentiality of data is a major impediment to the compilation of a provincial transportation database. Recent institutional and operational changes in the Canadian marketplace have affected data requirements, collection and dissemination. Divestiture, privatization or commercialization of key organizations in the Canadian transportation industry have each increased confidentiality demands. The opposite has occurred in the demand for such data to determine the effectiveness and track progress of these policy changes.

Confidentiality requirements of major players in certain transport sectors prevent the public release of many operating and financial details. Some would argue that the need for public data should supersede confidentiality requirements. Lack of data in the public domain prevents an assessment of policy changes. Given the current lag time in reporting, the release of data should have diminished value to competitors in any case.

5. Further Challenges for Transport Data and Policy

The production of greenhouse gas emissions appears to be linked to climate change and the increased frequency of severe weather events.

Warmer temperatures put transportation networks to remote communities at risk due to the thawing of permafrost and reduce the number of days that ice roads can be used safely. Measurement of greenhouse gas (GHG) emissions and the changes to transportation networks are needed to provide decision makers with information to support sustainable transportation policies.

The mitigation of transportation-related greenhouse gas emissions is under consideration. Primarily, attention is focused on increased mass transit usage, and shifting modes of freight transportation from to truck to rail. Data on travel and traffic demand are needed to estimate the cross-price and direct-price elasticities of alternative policy prescriptions. In particular, market fluctuation and intrusion that would result from the shift from a higher emission mode to lower emission vehicles should be modeled.

Promotion of alternative fuel use is another sustainability policy under experimentation. Data on fuel type, traffic patterns and total expenditures are needed to assess the effectiveness of policies to modify consumption and measure the costs of meeting Canada's Kyoto targets.

World events have reinforced the importance of the aspect of trade security. North American governments are tightening border security measures and increasing enforcement measures in an effort to reduce national security risks. Changes in this area have already occurred at a dramatic pace since the terrorist attacks of September 11, 2001. The effect on the transportation and trade industries is immense. Increased administrative work and the capacity of border crossings are the most visible ramifications. The collection of data on traffic patterns, flows and composition would both aid new policy development and evaluate the effect of the most recent policy changes.

Information technology provides carriers and shippers with easier control and more timely information on purchasing, order processing, tracking, and billing. New technology also provides the ability to

monitor shipments more closely, resulting in better customer service and greater security.

New supply chain practices continue to add pressure to the need for the secure and timely transfer of goods. The past decade has seen a significant boom in just-in-time inventory management with manufacturing companies. Meeting the needs of these manufacturing companies requires flexibility and the ability to deliver smaller shipments more often. These needs are most often best served by the trucking industry. Manufacturers and suppliers are now locating together to aid their just-in-time inventory management systems.

Shifting industry structure in the form of privatization or industry concentration is currently immeasurable due to a lack of data. This prohibits analysis of competition. As well, intermodal shipments are increasing in appeal for the flexibility and cost effectiveness that they provide. Data are essential to an integrated multi-modal approach to planning and policy assessment.

6. CONCLUSIONS

Major investment and policy decisions are being made increasingly on the basis of information that is neither current nor complete. Axiomatically, fact is being replaced by opinion in decision-making. The likelihood of successfully achieving a transportation vision is significantly decreased when neither the current conditions, nor the means of achieving the targets, are fully understood.

Of particular interest in this paper is the lack of provincial data for the transportation industry. Given the variety of regions and transportation needs in Canada, macro level data are inadequate to perform provincial policy analysis.

With all the forces of change that are present in Canada's transportation industry, a commitment to the accurate and timely provision of data for researchers and policy makers is necessary to

assess and aid policy decisions. Without data, policy makers are left with only perceptions or lobbyists to guide their attention.

In addition to the specific data gaps identified by mode in this paper, several underlying factors need to be addressed. Historic data must be reported in a consistent format in order to monitor changes and identify trends. Amalgamation of data over broad regions must be returned to provincial reporting. Furthermore, confidentiality requirements must be addressed in the light of public interest. Although some lag time is understandable, greater emphasis must be placed on the receipt of timely information to the public.

Standardization of data collection techniques would be useful in aiding the comparability of data between years and regions and modes, and may also result in the elimination of duplicate efforts. Areas of commonality among jurisdictions and users could be identified and this synergy of participants would result in cost benefits and improved products.

It is time that governments in Canada recognized that information is a public good. The Internet makes data distribution virtually free. Any additional costs of more extensive data collection have to be weighed against the benefits. An understanding of the benefits and necessity of measuring what you manage needs to be promoted to all system participants.

The implicit hypothesis of this paper is difficult to refute, but logic suggests that the poor state of provincial transportation data results in inaccurate and untimely decision-making. We have no cost estimates of the wasted resources, or missed opportunities, associated with a trial and error approach to policy development. It seems unlikely that the investment necessary to improve transportation data collection and reporting at the provincial jurisdictions would not be justified.

ENDNOTES

[i] Available free of charge at www.umti.ca.
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[iii] Transport Institute, *Economic Impact, Structure & Market Perspectives of the Manitoba Trucking Industry*, June 2000.
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[xv] Manitoba Bureau of Statistics, *Manitoba Trade Trends 1993-2001*, MBS 2002-3, Table 5: Manitoba Exports by Region and Selected Country 1993-2001, page 6.
[xvi] Manitoba Bureau of Statistics, *Manitoba Trade Trends 1993-2001*, MBS 2002-3, Table 8: Manitoba Imports by Region and Selected Country 1993-2001, pages 11-12.
[xvii] Statistics Canada, *Provincial Gross Domestic Product by Industry 1997-2002*, 15-203, Table 1: Gross Domestic Product at Basic Price by Industry in Millions of Dollars, page 163.
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Estimating the Cost of Delay to Motor Carriers Operating in the Lower Mainland and Fraser Valley

A Discussion Paper

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March, 2004

i) Executive Summary

The annual cost of delay to the motor carrier industry operating in the Lower Mainland and Fraser Valley in 2003 is estimated to range from $132 million to $164 million. These estimates represent the sum of incremental costs (wages, salaries and operating costs) resulting from delays incurred by firms operating light and heavy trucks in the study area. The underlying assumption in our model is firms are profit maximizers and cost minimizers and, as such, locate their place of business in a manner that allows them least cost delivery. As a result, the probability of delay is minimized in the sub-area in which each firm is domiciled and increases with distance traveled.

While our estimate is 68% to 74% lower than estimates of the costs of delay used by the BC Trucking Association, it is consistent with recent estimates by the Greater Vancouver Gateway Council (GVGC) in the 2003 report "Economic Impacts of the Major Commercial Transportation System"[1]. The GVGC report estimates that the cumulative cost of delay over the period 2001 through 2021 will approach $280 million in 2003 dollars[2]. Our estimate of the costs of delay for the year 2003 is approximately 50% of the value of the GVGC estimate of the costs of delay for 2021. Assuming the number of truck trips grows 2% per year from 2003 to 2021[3], our estimate represents a fair and unbiased estimator of the current costs of delay impacting the motor carrier industry in the Lower Mainland and Fraser Valley.

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[1] Draft Report as of August 19, 2003.

[2] The no-build scenario assumes no transportation infrastructure improvements through 2021.

[3] See "Economic Impact Assessment of the Major Commercial Transportation System" page 32. The 50% growth factor was also used in the 1999 Lower Mainland Truck Freight Study produced by TSi.

1. Introduction

This analysis estimates the cost of delay to commercial vehicles operating within the Lower Mainland and Fraser Valley. We use statistical analysis to examine the hypothesis that the current cost of delay ranges from $200 to $500 million annually.

"Between 10,000 and 12,000 trucks operate within the GVRD on any given day. If each of those trucks sit in traffic for an extra hour, that's going to mean another half a million to three -quarters of a million dollars in waiting time. The operating costs of a tractor-trailer is approximately $60 an hour. The trucking industry is already faced with congestion costs of $200 million per year. If light duty vehicles, such as delivery vans, are included, the total cost of congestion is over $500 million per year."[4]

To perform the analysis, we use information obtained from the BC Trucking Association (BCTA), BCStats, Statistics Canada, TransLink, the Greater Vancouver Gateway Council (GVGC), the United States Transportation Research Board (TRB), Insurance Corporation of British Columbia (ICBC) and the Lower Mainland Truck Freight Study (1999).

1.1. Differentiating Costs of Delay from Costs of Congestion

Differentiating the cost of delay to the motor carrier industry from the economic cost of congestion to provincial or national economies is critical to this analysis. The cost of delay is measured as the sum of wages, salaries and operating costs brought about by unexpected delay. The economic cost of congestion is measured as the sum of wages, salaries, operating costs, potential effects on inventory costs, logistics costs, reliability costs, just in time processing costs, reductions in market areas for workers, customers and incoming/outgoing deliveries. Put simply, the economic costs of congestion reflect impacts of delay on the entire supply chain from producer to consumer. The cost of delay impacting the motor carrier

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[4] Source: BCTA press release "Transit Strike Could Mean Millions in Congestion Costs", April 2, 2001

industry is a subset of the economic cost of congestion. The scope of this study is simply to estimate the costs of delay impacting the motor carrier industry in the Lower Mainland and Fraser Valley.

Impacts of delay vary over time. In the short term, increasing delay impacts the cost structure of firms in the industry. Because the industry is highly competitive, has low barriers to entry and freedom of entry or exit, an increase in costs must either be absorbed by the firm or passed through to the consumer[5]. Given the competitive nature of the industry, the individual firm will be reluctant to increase price if the price increase causes a change in relative prices across firms operating in the same market. So in the short-term, incremental costs incurred as a result of unexpected delay will be absourbed by the firm and impact the cost of doing business. Over the medium term, in the event of ever increasing costs with no corresponding increase in price, the financial viability of the motor carrier industry could be threatened. Industry wide cost pressures will lead to industry wide price increases (for example, the BC Trucking Association recently recommended an industry wide 5.3% price increase effective August 3, 2003). An increase in the price for motor carrier services will impact logistics. Logistics is the major determinant of the final price of goods and services. It involves planning, implementing and controlling the flow and storage of goods and services from producers to consumers. Firms in the logistics industry minimize costs by selecting the least cost method of producing, transporting and marketing goods in local, regional, national and international markets. Motor carriers are currently the major component of the logistics chain, earning more than 40% of all revenue generated by the industry[6]. Any increase in the price of motor carriers services and not in the price of service by other modes

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[5] In this paper, a consumer is a purchaser of a motor carrier service.

[6] See Logistics: Service Industry Overview, October 2001, Industry Canada. In 1998, the Logistics sector generated more than $50 billion in total revenue.

could influence decisions of firms in the logistics industry and impact market share of the motor carrier industry[7].

Over the longer run, increasing cost of delay could impact the production and flow of goods and services through the Lower Mainland and Fraser Valley if the increase in costs alters relative prices across regions. A change in relative prices across regions could impact the competitive position of the Vancouver Gateway vis-à-vis competing gateways in the Pacific Northwest and cause some businesses to relocate production facilities elsewhere to achieve lower costs. In the long run, all things being equal, the impact of increasing delay could lead to a reduction in the volume of goods and services moved through or produced in the Lower Mainland and Fraser Valley.

Of course, over the long run, all things are not equal. Supply side adjustments will occur to help mitigate excess demand and move the market to equilibrium. So the reader is reminded that the focus of this study is on the short-term impacts of delay to the motor carrier industry[8].

1.2. Factors That Contribute to Increasing Delay

There are many factors that contribute to the cost of delay to motor carriers operating in the Lower Mainland and Fraser Valley. In many respects, we are now victims of our past success.

1) The Canada-United States Free Trade Agreement (1988) eliminated barriers to trade between the US and Canada and created a climate conducive to increased trade and new investment. Firms operating in BC gained access to US markets and increased market share. The purchasing power of all British Columbians improved as costs decreased and the quality of goods and services increased.

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[7] A change in market share is equivalent to a modal shift

[8] In the medium to long term, supply and demand side adjustments will drive this market to equilibrium.

2) The Government of Canada redefined the role of Transport Canada from regulator to protector of public safety. Canadian National Railway was privatized to allow market forces to generate efficiencies necessary to successfully compete in the North American marketplace and the federal government initiated a process to divest airports, ports and harbors to local control.
3) The Inter-Provincial Agreement on Internal Trade initiated a process to eliminate economic regulations impacting inter-provincial trade. Barriers governing intra and extra-provincial trucking were eliminated January 1, 2000. Deregulation increased the number of firms active in the motor carrier industry, improved the efficiency of our transportation system and made a significant contribution to increased productivity.
4) Over the past decade, the population of the Lower Mainland and the Fraser Valley increased 21%, household income grew 30% and the number of licensed passenger vehicles increased by 27%. There are now more residents living and travelling in the Lower Mainland and Fraser Valley with more disposable income with which to buy an ever-increasing volume of goods and services.
5) An ever-increasing volume of users on our transportation system is generating an increasing frequency of traffic "incidents" which impacts the flow of goods and services moving in or through the Lower Mainland and Fraser Valley. Traffic "incidents" are now identified by the Transportation Research Board (TRB) as the major cause of delay impacting the movement of people, goods and services in the United States[9]. The "unexpected delay" resulting from traffic "incidents" is the principle source of unreliability and has a significant impact on the motor carrier industry. Unexpected delay impacts reliability, certainty and predictability of travel time.

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[9] See Measuring Improvements in the Movement of Highway and Inter-Modal Freight, Transportation Research Board, 2002.

1.3. Ok, So What!

We live in a global market where the demand for good and services is determined by relative prices and standards of living. Free trade, deregulation and growth have combined to increase competition, improve productivity and improve the efficiency and effectiveness of our transportation system.

- The dollar value of BC exports grew by more than 100% over the past decade. The value of BC imports grew 120% while imports re-exported to other parts of Canada grew 40%[10]. A large percentage of BC's export trade is in tourism. Increasing trade generates increasing demand on existing infrastructure and stimulating demand for new investments.
- Industry and shippers have internalized the lower cost of transportation services in place of the high cost of holding inventory. Markets are now characterized by just-in-time delivery where consumers benefit from lower prices and improved service. Industry benefits from the lower cost of not holding inventory. Just-in-time delivery means there are now more trucks making more frequent deliveries than ever before.
- To remain competitive, motor carriers engaged in national and international trade maximized productivity by restructuring terminal networks and taking advantage of inter-modal options. Regional and local motor carriers maximized productivity by increasing the number of direct shipments to users and making more effective use of warehouses.
- Deregulation increased the number of firms active in the motor carrier industry. In fact, over the past 10 years, the number of commercial vehicles licensed to operate in the Lower Mainland and Fraser Valley grew 64% while the number of licensed passenger vehicles grew 27%[11]. Increasing competition by firms in the motor carrier industry is driving freight rates lower and lower.

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[10] Source: BCStats, Dollar Value of Imports and Exports, 2003

[11] See BCStats, Licensed Passenger and Commercial Vehicles, 2002.

Today, many of the factors that contributed to productivity and efficiency gains over the past decade are close to exhaustion. Increasing growth is generating increasing demand on existing infrastructure and for new investments. Motor carriers are demanding additional capacity to reduce delay. The travelling public is demanding additional capacity to reduce travel times and improve safety. However, the ability to supply new capacity is often constrained by budgets, land use constraints or competing priorities.

As a result, it is essential that all projects be evaluated using a set of consistent assumptions to allow comparisons across projects and enable informed decisions. Only the set of projects that maximize benefits subject to a budget constraint should proceed to the construction phase. It is for this reason that differentiating costs of delay to truckers from costs of congestion is so important.

First, the variance between these measures can be substantial. For example, the value of time (cost of delay) for commercial vehicles operating in urban areas currently in use by the Ministry of Transportation[12] is $20.90 for light trucks and $23.41 for heavy trucks. By way of comparison, some estimates of the cost of congestion range from a low of $272 to a high of $410 per hour[13]. Second, attempts to estimate the cost of congestion in local or regional markets is meaningless unless an understanding exists about the relative cost of congestion across regions or nations (competitors). It makes no sense to infer the cost of congestion impacting market "A" will have an impact on economic activity in market "A" if congestion in markets "B" or "C" is the same or worse than in market "A". Third, in the long run, all factors become variable. Short term

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[12] MicroBencost is the Ministry of Transportation benefit cost model used to compare the relative merits of potential infrastructure projects. Default data was updated in May 2003 by Apex Engineering Limited.

[13] See "Economic Impacts of Congestion, Transportation Research Board, page 32. All values converted to C$ using the average value of the US/Can exchange rate.

market imperfections will be mitigated by a combination of supply (capital improvements, technological change) and demand side adjustments (industry restructuring, the engine of creative destruction). In the long run, market forces drive the market to equilibrium.

1.4. Congestion and Reliability

Currently, logistics companies, shippers, receivers and the motor carrier industry have the ability to adjust operations to minimize impacts of congestion if they are willing to do so. Because congestion is a recurring event, the knowledge (with certainty) that congestion will occur allows firms to adjust activity to minimize impacts of congestion and operate efficiently[14]. For example, delivery schedules could be adjusted to avoid periods of congestion that are known to occur during periods of peak traffic. Distribution centers could be relocated to shorten trip lengths in congested areas. The "certainty" that congestion will occur allows each firm to adjust and modify operations in an efficient and effective way. However, while firms have the ability to mitigate impacts of congestion, they have little ability to mitigate the impact of random events.

A traffic "incident" is a random event impacting a firms' reliability. Because traffic incidents are random, firms lack the ability to adjust operations and plan with certainty. Delays caused by random events increase the cost of doing business to firms in the transportation sector and to industries who depend on transportation for the movement of goods and services. Firms in the motor carrier industry may have to pay overtime[15] when trucks are delayed due to traffic incidents. Alternatively, industries dependent on just-in-time delivery must bear the cost of disruption in their production processes.

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[14] The Lower Mainland Truck Freight Study revealed that the distribution of light and heavy truck activity overlaps the distribution of total traffic.

[15] This assumption is debatable. Many firms pay by the kilometer, piecemeal or contracted price.

The TRB has identified traffic "incidents" as the major cause of congestion on US roads and highways accounting for 60% of all congestion on freeways and 52% of congestion on arterial roads[16]. The TRB is now assembling information on traffic "incidents" as a means to measure the economic costs of congestion. Information on traffic "incidents" occurring on Lower Mainland and Fraser Valley roads and highways is currently not collected. As a result, impacts of the cost of delay due to traffic incidents on the cost structure of the BC motor carrier industry remains unknown[17].

1.5. A Word On Costs

Operating costs are a real and tangible cost to the firm. Operating costs include wages, salaries and benefits and vehicle operating costs. Operating costs are incremental to capital costs. For a firm to remain solvent, revenue generated must be sufficient to cover capital and operating costs. On average, motor carriers spend 27% of total revenue on wages, salaries and benefits, 26% on owner payments, 25% on vehicle operating costs and 11% on other transportation services. Maintenance and depreciation costs represent 6% and 5% of total revenue[18]. The "operating ratio" is the ratio of a motor carrier's operating costs to total revenue. The operating ratio is commonly used as a measure of the relative health of the motor carrier industry. In 2000, the operating ratio was 94% and the average return on investment was about 6%. However, while the industry as a whole did generate more revenue than costs, the rate of return on investment is relatively low when compared to other high risk investments. For example, the minimum rate of return expected by investors on high-risk projects in the Lower Mainland averages from 8% to 12%[19]. This information suggests that investing in the

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[16] See Economic Impacts of Congestion, page 17.

[17] TransLink does not distinguish impacts of incidents from the cost of congestion in EMM2 modeling

[18] See Statistics Canada publication 52-222-XIB, Trucking in Canada, March, 2002 pages 23-26.

[19] Research by Longbow Properties with respect to rates of return expected on partnership projects.

motor carrier industry has a higher degree of risk when compared to other high-risk investments.

Given the structure of the motor carrier industry (highly competitive, low barriers to entry, large number of firms, price takers not price makers), in the short term, the ability of firms to pass increased costs caused by delay through to consumers is limited. So in the short term, increasing costs resulting from delay will cause some firms to exit the industry (the engine of creative destruction). However, over the medium to longer term, market forces will generate an efficient number of firms and a market-clearing price.

2. The Model

The section estimates the costs of delay (rather than the costs of congestion) to motor carriers operating in the Lower Mainland and the Fraser Valley. To estimate the cost of delay, we use survey information obtained for the Lower Mainland Truck Freight Study (1999), unit costs of vehicle operation from Trimac Logistics Inc.[20] and estimates of the value of time and shipping costs obtained from TransLink, MoT and the TRB.

2.1. Major Assumptions

We apply two major assumptions in estimating the cost of delay:

- We assume data used from the Lower Mainland Truck Study is a true representation of the Lower Mainland motor carrier industry
- We assume all firms active in the motor carrier industry are profit maximizers and cost minimizers. In other words, for any given trip, each firm chooses the least cost method of delivery to minimize costs and maximize profit.

2.2. Methodology

We use survey data from the 1999 Lower Mainland Truck Freight Study to generate a baseline on which truck trips can be modeled.

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[20] Trimac Logistics Inc. is now known as "Bulk Plus Logistics Ltd., A Trimac Company"

The 1999 baseline is adjusted to account for the increase in number of trucks and trips between 1999 and 2003. In 2003, there were approximately 15,400 light trucks and 6,900 heavy trucks operating in the study area generating 180,000 trips every business day. In addition, we assume 65% of all trips are made by "light" trucks and 35% of trips were made by heavy vehicles.[21]. We also assume origin-destination information obtained for the LMTFS is still valid to derive the distribution of truck trips by truck type and by geographic area. Appendix 2 provides a map showing the distribution of geographic sub-areas used in this analysis.

The distribution of truck trips by origin and destination allows for the application of a weighting mechanism (delay factor) to be used to estimate costs of delay. The percentage of trips originating in one sub-area having a destination in the same sub-area, a different sub-area or outside the study area are weighted to proxy the probability that commercial vehicles encounter unexpected delays. Weights vary by truck type and by sub-area. A weight of 0.1 implies 10% of all trips within a given sub-area encounter unexpected delay. A weight of 0.2 implies 20% of all trips in a given sub area encounter unexpected delay etc. Table 1 provides the breakdown of the number of light and heavy truck trips by sub area and weighting used to estimate the cost of delay by truck type and by sub-area.

To generate estimates for the cost of delay, we use a range of estimates for the value of time and vehicle operating costs for light and heavy trucks. We use estimates of "time cost" for commercial vehicles currently used by TransLink in the GVRD's EMME2 model[22] and estimates of the value of "direct shipping costs" (1996)

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[21] Truck with only two axles are considered as "light vehicles". Trucks with three or more axles, either as a single unit or in combination with a trailer are "heavy vehicles". Source: Lower Mainland Truck Freight Study 1999.

[22] The EMME2 model is used by TransLink to model traffic behaviour in the Fraser Valley. The value of shipping costs for 2003 was $36 for light trucks, $45 for heavy trucks.

obtained from the TRB. The TRB estimate is adjusted for the exchange rate applicable in 1996[23] which is then inflated to 2003 dollars.

The EMME2 estimate of "time costs" acts as a proxy for (1) the value of time (2) vehicle operating costs and (3) collision costs. The TRB estimate of "direct shipping costs" is a proxy for (1) vehicle operating expenses (2) safety related expenses and (3) driver time costs. Both EMME2 and TRB estimates are higher than "value of time" estimates currently in use in MoT's Microbencost[24]. The "value of time" measure used in MicroBencost reflects labour costs but abstracts from vehicle operating costs.

The underlying assumption in the model is firms are profit maximizers and cost minimizers and, as such, will locate their place of business in a manner that allows them least cost delivery. As a result, the probability of delay is minimized in the sub-area in which a firm is domiciled and increases with distance traveled.

3. Estimation

Using the methodology described above, the incremental cost of delay impacting the motor carrier industry operating in the Lower Mainland and Fraser Valley is estimated to range from a low of $132 million (using TRB assumptions) to a high of $164 million (using EMME2 assumptions). The labour component of incremental costs is estimated at about $89 million (using the MicroBencost assumptions on labour costs). Readers should note that the cost of labour is included in estimates of delay generated using TRB and EMME2 assumptions.

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[23] See NCHRP Report 403, Economic Implications of Congestion, page 39. The value of direct shipping costs inflated to 2003 Canadian dollars is $29 for light trucks and $37 for heavy vehicles.

[24] The value of time used in Microbencost *(2003) is $20.90 for light trucks and $23.41 for heavy vehicles.

4. Conclusion

Annual costs of delay for the trucking industry operating in the Lower Mainland and Fraser Valley are estimated to range from $132 million to $164 million. This annual cost represents the sum of all wages, salaries and operating costs brought about by increased delay. This estimate is about 70% lower than estimates of the cost of delay used by the BC Trucking Association.

While our estimate is 68% to 74% lower than estimates of the costs of delay used by the BC Trucking Association, it is consistent with recent estimates by the Greater Vancouver Gateway Council (GVGC) in the 2003 report "Economic Impacts of the Major Commercial Transportation System"[25]. The GVGC report estimates that the cumulative cost of delay over the period 2001 through 2021 will approach $280 million in 2003 dollars[26]. Our estimate of the costs of delay for the year 2003 is approximately 50% of the value of the GVGC estimate of the costs of delay for 2021. Assuming the number of truck trips grows 2% per year from 2003 to 2021[27], our estimate represents a fair and unbiased estimator of the current costs of delay impacting the motor carrier industry in the Lower Mainland and Fraser Valley.

Appendix 1
Data Definitions

a) Number of Trucks: the number of licensed commercial vehicles operating in the Lower Mainland and Fraser Valley. Data on fleet size is sourced from ICBC and TransLink. Trucks are divided into two components: light (maximum two axles; e.g. cube or panel vans) and heavy (three of more axles; single unit and combination vehicles).

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[25] Draft Report as of August 19, 2003.

[26] The no-build scenario assumes no transportation infrastructure improvements through 2021.

[27] See "Economic Impact Assessment of the Major Commercial Transportation System" page 32. The 50% growth factor was also used in the 1999 Lower Mainland Truck Freight Study produced by TSi.

b) Trips: movements from origin to destination (1 waybill) based on survey data from the Lower Mainland Truck Freight Study extrapolated to the population. On an average day in November 1999, there were 143,400 trips. Length and frequency of trips vary by truck type. The average length of each trip for light trucks was 8.5 kilometers and heavy trucks 15.8 kilometers. Light trucks averaged 10 trips a day, heavy trucks averaged 8 trips per day.
c) Study Area: The market for truck services used in the Lower Mainland Truck Freight Study is bounded to the south by the US border, to the west by the Straight of Georgia, to the north by the Coast Range mountains to the east by the town of Hope.
d) Origin-Destination Data: For origin and destination data, the study area was divided into eleven areas aggregated up by major municipalities. The markets are North Shore, Vancouver, Richmond, South Delta, White Rock/Surrey, North Delta/Surrey, Burnaby/New West North East Sector, Pitt Meadows/Maple Ridge, Langley, Valley North, Valley South.
e) Sample Size: A mail out survey was sent to 13,600 fleet managers of trucks in the study area representing 62% of the total fleet. A total of 1,740 responses were received (13% response rate) representing 8% of the population. Information on the number and type of trips, origin and destination and other information were extrapolated from the survey data to the population.
f) Capacity Utilization: Represents the average number of trucks per fleet in operation expressed as a percentage of fleet size. Survey data revealed only 63% of licensed light trucks and 60% of licensed heavy trucks were active in the study area during the time of the survey (35% of light trucks and 30% of heavy trucks were inactive).
g) Delay Costs: Costs of delay (the value of time) expressed as the sum of wages, salaries and operating costs. We use a range of estimates to establish the opportunity cost of delay to BC truckers. Estimates are sourced from the Ministry of Transportation's MicroBencost (revised June, 2003), TransLink (current EMME2 assumptions) and the TRB (converted to C$ and inflated to 2003 dollars).
h) Within Sub-Area: truck trips originating and terminating at points within the same sub-area.
i) Other Sub-Areas: truck trips originating in one sub-area and terminating in another sub-are within the study area.
j) Outside the Region: truck trips originating within one sub-area and terminating outside.

Road Infrastructures and Public-Private Partnerships: A Canadian Evaluation

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1. Introduction

During the 80s and until the mid of 90s, federal and provincial governments faced hard economic conditions. Successive deficits, rising service costs, higher income taxes, a steady rate of growth of the ratio of national debt to gross domestic product, insufficient investments to maintain existing infrastructures, long delays in making new investments when required and a long recession, finally induced governments to change how they provided good and services to citizens. In consequence, the federal government decided to transfer responsibility for transportation infrastructure to new organisations: airports, ports, the Canadian air navigation system and the St. Lawrence Seaway became non-for-profit institutions. As the federal government had no longer to care for these activities, taxpayers could expect a decrease in their tax burdens. The federal as well as provincial governments also sought alternative means of delivering public services to citizens-taxpayers. The conventional procurement process was challenged because governments looked for greater value-for-money. Among available options, the contracting-out concept became a cost-minimizing technique that arose to challenge old the fashioned in-house production of public services.

A sophisticated variant of contracting-out that is growing in the western world is the public-private partnership (PPP) or P3s. The basic idea of P3s is that firms often can manage some particular activities better than governments. Very few Canadian governments dare to experiment this new solution to containing the costs of road infrastructures whereas many other foreign countries enjoy great savings from P3s.

The purpose of this article is to throw light on characteristics of the P3s approach that influence its operations and determine why its performance is superior to the traditional means of building roads. Section 2 describes and assesses how and why the conventional procurement process for infrastructure projects does not lead to an efficient result. Section 3 presents the institutional foundations needed for the transition to P3s and shows how a sound institutional framework based on incentives on both government and private sides leads firms and governments to achieve a win-win solution. Section 4 evaluates two particular experiments, Highway 407, now privatized, in Ontario and the Confederation Bridge in Prince Edward Island. Our analysis compares them with the necessary requirements to be considered as a real public-private partnership. Section 5 explains briefly the main motives beyond the reluctance to accept this minimizing cost process in Canada.

2. The conventional procurement process

For more than fifty years, Canadian governments were the principal providers of infrastructure. Each level of government invested money and time to expand and improve its own infrastructures over the years. So our analysis describes the formal and successive steps made by a typical department when deciding to build a new road, a bridge and to maintain actual infrastructures. This conventional procurement process has been operational for so many years that it is legitimate to consider it as the benchmark for alternatives.

The ideal comparison

The first step of a government wishing to create or upgrade infrastructures is to decide how much money it intends to invest in overall highway infrastructures relative to its other investment priorities contained in its budget. Indeed, the government has a portfolio of investments to realize in a fiscal year subject to financial constraints determined by internal and external conditions. Having decided the appropriate level of investments in road infrastructures, it must find how to finance them. It faces two possibilities, either

government takes money from the consolidated revenue fund, or it borrows money on bond markets. Tax revenue generates a burden that is borne by current taxpayers, and, discounting issues of Ricardian equivalence, future generations get a free ride. Using taxes creates an excess burden or a deadweight loss that grows at an exponentially with the amount of the tax. So the real cost of using taxes to finance public investments is higher than revenue collected by the government[1]. If borrowing is the method of finance and is transacted at an interest rate reflecting the social marginal cost of public funds and not at a rate pertaining to long-term government bonds, future generations will assume mainly the overall burden as long as road infrastructures hold out. Bonds are reported taxes and are also subject to a deadweight loss.

The second step a government must take in its approach to infrastructures is a cost-benefit analysis. A cost-benefit analysis is a set of practical procedures for guiding public expenditure decisions in an efficient way. Before undertaking a cost-benefit analysis, the government must get good information on the physical conditions of its entire network, namely national highways, national and local roads and urban collectors. Such information leads to an idea of costs, the components of which emanate from planning, design, construction, maintenance, tendering costs and transactions costs linked to the project. The traditional procurement process typically involves a number of contracts by smaller production units.

Benefits of road construction are more difficult to measure than costs if there is no toll or direct user fee collected. The government must have a good profile of traffic volumes to estimate the future benefits enjoyed by travellers. The conventional approach uses the people's willingness to pay for such services. Benefits are estimated for each category of travellers by their real time saving, safety improvements as a lower probability of having a severe accident, a lower probability of death and by other intangibles. A discount rate is required to compare costs and benefits that occur in different time periods. Then, each infrastructure project is evaluated in net present value terms by a discount rate. However, there is no consensus on what is the

appropriate real social discount rate for government projects. Sensitivity analysis is recommended to check if the net present value is sensitive or not to the discount rate. Finally, each project is considered admissible only if the net present value is positive. If there are many projects that are mutually exclusive, the government invests in those having the highest net present value and stops to invest when the amount allowed by the budget is nil.

The third step begins as soon as the government specifies in exhaustive detail the road infrastructure to be built. A call for tenders is done and bidders submit a schedule of total cost (or a unit cost) how the means by which they plan to stay within the estimate of these costs. The government analyses each received tender, compares them, eliminates firms that do not comply with the original design and chooses, in most cases, the lowest-cost bidder who meets the public sector's detailed specifications[2]. If the tendering process is very competitive, it can lead to better value-for-money for the government. The duty of the successful private firm is to supply the highway project at the time and place specified. The only financial risk taken by the supplier is the business risk associated with seeking a profit by producing the output called for by the terms and the conditions of the contract. The winning firm can reduce it by outsourcing some activities to reliable subcontractors.

However, the government as procurer is not involved with the production process *per se* but it is exposed to the majority of risks emerging from the construction of road infrastructure. First of all, the government when requiring bonding expenditures from the winning bidder is ensured that the bidder will comply with the terms of the contract. Secondly, as the government assumes the overall project risk, it has incentives to invest energy, money and time to monitor the inputs of the production function used by the chosen firm. Those monitoring expenditures reduce moral hazard or *ex post* opportunism by the firm and depend on the terms of the contract. More precisely, the public agency cannot properly asses the winning firm's efforts in detail and the results may end up not meeting expectations. Finally, civil servants or hired professionals in charge of inspecting and

monitoring the firm must look at the inputs and their qualities, the techniques used by the firm to fulfil its contractual obligations, the coordination of different activities on the working site or on-site, the follow-ups needed to check the pace over the time period and the respect of the timetable, so that delays in delivering the output and cost overruns do not exist and travellers enjoy right away benefits.

In short, private firms engaged in a typical conventional procurement process tend to execute the functions prescribed by the department. Performance is measured by adherence to detailed specifications as contained in the contract. As the majority of risks are retained by the public agency, it must invest in monitoring expenditures so that the infrastructure project corresponds to the anticipated output.

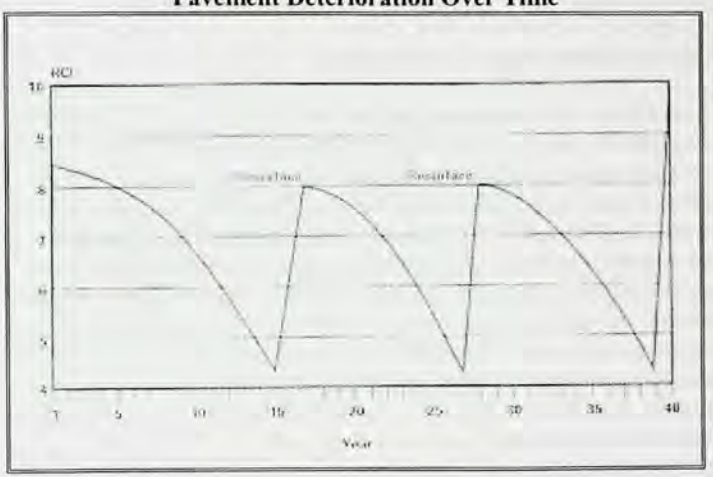
A more realistic means of comparison

However, the ideal conventional procurement standard, as described in textbooks, is full of failures from beginning to end. These breakdowns are endogenous, being created by politicians. They are not the results of malicious, stubborn or perverse politicians, but the natural consequences of their successive political decisions and actions over the years that generate positive short run effects and neglect negative long run consequences. The former are visible and tangible for the citizens. Taxpayers perceive them as achievements that seem to promote the wealth of the nation. The latter are invisible, intangible, diffused in time and space and far too distant from the initial cause for many to care. In other words, no one is able to link these unanticipated and perverse consequences to the initial situation generated by politicians' preceding actions. When politicians promote the interests of pressure groups, they transfer them resources that could be more useful elsewhere. Politicians are able to adopt this strategy as they own temporarily public assets for their full term. This perspective persuades us to reformulate or to reinterpret the previous sequence of events.

Figure 1 shows the strategy used by a department when road pavements deteriorate. New pavements typically have an initial

Riding Comfort Index (RCI) of 8.5. This riding quality of a pavement is a subjective estimate rated on a scale of 0 to 10. This decreases as the surface distorts under the traffic load and climate. On first-class highways, pavements are normally considered to have deteriorated to an unacceptable condition when the RCI has declined to a level of 4.5. At year 15 and again at year 27, the pavement is resurfaced with an overlay which would vary based on how lightly or heavily is the traffic density. Generally, flexible pavements in Canada will be resurfaced twice in 40 to 50 years before a decision is made to reconstruct the pavement.

Figure 1
Pavement Deterioration Over Time

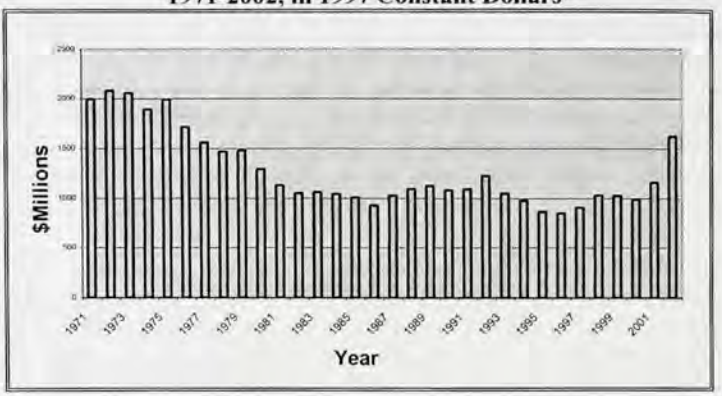


So when the RCI measure converges toward the 4.5, the pavement and maybe its components (base and sub-base) deteriorate at an exponential rate. All network users assume at the margin the overall expenses caused by the lack of investments done by the ministry of transportation. In other words, when a department does not invest efficiently in road infrastructures, car owners as well as truck owners must incur supplementary private costs to use the roads. As there are economies of scale in building and maintaining infrastructures,

travellers using roads pay for the upkeep of their cars and trucks more than the public agency will pay to repair its network[3]. On the other hand, when the department invests in road infrastructures that have strongly deteriorated or have a low RCI value, its expense is far higher than those that would have been incurred if the department had minimized the life-cycle costs of the network[4]. So politicians can neglect or decrease their investments in infrastructure projects and shift their priorities to other valuable political places because they know that travellers will assume the costs of driving on mediocre highways. They are captive and few substitutes are available.

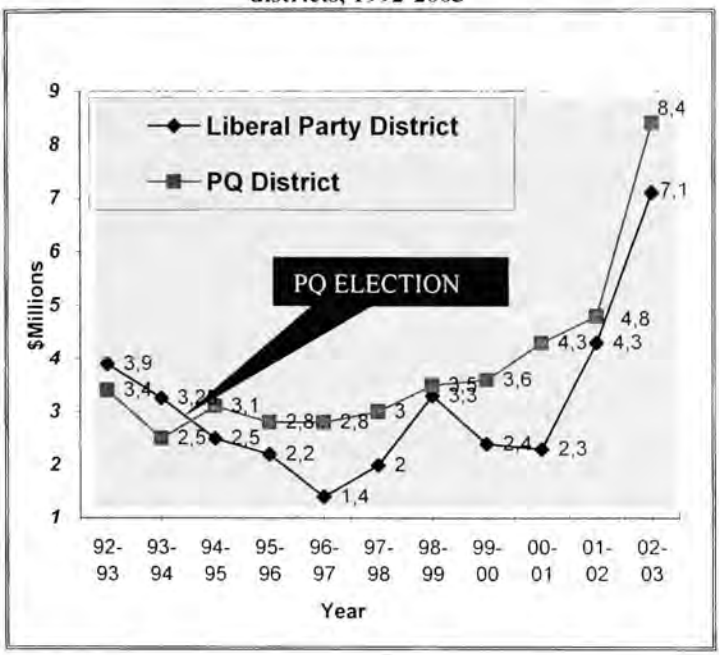
Figure 2 presents the evolution of Québec investments and maintenance costs done during the 1971-2002 period by the Department of Transportation[5]. Data are in 1997 constant dollars. The figure reveals clearly a real decline in the physical quality of infrastructures for most of the period and a light increase since 1997. The situation can only be explained by the absence of veritable benefit-cost analyses. Many motives can explain this lack. First of all, the department does not know well the real cost incurred when building or maintaining a road infrastructure. Secondly, it does not have good estimates of the rate of growth of the demand for the main components of its network. Therefore, it is impossible to have available data and to produce a benefit-cost analysis and to know if the net present value is positive or negative. Thirdly, maybe at hand is all the information needed to start a real benefit-cost analysis, but the chosen projects are decided by politicians to please pressure groups. Politicians adopt a strategy that differs from a traditional benefit-cost analysis. They use a new criterion that is the difference between the discounted political benefits and the discounted cost of public funds. This political choice results in an accelerated deterioration of the network.

Figure 2
Evolution of Québec Investments and Maintenance Expenditures, 1971-2002, in 1997 Constant Dollars



The end-result of those political actions generates a politically optimal allocation of resources that differs from the traditional definition as developed by economics science. Figure 3 compares the average expenditures undertaken by the Department of transportation for the PQ and the Liberal party districts from 1992 to 2003. When the Liberal party was in power, Liberal districts enjoyed higher average expenditures than those received by the PQ districts. When the PQ was elected two mandates in a row, the situation changed as expected. PQ districts got higher average expenditures from the Department of Transportation than those allocated to the Liberal party districts. As expected, ministers get higher average expenditures than deputies, whatever is the party.

Figure 3
Evolution of the Average Expenditures by the Québec Department of Transport for the PQ and the Liberal party districts, 1992-2003



Evidence from the Province of Quebec shows that infrastructure projects are generally done without a traditional benefit-cost analysis. In its 2001-2002 *Annual report*, the Ministry of Transportation admits that "the ameliorations brought annually by the Department are insufficient to stop the deterioration pace"[6]. Indeed, the RCI index for the highway segment has dropped from 6.60 to 6.31 and that of the overall infrastructures from 6.00 to 5.87 during the last two years.

The Québec Auditor General discloses a similar behaviour for bridges. In his 2002-2003 *Annual Report*, he writes "that interventions made during the last three years in maintenance and

resurfacing have been insufficient to cover the most important needs[7]". From 1998-1999 to 2002-2003, the number of bridges having one or more than one defect relative to its condition and its capacity has increased by 16 %. In other words, 42 % of the highway bridges and urban collectors in Québec are in this peculiar class. The main reasons cited by the Auditor General explaining this non optimal situation are the following: an absence of global strategies; benefit-cost analyses are not performed because costs are always underestimated and benefits are not estimated at all; preventive actions are minimized; planning and design are incomplete or erroneous; time schedules are not respected resulting in delays and cost overruns; follow-ups are deficient; monitoring expenditures are lacking and the public agency does not minimize the total life-cost of the network it owns[8].

Table 1 describes how the actual process with its long list of failures generates an important misallocation of resources[9]. Four successive phases are considered when deciding to build a bridge. A quick look shows that discrepancies between the first, the initial planning and design estimates, relative to the other three phases until the work is over are significant. These repeated mistakes are endogenous and they come from the politico-bureaucratic ambience that prevails in a department. A general inference emerging from this list is that public managers from the top of the hierarchy to the bottom do not have in general a strong incentive to closely monitor project management as they do not share directly the financial benefits of a successful project.

Table 1
Comparison of Different Highway Bridge Estimates for Maintenance and Refection from Eight Chosen Projects by the Québec AuditorGeneral in $ Current Millions

Projects	1	2	3	4	5	6	7	8
Planning Estimates	374.3*	63 0.6	990 .0	572 .5	154 .1	68. 2	43. 7	2.2 **
Estimates before the bid	225 .3	73 3.0	156 6.4	923 .7	549 .6	326 .7	929.3	177 4.9
Signed Contracts	314 .3	864. 8	155 5.0	101 9.8	590 .0	338 .4	125 5.2	167 5.4
Real costs	282 .8	94 3.3	165 2,3	117 6.5	712 .9	403 .8	136 6.9	172 6.4

Notes: *Incomplete work: to be completed in another project.
**No data available in the management files.

The comparison of the nirvana approach with the real context of the political decision-making process reveals the existence of a large divergence that comes from the transactions costs of the political regime. The chosen public sector standard cannot be the hypothetical publicly financed scheme, a faraway ideal, but must be the real procurement process that is in operation on a daily basis in a department of transportation investing in infrastructures. So two imperfect plans are compared, one being generated by the imperfect mechanism of the political system, the other coming from private firms in search of profits to serve customers. Both compete to produce outputs subject to constraints that differ.

3. The public-private partnership arrangement

Over the years, some new private organizations have competed with public institutions to deliver public services. Among them, the public-private partnership is becoming more and more important in many

countries of the western world. British evidence[10] shows that departments get better value-for-money when they contract out not only services, but also outputs for a long period. The public-private partnership offers some independence from Whitehall control. It can reduce bureaucracy, foster innovation, and provide a more focused view on finance. It also helps provide more diversity in public service provisions.

Its evaluation requires developing some theoretical concepts, among them the agency theory and its delegation process, the analysis of risks among various partners when working together and the incentives put in place to link the principal, the public agency, and the agent, a third party. As a matter of fact, the public-private partnership or P3s relies on contracts where the public sector specifies the outcomes desired and the private sector sets about achieving these outcomes in what it considers to be the most efficient way.

Considerations on the agency theory

The agency theory[11] allows for and interprets all possible forms of delegation, whether it occurs within a hierarchy or externally between two parties that buy and sell goods and services. Since parties to an agreement can have diverging interests, mechanisms must be introduced to ensure a convergence of interests and monitor the contractual relationship. There are three components of agency costs. The first refers to the monitoring expenditures that the principal must incur to be sure that the agent serves its interests. The main problems that threaten an inattentive principal are two specific forms of opportunism, adverse selection which occurs before hiring and moral hazard which results from the types of contract. These two problems stem from the difficulties in observing and measuring the expected behaviour of the agent. In the first case, which is *ex ante* opportunism, the agent has observed facts that the principal has not seen. The agent can use them in his decision-making, but the principal cannot check whether the agent uses his information in a way that best promotes his interests. In a word, adverse selection involves hidden information. In the second case, which is *ex post*

opportunism, the principal cannot properly assess the agent's efforts in detail, so that the results may end up not meeting expectations. Briefly, moral hazard involves hidden action.

The second component of agency costs concerns bonding expenditures that the agent incurs to provide a guarantee for the principal that it will not undertake actions that could be detrimental to him or to ensure that it will compensate him for such actions. The agent commits himself through credible commitments that considerably reduce uncertainty in the event he does not meet them.

The third component of agency costs is the residual loss that results from unresolved conflicts between the two parties. Both parties minimize the residual loss when neither of the contracting parties can improve the terms of the contract. No means are taken to mitigate these costs because the game is not worth playing. Every contract is incomplete due the high costs associated with including all contingencies and expected effects that may never be harmful to the parties in the long run. Firms have strong incentives to develop long-term contractual relations as a substitute for agency costs because "these arrangements not only reduce contracting and monitoring costs, they build trust, facilitate the flow of information, make it possible to make-offs at the last minute, and offer some risk-spreading advantages"[12]. In conclusion, the delegation process with proper incentive mechanisms obviously serves to keep down operation costs.

PPP solution as an integral delegation process

An appropriate definition of what is a public-private partnership can be expressed in the following: arrangements where public institutions enter into long-term contractual agreements with private entities for the construction or management of public infrastructure facilities by the private entity, or the provision of services, using infrastructure facilities by the private entity to the community on behalf of a public entity[13]. A hypothetical case presents the different steps done by a

department when it intends to participate in a public-private partnership.

So a ministry of transportation solicits a request for proposals (RFP) for an important highway infrastructure. The contract stipulates that the private entity is responsible for the design, building, financing and operation or (DBFO) of the future infrastructure project. A value engineering exercise is done by internal experience evaluation teams that use predetermined evaluation criteria. The contract specifies the output it requires for a guaranteed maximum price contract and a fixed completion date (SG Hambros[14]). It gives a 30-year concession to the private sector before transferring it over to the province. Finally, the department monitors quality and progress by hiring an independent engineering consultant and in-house construction managers. As the procuring entity, it instigates and facilitates the commissioning of the project. To obtain the best proposed project, the number of bidders must be many and competition must be effective. British experience shows that for important infrastructure projects at least four consortia are necessary to get sensible savings (H M Treasury, 2003)[15]. When the number of bidders is lower than expected, it is recommended that the department provides subsidies up to a maximum, so each firm willing to participate in the bidding process can produce its value engineering assessment report. It is cost-minimizing to do it because more bidders bring in new technologies, innovations and suggestions that the procurer agency can integrate when initiating the bidding process.

In the meantime, different consortia are formed to offer their services. They are mainly composed of investment bankers, engineers, management consultants, lawyers and accountants. Each leading firm must analyse the nature of the risks and who bears them. The main principle of allocating risks among partners is very well known: "As a rule, a risk should be borne by the party with the most control over it and the greatest ability to reduce it". Table 2 presents a list of nine risks that face any infrastructure project. Five of them are borne by private agents; three are shared by private agents and the public sector and only one by the public sector. The public sector transfers a

significant level of responsibility and risks to the private sector and manages those it is best able to.

Table 2
Typical Infrastructure Project Risks and Hypothetical Allocations

Risk Category	Examples	The best risk bearer
Technical risk	Engineering and design failures	Private
Construction risk	Cost escalation due to faulty techniques and delays	Private
Operating risk	Higher operating costs and maintenance costs	Private
Revenue risk	Deficient revenue due to low volume or price of delivered service	Public/Private
Financial risk	Costs of inadequate revenue hedging, debt management	Private
Force majeure	Losses from war, other calamities and acts of God	Public/Private
Regulatory/Political risk	Changes in law or policy undermining project finances	Public
Environmental risks	Damage caused by adverse environmental impacts or hazards/ liability	Private
Project default	Failure through any combination of the above or other factors	Public/Private

Source: D. Grimsey and M. K. Lewis, 2002.

The main concern faced by the principal, the leader of a consortium, is that properly aligned incentives require private partners, the agents, to assume appropriate shares of risks and rewards. This strategy provides powerful incentives for the private firm to perform and ensures value-for-money to the public agency. Internal contractual arrangements among partners are built around performance-based outcomes. A successful proponent is the consortium that demonstrates that its team of partners can meet the performance requirements for the least life-cycle costs. Efficiency gains arise as the result of five principal reasons. The first, external to each consortium, is naturally an intensive competition among bidders so that they will provide their services skilfully and cheaply. There should be no barriers to entry to exclude foreign-based consortia. The four remaining sources of efficient gains are internal to each consortium. Each organizes its activities to jointly offer the best output specification defining the service required for the public agency.

The second concerns the internal composition of the consortium and its activities. As a single entity, the principal as the manager of the project is able to minimize transactions costs in his consortium and to benefit from efficiency savings generated by his partners. All have incentives to be efficient as they are judged on their respective outcome. The coordination process leads to a better performance when buying materials and using more intensively production factors as physical equipment and skilled labour. The third reason is related to the time of completion. Again, the principal who coordinates and monitors all the activities leading to the final output can enjoy greater flexibility in rescheduling the project timetable. He is in position to reduce the time needed to complete the project. The cumulative of all savings from each partner become an opportunity to reduce the initial time allowed by the contract.

The fourth comes from potential innovative construction techniques. If the project is realized over many periods, learning by doing emerges and workers become more skilled at their jobs due to

experience. New discoveries in production can also decrease costs over time and also save time. The fifth reason deals with value engineering assessment. A consortium applies a value engineering exercise which typically results in reductions in the overall design, construction and future maintenance costs while maintaining appropriate design and safety standards required by the contract. It infers from that new tradeoffs between costs and safety relative to existing standards are made. So a society is better off by shifting the standard if equivalent safety performance based on the cost-per-life estimate can be delivered at lower cost[16]. It involves an increase in the scope and the cost of the design phase which is offset by the resulting life-cycle cost reductions.

On the revenue side, the winning consortium collects tolls, using transponder technology, from road users that are based on the traffic forecasts carried out by the ministry. The only constraint affecting the successful consortium happens when the estimated traffic volume of cars and tractor trailers is insufficient to generate enough revenue. The department has to give subsidies as it is responsible under the terms of the contract.

4. Evaluation of Two Canadian P3s

Until now, many Canadian governments have been reluctant to use the public-private partnership for highway infrastructures. The analysis focuses on two experiments, the Highway 407 Central project in Ontario and the Northumberland Strait Crossing project in Prince Edward Island. Our main interest is to answer the following two questions: Are these two projects authentic applications of the 3Ps as in the United Kingdom? If not, why do they diverge from the description presented in the preceding section?

The Ontario Provincial Auditor states in its *1996 Annual Report* that the Highway 407 Central project is not "in our opinion a public-private partnership"[17]. This diagnostic is based on the fact that the risk sharing among involved respective parties is not optimal. More precisely, the ministry assumes higher financial risks than initially

expected as it has to borrow money on the bond markets. The reason invoked is that both consortia have unacceptable financing plans and that they require substantial support and guarantees from the government. Moreover, as the owner of the project, it bears also many of the operational risks that a typical consortium will generally allocate to it own partners. In a word, when changing the initial project in a design, building, financing and operation or DBFO into a design-build-operate project or DBO, it modifies strongly the optimal allocation of risks by reducing what that should have been borne by the consortium, the agent. This bias leads the department to be overexposed and to assume risks it does not have expertise at all.

Although it is not a complete P3s, it does not imply that savings in time and in cost are not important. For instance, it is estimated that the conventional procurement process would have required 20 years to complete the 407 highway. Actual users enjoy benefits through an incomplete P3s that would have been delayed for many years. Substantial savings coming from the consortia's requests for proposals (RFP) are estimated at $300 million relative to the original design using existing ministry standards. Finally, an independent engineering firm assisted by in-house construction managers has monitored costs. The budget is "one half of 1% of the total highway cost, which is less than the normal 8-10 % for department contracts". No benefit-cost analysis is done, although data are easily collected on both sides of the equation.

The second evaluation refers to the Northumberland Strait Crossing project in Prince Edward Island. The type of P3s used by the federal government is called build-own-operate-transfer scheme or BOOT. The structure of the delegation process allows Public Works and Government Services Canada or PWGSC to allocate different risks to the best risk bearers as described by the content of Table 2. The principal, PWGSC, is able to "transfer as much commercial risk as possible to the agent"[18], the successful proponent. The latter shares these risks with his partners accordingly. However, there is a major exception; the government assumes all the financial risks of the operation. As the federal government has a constitutional obligation

to maintain a continuous connection between PEI and the mainland, it uses the stream of annual subsidy payments ($41.9 million for 35 years) made to the existing ferry service, as the first step to finance the fixed link. It raises approximately $661 million through an issue of indexed fully amortizing bonds[19]. This action enhances the credit rating of the subsidy bonds to finance construction of the bridge.

PWGSC commissions a benefit-cost analysis of the bridge project. The net present value of building the bridge is estimated to $263.6 million relative to the status quo of continued ferry operation. As expected, the principal benefits generated by the construction of the Confederation Bridge are the ferry cost savings from discontinuing it and the value of time saved by cars and trucks. This result is based on a discount rate of 7%. However, a commentator writes that "the only highly sensitive variable was indicated to be the discount rate to be applied to the calculation", namely a range from $16.7 million to 771.9 million[20]. Finally there is no evaluation of benefits that the bridge, a high quality asset, replaces the ferry, a low quality asset.

This short evaluation of the net present value generated by using a public-private partnership rather than the traditional procurement process reveals the importance of savings. They are composed of reduction in the overall construction costs, time savings for the users and the optimization of the life-cycle of the infrastructures. A long run effect is that the P3s induces future successful proponents to innovate and to minimize the costs of sharing risks. Briefly, they will develop a learning curve based on incentives that did not exist at all in the conventional procurement.

5. Final Observations

This preliminary evaluation of two experiments in public-private partnership shows that savings are important even when the bidding process is not as competitive as it should be. So how to explain that Canadian governments do not seem to share this view when investing in road infrastructures? The answer is that many pressure groups do not want this new approach to flourish. They fear that their vested

interests are in danger, namely they will lose either their jobs or their capital stocks and to pay for services that they enjoy now free. The Ontario government is until now the exception with the highway 407, now privatized. The British Columbia government that once sought to lease the Coquihalla Highway to a private partner changed its view when meeting stiff resistance from those people living along the highway. On the other hand, the Quebec government has not dared until now to use the build-own-operate-transfer scheme or BOOT for Highway 30 in the Montreal Metropolitan Area. It will reduce the congestion on the Trans Canada Highway and Highway 20, increase the speed on these highways and decrease the probability of accidents and death. The protection of vested interests is the sole motive impeding innovations to be implemented in Canada. Important pressure groups with their political allies do not want technical changes to be introduced in the production of highway infrastructures.

Notes and References

[1] Dahlby estimated in 1993 that lowest marginal cost of increasing public funds was 0. 40 $ in Alberta and the highest was 0.99 $ in Québec. B. Dahlby (1993), *The Distortionary Effect of Rising Taxes* edited by W.B.P. Robson and W.M. Scarth, in Deficit Reduction. What Pain, What Gain?, C.D. Howe Institute, Toronto, p. 42-47.

[2] We exclude voluntary cases where the general contract is partitioned among many contractors.

[3] Department of Transportation, (1994), *Les infrastructures routières: vers l'an 2000*, Research Paper. A transport specialist writes the following: "each dollar invested in improving pavements generates $5. 10 cost savings for users of the network". July, p. 33.

[4] Department of Transportation, (1994), *Les infrastructures routières: vers l'an 2000*. Research Paper. The transport specialist writes that if the department rehabilitates its network now, "each dollar invested will generate between 1995 and 2000 a reported rehabilitation cost decrease from $1.75 to $1.85 in the year 2000". July, p. 41-48.

[5] Data come from the Department of Transportation, various years.

[6] The 2001-2002 *Annual Report*. Department of Transportation, Québec, p. 64.

[7] The 2002-2003 *Annual Report*, Auditor General of Québec, Chap. 4, p. 84.

[8] The Auditor General of Québec writes many times a new invoked justification, namely "as long as we are here, we will do what is necessary. "

[9] The 2002-2003 *Annual Report*, Auditor General of Québec, Chap. 4, p. 98.

[10] *PFI : meeting the investment challenge*, (2003), H. M. Treasury, London, U K, July.

[11] M. C. Jensen and W. H. Meckling (1976), *Theory of the Firm. Managerial Behavior, Agency Costs and Ownership Structure*, Journal of Financial Economics, vol. 3, October, p. 305-360.

[12] J. W. Pratt and R. J. Zeckhauser (1985), *Ownership Principals and Agents: An Overview* in *Principals and Agents: The Structure of Business*, edited by J. W. Pratt and R. J. Zeckhauser, Harvard Business School, Boston Mass. p. 16.

[13] D. Grimsey and M. K. Lewis (2002), *Evaluating the risks of public private partnerships for infrastructure projects*, International Journal of Project Management, vol. 20, p. 109.

[14] S G Hambros, (1999), *Public-Private Partnerships for Highway: Experience, Structures, Financing, Applicability and Comparative Assessment*. Objective One Final Report, March, p. 75.

[15] H. M. Treasury (2003), *PFI: meeting the investment challenge*, London, UK, July, p. 34.

[16] F. Poschman (2003), *Private Means to Public Ends: The Future of Public-Private Partnership*, Commentary, The C.D. Howe Institute, Toronto, June, p. 18.

[17] The 1996 *Annual Report*, Office of the Provincial Auditor, Toronto, p. 236.

[18] The 1995 *Report* of the Auditor General of Canada, chap. 15, p. 6.

[19] The Auditor General of Canada argues that "the financing costs could have been reduced by about $45 million had the government raised this debt through its own borrowing". This sentence is wrong as the Auditor General does not include the deadweight loss of borrowing." Chap. 15, p .9.

[20] S G Hambros (1999), *Public-Private Partnerships for Highway: Experience, Structures, Financing, Applicability and Comparative Assessment*. Objective One Final Report, March 1999, p. 114.

The Welfare-Distributional Impacts of Congestion Pricing on a Road Network

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1. Introduction[1]

The gradually accelerating pace at which tolls are being implemented on urban roads worldwide suggests that road pricing is an idea whose time has finally come. Between 1986 and 1992 toll rings were established in Bergen, Oslo and Trondheim, and tolls have since been introduced in other Norwegian cities. Since 1995 a series of facility-based road pricing projects have been set up in the U.S. with the aid of innovative federal legislation (U.S. DOT, 2002). In 1997, Highway 407 north of Toronto began operation as an all-electronic open access toll highway, and after a series of extensions it is now 108 km long. In 1998, Singapore launched electronic road pricing of major arterials and expressways. And in February, 2003, London boldly introduced congestion pricing within an area around the city centre.

While these developments are encouraging, various technological, institutional and acceptability barriers still impede widespread adoption of congestion pricing. One of the longstanding barriers is the fear of adverse impacts on certain groups such as low-income households or individuals who travel long distances (Rajé, 2003). The purpose of this paper is to explore the welfare-distributional impacts of urban road congestion pricing. A stylized urban road network is

[1] Financial support from SSHRCC for the project "Road pricing in urban areas" is gratefully acknowledged. Thank are also due to André de Palma and Fabrice Marchal for extensive assistance in using the METROPOLIS software, and to André for collaboration on related projects.

considered on which individuals with different job characteristics commute from home to work. Computations are performed using METROPOLIS: a fully dynamic traffic simulation model that treats endogenously mode, departure time and route choices of individual travelers. Section 2 of the paper provides a brief overview of the METROPOLIS program, and a description of the travel demand characteristics of workers and the road network. Section 3 describes the equilibrium in the absence of tolls.

Section 4 analyzes the welfare-distributional impacts of a network-wide system of variable[2] (*i.e.* time-varying) tolls that support an approximate welfare optimum. It is anticipated that comprehensive tolling of this sort could be implemented using GPS-based electronic road pricing technology within a few years, and such a scheme is indeed now being given serious consideration in the UK. However, electronic road pricing has only been introduced in Singapore so far. The other existing schemes involve tolling of limited areas or individual roads, and some schemes employ little or no toll variation by time of day.

The welfare impacts of road pricing schemes depend on what links are tolled, the extent of time variation of tolls, the magnitude of geographical boundary/spillover effects, *etc*. To explore some of these factors Section 5 considers a cordon scheme. As a base case an optimal flat (time-invariant) toll is computed for the whole cordon. Three variants are then considered: (i) an optimal flat toll applied to half the traffic lanes of the links that define the cordon while the other half remain toll free, (ii) a pair of optimally differentiated flat tolls applied to the two sets of lanes, and (iii) an optimal variable toll with four time steps. Variants (i) and (ii) allow travelers to choose whether to pay a toll premium in order to save travel time. The welfare impacts of all three variants are compared with the base-case cordon

[2] The term "variable pricing" is often used to describe variation of tolls by time of day. Other frequently used terms are "value pricing", "congestion pricing" and "peak-period pricing".

toll and with the congestion toll of Section 4. Section 6 summarizes the main conclusions.[3]

2. The Model

The dynamic network equilibrium simulator METROPOLIS describes mode, departure time and route choices of individual travelers (De Palma and Marchal, 2002). A two-stage nested logit framework includes choice between auto and public transport in the outer nest, and choice of departure time in the inner nest. Route choice is governed by a heuristic based on minimization of travel time and a day-to-day adjustment process guides the system towards a stationary regime. The generalized systematic cost of an auto trip is

$$C_A(t) = \tau(t) + \alpha_A \mathrm{T}_A(t) + \beta Max\left[0, t^* - \Delta - t - \mathrm{T}_A(t)\right] + \gamma Max\left[0, t + \mathrm{T}_A(t) - t^* - \Delta\right],$$

where t denotes departure time, τ the amount paid (if any) in tolls, T_A auto travel time, α_A the unit cost of auto travel time (henceforth value of travel, or VOT), t^* the midpoint of the on-time arrival window, Δ the half-width of the window, β the unit schedule delay cost of arriving early, and γ the unit schedule delay cost of arriving late. For public transport generalized trip cost is exogenous and independent of time of day:

$$C_P = C_{P0} + \alpha_P \mathrm{T}_P,$$

where T_P denotes travel time by transit, α_P the unit cost of transit travel time, and C_{P0} the fare plus costs of walking time, waiting time,

[3] The analysis in this paper follows up on de Palma *et al.* (2003a) who use METROPOLIS to study a variety of tolling schemes on the same road network. (This paper is available on request; a condensed version is published as de Palma *et al.* (2003b).) The current paper builds on the predecessor by: (a) focusing on the welfare-distributional effects of tolls, (b) featuring heterogeneity of travelers in unit costs of travel time and arrival time preferences, (c) computing welfare-optimal time-varying tolls (Section 4), and (d) examining variants (i) and (ii) of the cordon toll (Section 5).

average schedule delay, *etc.*

The population of workers is assumed to be evenly divided between four stylized types. For each type t^* is uniformly distributed with a mean value of 8:00 and a standard deviation of 20 mins., and Δ=10 mins. Remaining parameters are assumed to have mean values across types of α_A=\$10/hr, β=\$6/hr, γ=\$25/hr, α_P=\$15/hr, C_{p0}=\$10, μ_{mode}=5 and μ_{dept}=2, where μ_{mode} and μ_{dept} are the logit scale parameters for mode and auto departure time choices respectively.

Table 1: Demand parameter values

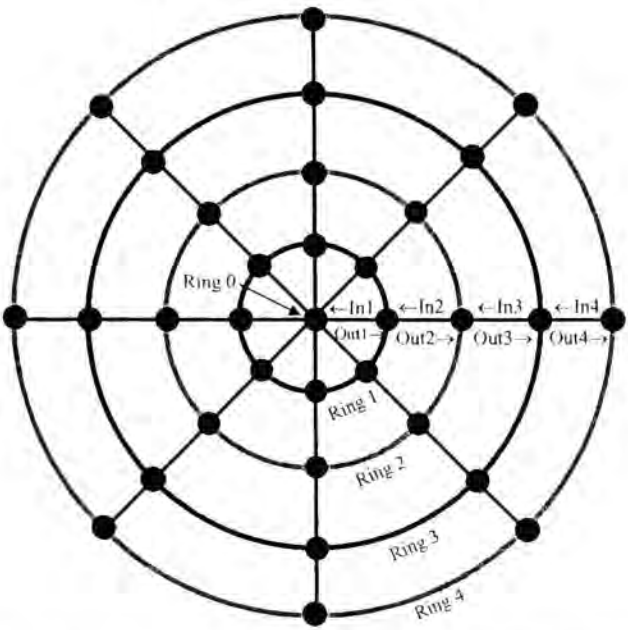
Worker type	α_A	β	γ	α_P	C_{p0}	μ_{dept}	μ_{mode}
Clerical	20/3	4	50/3	10	20/3	4/3	10/3
Autonomous professionals	40/3	4	50/3	20	40/3	8/3	20/3
Factory	20/3	8	100/3	10	20/3	4/3	10/3
Interactive professionals	40/3	8	100/3	20	40/3	8/3	20/3

The distribution of these parameters over the four types is specified in Table 1.[4] "Clerical" workers have a relatively low VOT and low unit schedule delay costs to reflect low wages and (by assumption) flexible work hours. "Autonomous professionals" (*e.g.* academics) have similarly flexible work hours, but a higher VOT. "Factory" workers by contrast have the same VOT as clerical workers but high schedule delay costs because of the assembly-line nature of their jobs. Finally, "interactive professionals" (*e.g.* stock brokers) have a high VOT, and high schedule costs to reflect the need to interact with

[4] Despite recent empirical research on trip-timing preferences there is inadequate evidence to construct a joint frequency distribution of all the parameters of the model. The four-point distribution facilitates description and interpretation of the welfare-distributional effects of congestion pricing. For all types $\gamma/\beta = 25/6$, and μ_{dept} and μ_{mode} are proportional to α_A.

clients and colleagues. The ratios of unit schedule delay costs to VOT (β/α and γ/α) govern willingness to suffer queuing delays in order to arrive on time. Factory workers have the highest "queuing tolerance", and autonomous professionals the least tolerance.

Figure 1: The urban road network



The road network (see Figure 1) has four concentric ring roads spaced 4 km. apart. For ease of reference, the city centre is called Ring 0. Eight arterial roads, uniformly orientated around the compass, run in both directions between Ring 0 and Ring 4. Arterial links that connect Ring x to Ring x-1, x=1,...,4, are called "*Inx*" links, and arterial links that connect Ring x-1 to Ring x are called "*Outx*" links. The *In1* and *Out1* links have a flow capacity of 3,000 vehicles/hr. and a speed limit of 50 km/hr. The other inbound and outbound links comprise

two lanes, each lane having a flow capacity of 2,000 vehicles/hr and a free-flow speed of 70 km/hr. All links on the ring roads have hourly flow capacities of 2,000 and a speed limit of 50 km/hr. Congestion on all links takes the form of queuing. If the arrival rate of vehicles at a link exceeds its flow capacity, a queue develops. Public transportation service runs on the same road network, but using dedicated lanes at a traffic-volume-independent speed of 40 km/hr.

Residences and workplaces are located at zones joined to each of the 33 intersection nodes. Each zone houses 8,000 commuters. The number who commute to each of the other 32 zones is an exponentially decreasing function of the free-flow auto travel time, with a decay rate of –0.07/min. Workplaces are thus concentrated towards the city centre because of its greater average accessibility.

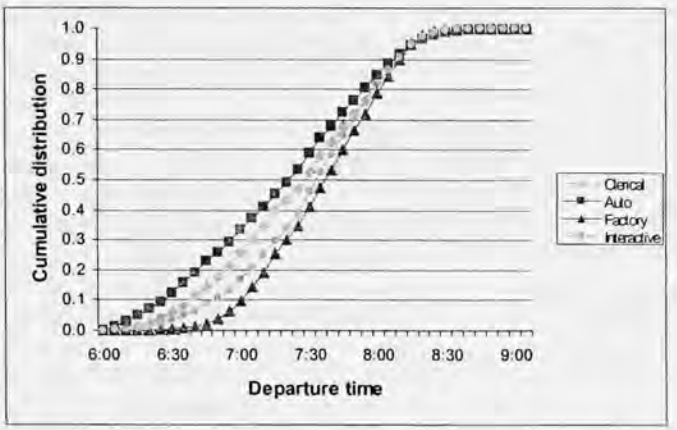
Because of the day-to-day adjustment process employed with METROPOLIS, about 50 days (iterations) are required to approach a stationary regime, and travel conditions continue to fluctuate slightly thereafter. In order to identify social surplus and toll revenue with reasonable accuracy, an average is taken over a further 75 iterations. To reduce computation time the O-D matrix and the capacities of each link are reduced to 1/10 of their "actual" scale. Due to a homogeneity property of METROPOLIS this scaling has little effect (other than for randomness of individual behaviour) on the level of congestion or other per capita statistics of interest.

3. Equilibrium with no tolls

In the equilibrium without tolling 72% of trips are made by auto. The average auto trip is 15 km. long at a speed of 41.5 km/hr. Travel time is 36% higher than under free-flow conditions (on the same route). Mean queuing delay cost is $0.92, while mean schedule delay cost is $1.41. Congestion is most severe on the inbound links because jobs are concentrated in the centre and traffic is primarily inbound. Congestion is lower on the ring roads, and lower still on the outbound links where it peaks a few minutes later. Congestion also falls progressively towards the city boundary.

Figure 2 shows the cumulative departure distributions for the four worker types, aggregated over origins and destinations. Autonomous professionals depart earliest on average because they have the lowest queuing tolerance and correspondingly greatest willingness to arrive early to avoid congestion.[5] Factory workers, who have the highest queuing tolerance, arrive the latest and have the most concentrated distribution of arrival times.

Figure 2: Cumulative departures in the no-toll equilibrium



4. Social Optimum

At the social optimum, social surplus – the sum of consumers' surplus and toll revenue – is maximized. Solving for the social optimum is complicated by several considerations. First, there is no guarantee even in static models that marginal cost pricing of all road links supports a global optimum (Yang and Bell, 1997). Second, it is not necessarily optimal to eliminate even pure queuing congestion on each road link on a network (de Palma and Jehiel, 1994). And third,

[5] Because arriving late is 25/6 times as costly per minute as arriving early for all worker types, the majority of workers arrive early in equilibrium.

because of persistent day-to-day fluctuations in METROPOLIS queuing cannot be consistently eliminated on all links unless tolls are set at inefficiently high levels.

These caveats notwithstanding, it would be prohibitively time-consuming to maximize social surplus directly by trial and error application of separate time-varying toll schedules on each of the 12 link types. Instead, an iterative procedure is employed to reduce queues to relatively low levels. This is done by setting tolls on each link type in 5 min. steps, raising tolls when queues are present and lowering tolls (to a minimum of zero) when links are utilized below flow capacity, and terminating iterations when improvements in social surplus cease. The resulting toll will be referred to as the Social Optimum toll or "SO toll". The time pattern of the SO toll is similar, but not identical, to the time pattern of congestion without tolling. On the most heavily congested *In1* links the toll starts to rise at 6:45, reaches its highest value of $3.59 at 7:15, and returns to zero by 8:15. On the other 11 link types the toll reaches a much lower maximum value, and in most cases it begins later and ends earlier.

Figure 3: Changes in mean departure times in the social optimum

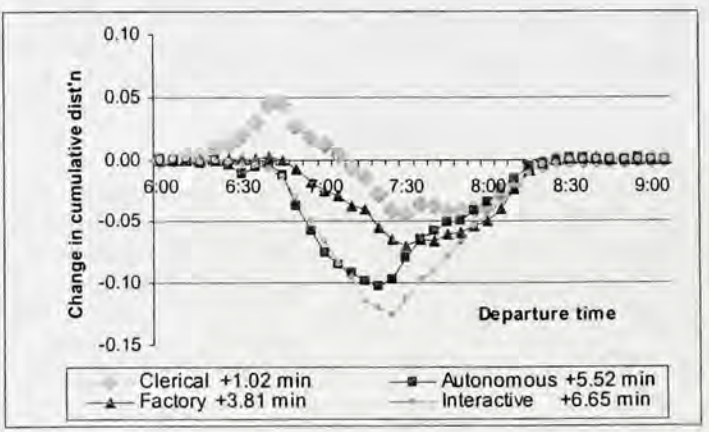


Figure 3 depicts changes in mean departure times induced by the SO toll. All four worker types postpone departures because, with shorter queues, they can leave home later without arriving at work later. As indicated by the box at the bottom of Figure 3 the shift is greater for the two professional worker types with high VOT who are more averse to congestion and correspondingly more responsive when congestion is alleviated. The shift is also greater for types with higher unit schedule delay costs (factory workers, and interactive professionals) who have a greater incentive to reduce early arrival costs when traffic conditions improve. Clerical workers, who have both low VOT and weak arrival-time preferences, actually advance their departures early in the morning to avoid paying tolls that grow quickly at this time.

Some summary statistics of the social optimum are listed in Table 2 (see end of paper) in the column "System Opt". The auto share of trips declines only slightly from 72% in the no-toll equilibrium to 70%. But because of favorable departure time and route choice shifts, the average congestion level measured by the ratio of queuing time to free-flow travel time falls from 36% to just 4.7%, and mean schedule delay cost drops by about 10%. Social surplus per capita[6] rises by $0.82, whereas toll revenue per capita is only $0.75 so that aggregate consumers' surplus actually rises. However, because the distribution of gains is skewed to the right, only 34% of individuals gain in the absence of a toll rebate or other beneficial use of toll revenues (row "Gainers no rebate"). Thus, the SO toll regime would be rejected in a plebiscite with a simple majority rule. But the fraction of individuals who gain rises to 82% if all toll revenues are rebated as a uniform per capita lump sum (row "Gainers 100% rebate"). And half the population gains if just 23% of toll revenues are returned (row "Rebate for 50% gain"). Thus, there is considerable scope for tolling to be made acceptable to the public even if some of the revenues are

[6] For the whole population, including individuals who choose public transport. With 250 commuting days per year, the annual welfare gain would be about $200 per capita.

"used up" in collection costs and/or spent in ways that do not benefit travelers.

The final four rows of Table 2 indicate that, while aggregate consumers' surplus rises with tolling, clerical and factory workers lose. These two groups shift from auto to transit by 3.9% and 4.7% respectively (figures not shown in table), whereas the professionals shift marginally (by 0.2% and 0.3%) to auto. This pattern is consistent with the fact that clerical and factory workers do not shift departure times as much as the other types in Figure 3. The pattern is also consistent with the possibility noted by Layard (1977) that individuals with high VOT can be attracted to drive by tolling.

The welfare-distributional effects of the SO toll are broken down by worker type and by home and workplace location in Table 3. The first entry in each cell records the fraction of individuals in the group that gain, with fractions equal to or greater than 0.50 shaded for ease of identification. The second entry in each cell notes the mean change in consumer's surplus, with positive changes highlighted.

While on average clerical and factory workers lose, and professional groups gain, winners and losers are scattered about the cells for all four types. Clerical and factory workers living in the centre fare better than those in the suburbs because they travel less far to work on average. But those who work in the centre fare the worst because they have to commute in on the formerly congested and correspondingly most heavily tolled inbound arterial links. For the two professional groups the impacts are qualitatively rather different, with residents in Rings 1 and 2 faring the best. For autonomous professionals those working in Rings 1-3 gain the most, whereas for interactive professionals no strong trend is apparent with respect to location of work. Overall, Table 3 reveals a rather complex pattern of welfare distributional effects. These effects derive in large part from departure-time-choice adjustments that could not be deduced with either static models or dynamic models lacking a network dimension.

5. A Cordon Toll

Cordon tolls can be levied on any of the four ring roads[7], and in the inbound direction, the outbound direction or both directions. Since inbound links are the most congested it is natural to focus on inbound cordons. Ring 2 yields the highest welfare gain from an inbound flat cordon toll, and attention is hereafter restricted to inbound tolls on Ring 2, which are levied on the eight *In2* links shown in Figure 1.

The cordon toll cannot be optimized in the same way as the SO toll because, as is well known from the theory of second best, it is generally not optimal to eliminate congestion on tolled links if roads elsewhere on the network are congested and not tolled. Instead an iterative optimization procedure developed in de Palma *et al.* (2003a) is adopted to maximize social surplus directly.

The first "base case" version of the cordon toll considered is a flat (time-invariant) toll applied to both lanes on each of the *In2* links. The optimal toll level is $4.00. As reported in Table 2, this toll has a larger impact than does the SO toll in terms of reducing the number of auto trips and average schedule delay costs. But the cordon toll does not reduce congestion nearly as much as the SO toll, and it yields less than 1/5 the welfare gain. The cordon toll has a limited potential because it does not vary over time, and because it is levied on only one type of link so that some traffic diverts onto other routes to avoid paying the toll. The mean congestion level on Ring 2 rises from 42% in the no-toll equilibrium to 48%, whereas with the SO toll it falls to just 5%. Moreover, all four worker types are worse off with the cordon toll although the fractions who gain with and without toll rebates are similar to the fractions for the SO toll.

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[7] Tolls can also be levied on more than one of the rings. However, de Palma *et al.* (2003a) find that on the road network shown in Figure 1, double cordons yield less than the sum of the gains of the independent constituent single cordons. Consequently, double cordons may not be cost-effective.

The first variant of the cordon toll is levied on only one of the two traffic lanes on each link. Because tolling one lane induces unwanted diversion of traffic to the adjacent untolled lane this variant proves to be ineffective. The welfare gain is minimal, and even if all toll revenue is redistributed fewer than half of workers end up better off.

The second variant allows different, but nonzero, tolls to be levied on the two sets of lanes. Toll differentiation results in a slightly lower loss of consumer's surplus for all four worker types relative to the base case, but only a minimal improvement in overall welfare gain. The final variant restores uniformity of tolling across lanes, but allows the toll to vary in 30-minute steps between 6:30 and 8:30 when congestion is appreciable.[8] The optimal toll turns out to be higher than the optimal $4.00 flat toll between 7:00 and 7:30, and lower at other times. It yields an appreciably higher welfare gain than the flat toll while raising less revenue and suppressing fewer auto trips. Consequently, individuals fare better on average than under the uniform flat toll. Furthermore, the two professional worker types gain although all four types still fare less well than under the SO toll.

6. Concluding Remarks

This paper explores the welfare-distributional impacts of congestion pricing on a stylized urban road network for the morning commute with individuals who differ in their places of residence and work, their values of travel time, and their trip-timing preferences. Two types of tolling regimes are considered: (1) a comprehensive system of finely time-varying tolls (the "SO toll") that approximately supports a social optimum, and (2) a single toll cordon. The SO toll succeeds in largely eliminating congestion with only a small reduction in the number of auto trips, and leaves workers with high values of time better off even before accounting for use of toll revenues. Not surprisingly, the cordon toll is much less effective. This

[8] Incorporating shorter time steps would permit somewhat higher welfare gains, but at the cost of a considerable increase in computation time.

is attributable to the fact that (like single facility and area tolling schemes) the cordon toll covers only part of the road network, and shifts congestion onto untolled neighbouring roads.

These findings are only suggestive since simulations were limited to one road network and a particular distribution of traveler types. Investigations with other networks and other traveler types are needed to test robustness of the results, and to develop a fuller understanding of the complex efficiency and equity impacts of congestion pricing.

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Table 2: Summary statistics for alternative tolling regimes

Toll regime		*No toll*	*System opt.*	*Inbound cordon toll, Ring 2*			
Tolled infrastructure			All links	Both lanes	One lane	Both lanes	Both lanes
Toll differentiation			Unequal	Equal	Unequal	Unequal	Equal
Time variation			Variable	Flat	Flat	Flat	Variable
Optimal toll levels			Vary by link in 5 min. increments	$4.00	$0.27	$4.00	6:30-7:00 $0.45 7:00-7:30 $6.61
				$4.00	$0.00	$3.90	7:30-8:00 $3.50 8:00-8:30 $0.90
Auto Share		72%	70%	67%	71%	68%	70%
Congestion		36.0%	4.7%	24.4%	37.8%	24.3%	22.0%
Schedule delay cost		$1.41	$1.27	$1.22	$1.32	$1.22	$1.43
Welfare gain per capita			$0.82	$0.15	$0.01	$0.15	$0.26
Toll revenue per capita			$0.75	$0.58	$0.02	$0.58	$0.35
Gain/TR			1.10	0.25	0.58	0.26	0.74
Gainers no rebate			34%	35%	32%	36%	41%
Gainers100% rebate			82%	69%	48%	69%	74%
Rebate for 50% gain			23%	20%	>100%	19%	14%
Mean change in CS	Clerical		-$0.15	-$0.50	-$0.03	-$0.48	-$0.17
	Autonomous		$0.33	-$0.55	-$0.05	-$0.53	$0.02
	Factory		-$0.15	-$0.44	-$0.03	-$0.43	-$0.16
	Interactive		$0.37	-$0.42	-$0.02	-$0.40	$0.00

Table 3: Welfare-distributional impacts of the Social Optimum toll

CLERICAL	Origin Ring 0		Origin Ring 1		Origin Ring 2		Origin Ring 3		Origin Ring 4		All	
Dest. Ring 0	Frac gain	Av. ΔCS	0.26	-0.12	0.23	-0.30	0.14	-0.80	0.20	-0.58	0.21	-0.43
Dest. Ring 1	0.29	0.06	0.26	-0.14	0.24	-0.12	0.24	-0.45	0.18	-0.54	0.23	-0.31
Dest. Ring 2	0.47	0.03	0.33	0.02	0.34	0.17	0.20	-0.35	0.25	-0.26	0.28	-0.12
Dest. Ring 3	0.33	0.05	0.31	0.05	0.30	-0.06	0.37	0.09	0.24	-0.05	0.30	0.00
Dest. Ring 4	0.27	-0.18	0.28	-0.01	0.22	-0.14	0.13	-0.08	0.11	-0.06	0.19	-0.07
All	0.35	0.01	0.29	-0.03	0.27	-0.05	0.23	-0.26	0.20	-0.27	0.25	**-0.15**

AUTONOMOUS	Origin Ring 0		Origin Ring 1		Origin Ring 2		Origin Ring 3		Origin Ring 4		All	
Dest. Ring 0	Frac gain	Av. ΔCS	0.55	0.52	0.31	0.17	0.03	-0.46	0.08	-0.37	0.26	0.00
Dest. Ring 1	0.40	0.10	0.44	0.64	0.59	0.77	0.36	0.12	0.35	0.03	0.44	0.40
Dest. Ring 2	0.29	-0.06	0.50	0.59	0.50	0.64	0.38	0.43	0.38	0.38	0.44	0.51
Dest. Ring 3	0.40	0.22	0.58	0.64	0.47	0.33	0.39	0.24	0.37	0.10	0.45	0.32
Dest. Ring 4	0.42	0.19	0.49	0.25	0.39	0.28	0.22	-0.03	0.17	-0.04	0.32	0.12
All	0.37	0.10	0.50	0.55	0.49	0.53	0.33	0.17	0.32	0.12	0.41	**0.33**

FACTORY	Origin Ring 0		Origin Ring 1		Origin Ring 2		Origin Ring 3		Origin Ring 4		All	
Dest. Ring 0	Frac gain	Av. ΔCS	0.30	0.08	0.14	-0.59	0.00	-1.07	0.03	-0.91	0.13	-0.59
Dest. Ring 1	0.31	0.17	0.33	0.11	0.26	-0.11	0.22	-0.54	0.20	-0.52	0.25	-0.27
Dest. Ring 2	0.38	0.01	0.26	-0.13	0.40	0.22	0.18	-0.40	0.22	-0.38	0.26	-0.19
Dest. Ring 3	0.38	0.14	0.30	0.02	0.32	-0.07	0.39	0.21	0.28	0.02	0.32	0.03
Dest. Ring 4	0.27	-0.02	0.30	-0.05	0.29	-0.11	0.10	-0.10	0.10	-0.03	0.20	-0.07
All	0.34	0.09	0.30	0.00	0.31	-0.05	0.21	-0.30	0.20	-0.29	0.26	**-0.15**

INTERACTIVE	Origin Ring 0		Origin Ring 1		Origin Ring 2		Origin Ring 3		Origin Ring 4		All	
Dest. Ring 0	Frac gain	Av. ΔCS	0.58	1.33	0.46	0.31	0.16	-0.05	0.16	-0.04	0.35	0.43
Dest. Ring 1	0.41	0.31	0.51	0.72	0.58	0.90	0.37	0.12	0.36	0.17	0.46	0.49
Dest. Ring 2	0.47	0.20	0.47	0.34	0.52	0.59	0.32	0.10	0.37	0.26	0.42	0.31
Dest. Ring 3	0.46	0.28	0.56	0.63	0.43	0.38	0.40	0.29	0.39	0.20	0.44	0.37
Dest. Ring 4	0.29	-0.06	0.59	0.49	0.50	0.40	0.26	0.06	0.17	0.02	0.39	0.24
All	0.42	0.21	0.53	0.59	0.51	0.59	0.33	0.13	0.33	0.17	0.43	**0.37**

The Survivability of Short-Haul Small Market Air Transportation

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Air service to small communities was guaranteed by the Government of Canada for a three year period following the merger between Air Canada and Canadian Airlines. That guarantee expired January 4, 2003. Others have experienced reductions in service.

Short-haul air transportation has been traditionally defined as stage lengths of less than 800 kilometres. These services have been traditionally provided by regional airlines which might or might not be affiliated with a national carrier. Air Jazz survives as the Air Canada feeder. Some services are provided by independent carriers such as Westjet, Canjet and Jetsgo in competition with Air Jazz in various markets. The changing dynamics of aviation in Canada places such services at risk, particularly where the routes involved are of low density. A number of cost pressures have emerged which have forced short-haul airlines to raise passenger ticket prices. These cost pressures include rising fuel costs, airport rent charges as a result of airport devolution, and NavCan charges to provide for a

privatized air navigation system. In addition, airport improvement fees (AIF) and an airport security charge are added to passenger ticket prices. Flat fees/charges applied on a per ticket basis are highly regressive with respect to distance. While legislation was proposed to deal with these and other issues, both bills died on the order table when Parliament prorogued in 2003.
This paper considers a variety of these issues. It begins by examining the pattern of fare and cost changes since *Freedom to Move*.

1.0 The Canadian Airline Industry Since *Freedom to Move* :

This section of the paper examines various aspects of the industry in the period since 1984. It first defines the time-line of significant events. It then considers a variety of economic measures not only to explain these events but also to lay the basis for the analysis of the question at hand - the survivability of short-haul air transportation.

Fare Indexes Through Time:
Fare indexes for domestic southern service between 1983 and 1997 (in 1997 dollars) are shown in Table 1. Over the period, economy fares rose by 72.5 per cent while average fares increased by 28.4 per cent.

Table 1
Fare Index Domestic Southern Service
(1997 dollars)

YEAR	ALL FARES	ECONOMY FARE
1983	126.1	122.9

1988	132.6	141.9
1993	157.2	177.2
1998	161.9	212.1

Source : Canadian Civil Aviation, various years

These data are not available after 1998.
Between 1983 and 1988, overall fares increased by less than 1 per cent per year in real terms. Economy fares increased by about 2.5 per cent annually. This reflects the increased use of a variety of discount fares. Between 1988 and 1993, overall fares rose by 18.54 per cent while economy fares increased by 24.93 per cent. In the final sub-period, all fares increased by only about 3 per cent while economy fares rose by almost 20 per cent. The discrepancy between the two can be explained by the seemingly endless rounds of seat sales caused by the financial turbulence in part of the industry.

These increases are substantial and beg the question of what happened to the low-fare, highly competitive airline industry that deregulation was to spawn. We do not propose to discuss this issue here.

Fare Behaviour at the Hub Level

In an attempt to shed additional light on the changing fare patterns, it was decided to examine fares broken down by hub level. The data here were expressed in cents per domestic passenger kilometre. The results of this analysis are shown in Table 2. One is immediately struck by the diversity in the patterns.

For the 1983-1998 period, only traffic among the largest hubs showed a decline in revenue per passenger kilometre, the decline being about 14 per cent. All other hub pairings had higher real revenue per domestic passenger kilometre in 1998 than had prevailed in 1983. At the other extreme, there was an increase of about 58 per cent in the

measure for movements between small hubs. For other combinations, the increases ranged between 7.5 per cent (medium-medium) through 27.5 per cent (medium-small). There were, however, differences in trends among the sub-periods.

Table 2
Revenue Per Domestic Passenger Kilometre by Hub Size
Level I Carriers Scheduled Service
(1997 cents)

	1983	1988	1993	1998
Large-Large	13.0	12.4	12.2	11.1
Large-Medium	13.8	13.0	17.2	17.3
Large-Small	16.2	14.7	18.1	17.9
Medium-Medium	16.2	14.6	17.7	17.4
Medium-Small	20.2	18.0	25.0	25.8
Small-Small	20.7	16.5	31.8	32.8

Source: Canadian Civil Aviation, Various issues.

In the period 1983 to 1988, while all changes were negative, the largest decline came in the case of small hub pairs (-20.2 per cent) while the smallest decline came in the case of large hub pairs (-4.5 per cent). The pattern is consistent throughout. As the size of the pairings declined, the percentage decline in revenue per passenger kilometre rose. This is a surprising outcome given that the fare formulae

employed under regulation favoured short-haul traffic.

Looking at the 1988 to 1993 period, it is seen that for the large hub pairs there was a marginal decline of about 1 per cent. At the other end of the scale, the increase was almost 93 per cent. For the other four pairings, the increases ranged from 21 per cent through 39 per cent. The final period saw the patterns reversed again. The large pairing experienced a decline of about 9 per cent, while the large-medium and medium-medium pairings experienced declines of between 1 and 2 per cent. For the large-medium and small-small, there was more or less stability with increased of less than 0.7 per cent. In the medium-medium case the increase was 3.2 per cent.

Forces Driving Fare Escalation

One hears a great deal about the inflationary impacts of increases in both fuel costs and landing and navigation fees. To examine the validity of these claims, we now turn our attention to some cost issues. We begin by looking at aircraft operations costs, defined to include flight crew salaries and expenses, aircraft fuel and oil, landing and navigation fees, and other costs such as those for aircraft insurance and rentals which we do not show . To the costs of aircraft operations are added maintenance of flight equipment, the costs of in-flight services, depreciation of flight equipment and interest expenses (excepting Air Canada) to get total direct flying expenses. These appear, recast in terms of costs per 1000 passenger kilometres, in Table 3.

Table 3
Aircraft Operating Costs Level I and II Carriers
Constant (1997) Dollars per 1000 Passenger Kilometres

	1986	1991	1996	2001
Fuel and Oil	341	209	179	202

Flight Crew Sal/Exp	114	103	76	91
Land/Nav Fee	45	42	34	78
Aircraft Operations	569	468	405	509
Direct Flying Expenses	1088	843	699	794

Source :Canadian Civil Aviation ,various issues.

An examination of these data reveals that it clearly has not been either the cost of aircraft operations or total direct flying expenses which have been driving the upward trend in airfares. It is true that fuel costs per 1000 passenger kilometres were higher in 2001 that in 1996. At the same time it must be noted that they were considerably lower in 2001 that they had been in 1986. On this basis, we conclude that the fuel surcharge was not necessary in 1991, and it is encouraging to see that as of early 2004, the fuel costs now fully incorporated into the ticket price with the exception of Canjet. Flight crew salaries and expenses were also lower in 2001 than in 1991. There was significant cost escalation is in the area of landing/navigation fees. These increased by about 73 per cent between 1986 and 2001, rising from roughly 8 per cent of the cost of aircraft operations to about 15 per cent.

On balance, however, the declines in the costs of fuel and flight crew were more than enough to offset the increase in these fees. In 2001, measured in reals terms, the cost of aircraft operations was only about 89 per cent of what it had been in 1986 per 1000 passenger kilometres. When the same comparison is made with regard to total direct flying expenses, the 2001 figure was only 73 per cent of that for 1986. Thus, it is necessary to examine the question further.

Total operating revenues and expenses are shown in Table 4.

In two of the years in the table, operating income was negative. In 1991, this was presumably explained by the recession, in 2001 the events of 9/11 and by a set of federal policies which precluded the post-merger Air Canada from making the sort of structural adjustments which would normally follow such a merger. In hindsight, it would have been a better strategy for Air Canada to allow CAIL to go bankrupt and then to pick and choose which pieces it wished to absorb. That option, apparently, was never on the table. It is fair to conclude that some of the agonies of the past couple of years can be attributed to federal policy.

Table 4
Total Operating Revenues and Expenses
Level I and II Carriers per 1000 Passenger Kilometres (1997 $)

	1986	1991	1996	2001
Total Op. Revenue	1746	1308	1143	1162
Total Op. Expenses	1668	1365	1131	1233
Op. Income/Loss	77	(57)	11	(71)
Net Income/Loss	28	(87)	(5)	(79)

Source :Canadian Civil Aviation, Various Issues.

In the 1986 - 2001 period, flying expenses ranged between 62 and 65 per cent of total expenses, the two highest ratios being in the first and last year. The ratio fo flying expenses to total revenues fluctuated more broadly, from 61 per cent in 1996 to 68 per cent in 2001.

NavCanada En Route and Terminal Fees/Landing Fees

As the data above indicate, the relative importance of landing and navigation fees as a cost component of direct flying expenses rose by 86 per cent between 1991 and 2001. While these are combined in the StatsCan data , we shall discuss them separately .

NavCanada is a not-for-profit corporation which is required to operate on a break-even basis. It provides both en route and terminal navigation/control services. Service charges have been rising and this trend will continue in the future. En route navigation fees are, as one would expect, are based upon distance, in NavCanada parlance , "billing Distance". This term appears to be somewhat elastic. For a Dash-8 flight from Fredericton to Halifax, it is 100 kilometres less than actual distance. With the same equipment, the billing distance between Montreal and Toronto is 130 kilometres less than the actual. There is a basic unit rate and an adjustment, both based on distance. We have combined the two into a single number. In the case of terminal fees, the basis is aircraft weight, the same aircraft taking the same terminal fee regardless of which airport is employed for landing. As above, there is the basic unit charge and an adjustment factor. Again we have combined the two. Where flights originate at Pearson, there is an additional charge to cover the cost of Air Surface Detection Equipment (ASDE). As the charge is not levied on arriving flights, one can only assume such equipment is not necessary for landing.

To illustrate the relationship between fees and distance, we employ a B-737 with a weight of 69.4 metric tonnes. The en route charges are 0.28915 multiplied by the billing distance. The terminal fees are 9.7708 multiplied by the aircraft weight. The data are shown in Table 5 and have a common departure airport (YUL). It is clear from the table that for this aircraft, and for those distances associated with short-haul air transportation, that is less than 800 kilometres, the terminal fees make up the bulk of the charges. For the Montreal-Toronto segment, they were over 86 per cent of the total. For Montreal-Winnipeg, a range beyond short-haul, they still accounted

for over 58 per cent of the total. For this particular aircraft, the stage length would over 2000 kilometres before the two charges equalized.

One could look at the matter differently. Instead of varying stage lengths, one could pick a link and vary the aircraft employed. This is done for the Moncton-Toronto link in Table 6. The stage length is 1208 kilometres, and two aircraft are compared : a B-737, and a CRJ-100. Ideally, the data would be presented in terms of cost per

Table 5
NavCanada Charges B-737 for Montreal Departures
to Selected Destinations February 17,2004

Destination	Distance	En Route	Terminal	Total
Toronto	377 Km	109.01	678.09	787.10
Winnipeg	1687 Km	487.80	678.09	1165.89
Calgary	2867 Km	829.01	678.09	1507.10
Vancouver	3541 Km	1023.90	678.09	1701.99

Source: NavCanada Website Calculator.

passenger. However, in the absence of specific data concerning average load factors, this is not possible. Canjet services this link with B-737 aircraft with 120 seats. Air Canada services it with the CRJ, a fifty-seat aircraft. When the NavCanada charges are reduced to a per seat basis, the cost for the B-737 is $8.32 Westjet will begin service in April 2004 with the B-737 aircraft.

Table 6
NavCanada Charges for the Moncton Toronto Link

Various Aircraft, February 17, 2004

Aircraft	En Route	Terminal	Total
B-737	320.39	678.09	998.48
CRJ-100	171.99	221.30	393.29

Source: NavCanada Website , Fee Calculator.

while that for the CRJ-100 is $7.87.

Two things are troubling about the way in which the airlines deal with the NavCanada charges. In the first place, it must be admitted that navigation charges, whether en route or for safely moving aircraft around congested airports, are a normal cost of business. As a normal cost of doing business, they should be incorporated into the ticket prices. One could argue that the use of this, and the fuel, surcharge are simply ways of increasing ticket prices while shifting the blame for so doing from the carrier to others.

More troubling, and more serious for short-haul air travel is the way in which the surcharges are levied. For travel within Canada, these surcharges vary by airline. For Air Canada, they are now $24.00 per round trip, or $12.00 in each direction. The Westjet surcharge varies by distance. For legs under 300 miles, it is $10. From 301 to 1000 miles, it is $14. Beyond that, it is $20. Provincial Airlines uses a surcharge of $7.50 per leg. Using the figures from Table 5 and the 120 seat B-737, it is clear that the airlines earn significant contributions to overhead with the navigation surcharges. Using the Montreal origin, the per seat cost to Winnipeg is $9.72, to Calgary, $12.56, and to Vancouver $14.18. Montreal to Calgary is about a break-even situation; shorter distances are "profitable", while longer distances are

internally cross-subsidized.

We had hoped to discuss airport landing fees and terminal rental charges in detail. However, specific data has eluded us so the discussion will proceed at a more general level than we wish. With others, we echo the concern that there are few constraints imposed on the airport authorities. The largest airport expansion currently underway is at the GTAA, and expansion of some $4.5 billion dollars. This is complicated by Transport Canada's apparently insatiable desire for increased rentals from the Airport Authorities. These amounted to some $240 million dollars in 2002, and are forecast to increase to some $500 million annually by 2012. With these two dimensions combined, it is not surprising that the GTAA announced a 27.7 per cent increase in landing fees and a 19.6 per cent increase in ground terminal fees on October 24, 2003. These increases took effect on January 1, 2004.

Other surcharges are an insurance charge of $3.00 each way within Canada, the air transportation security charge, presently $7.00 one-way in Canada, and the local airport improvement fee charges.

Impact on Air Transportation Costs:
To illustrate the impact of this plethora of supplemental charges (similar we suppose to the accessorial charges of the railways) on the air traveller, we use a real-life example. The trip was from Moncton to Toronto in late 2003. The data below are for two travellers. The fare and charge details are shown in Table 7.

One might begin by discussing the surcharges. In total, they amount to a premium of almost 40 per cent of the base fare. The fuel surcharges can range up to $25.00 per ticket each way in Canada. As well, the NavCanada surcharges vary by airline; the insurance surcharge is $3.00 per ticket each way.

In addition, the airport improvement fees add another 15 per cent to the base price as does the security charge. In total, the accessorial charges amount to almost 63 per cent of the base fare. Inclusive of the GST/HST, the proportion rises to 84 percent. Even were the "surcharges" on fuel and navigation services incorporated into the basic ticket price, the sum of taxes, the security charge and the AIF's would still represent about 33 per cent of the recalculated base fare. While one can see the benefits of the AIF, it appears that the Federal Government receives large injections of money for which it gives little in return.

Table 7
Moncton to Toronto Fare and Charges Detail
Two Passengers

Return Air Fare	296.00
Nav-Fuel-Ins Surcharges	116.00
GST-HST	65.72
AIF - Moncton	20.00
AIF - Toronto	25.68
Security Tax	26.16
Total for 2 Passengers	549.56

The basic difficulty with the surcharges and with the security tax as well is that they do not reflect the realities of the air travel market. It is known that fuel consumption is related to distance as are a portion of the NavCanada charges. The technology exists to make these charges - whether incorporated into the base fare as they ought to be or listed as

add-ons - route specific. In other words, the surcharge should be calculated on a route by route basis. This would allow for variations in stage lengths and also in average load factors per flight so that the charge would more accurately represent the true cost to the carrier. In this fashion, they would become more proportional to distance and thus less regressive. As regards the security charge, we ask, as have others, why the air mode is being singled out for special treatment.

2.0 Service to Small Communities:

One of the issues with which we began dealt with the provision of air service to small communities. Service to certain of these communities was guaranteed as a condition of the merger and expired on January 4, 2003. Air Canada Jazz discontinued service to Yarmouth, St. Leonard and Stephenville. It also ceased operations between Goose Bay and St. John's , Goose Bay and Deer Lake, Deer Lake and St. John's and Deer Lake and Wabush. Realignment of services was also undertaken in Western Canada during 2002. As well, an agreement was reached between Air Canada and the Government of Quebec regarding service to small communities in that province.

In many cases, when Air Canada/Air Canada Jazz abandons a route or discontinues service to a point, it does not mean that the air service in question ceases. Other service providers may well step forward or alternative financial arrangements made.

The realignment of services in the west alluded to above involves the entry of Tier 3 Airlines entering the picture to provide service to the regional traffic. In the same fashion that Air Canada Jazz is better positioned to provide certain services than is Air Canada, so these Tier 3 are better positioned to provide certain services than is Air Canada Jazz.

One such carrier is Central Mountain Air (Smithers). It services small

communities within Alberta and BC, has a code sharing arrangement with Air Canada and a contract with AC Jazz to provide service to discontinued routes. Calm Air (Thompson) provides scheduled service in Manitoba and Nunavut and also code shares with Air Canada. Bearskin Airlines provides service in Northern Manitoba and Northern Ontario including flights to Winnipeg, Thunder Bay and Ottawa. Other carriers include First Air, Air North, Hawk Air, Pacific Coastal and Transwest. In the east, Provincial Airlines provides scheduled services in Newfoundland and Quebec/Labrador. It is true to say that where a service vacuum exists and there is a sufficient volume of traffic to justify service, some service provider will emerge.

A different approach to the problem has emerged in Quebec. There the Government reached an agreement with Air Canada to provide service throughout Quebec for a three year period. The fares in question are for half of the local traffic capacity and represent savings of up to 70 per cent off regular fares. These had been introduced at a limited number of points but will be expanded to all points in Quebec served by Air Canada Jazz. The fares are internet only, and vary with the number of days of advance booking. None of these fares require a Saturday night stay. In return, the Government of Quebec has agreed to purchase an additional $2.5 million in additional tickets annually for travel by employees of Government and Government agencies.

This must be regarded as a creative move by the two parties. It should stimulate traffic volumes thereby ensuring the continuation of some services which might otherwise be considered marginal. One other aspect of the agreement should be noted. Air Canada Jazz agreed to continue certain services in the Gaspe Region until February 2003 to provide a window of time to determine whether they could be assumed by a smaller regional carrier.

On balance, we conclude that service to small communities will continue where sufficient traffic volumes exist. One could almost

consider the situation to be one of "use it or lose it" to borrow a phrase used with regard to the US regional carriers several decades ago. The communities must be prepared to generate sufficient volumes of traffic to cover at least the direct flying expenses on the link. If that cannot be done, either the service will be lost or the relevant provincial government will have to make a capacity purchase agreement as did the Government of Quebec.

Two final points need to be made here. The first is that it will be easier to maintain service than to restore it if is lost. The other is that communities should focus on the nature of the service being provided, not on the colour of the aircraft.

3.0 A Summing Up:

When we began the research associated with this paper, we had serious reservations about the future of air service on short-haul, low density routes. We have found that, while there are some issues of discrimination against such movements, the situation is not nearly as bad as we had thought. We are confident that such services will continue, though perhaps not with same frequency of service or even with the same carrier(s). The service may well be different, but by the same token it may be better suited to the needs of the local communities. There may be the inevitable trade-off between service frequency and aircraft size. The former is likely more important as a measure of quality of service than is the latter.

The Low Cost Revolution in Western Canada: WestJet's Impact on Regional Schedules and Fares

Philip Davies (Pacific Region) and Geoffrey Horner (Prairie and Northern Region) Coordination and Policy Advice, Transport Canada

Overview

When the deregulation of the air carrier industry was announced in the early 1980's, the expectation was that market forces would prevail and that competition would arise in the form of new entrants. It took some 10 years for a successful low cost air carrier -WestJet - to be launched and become profitable. Since its inception, WestJet has expanded its operations beyond the west and provides competition and an alternative service. This paper examines historical route and fare structure for selected western Canadian community pairs.

Background

WestJet was founded to provide low-fare air travel across Western Canada. On February 29, 1996, the airline commenced operations with three Boeing 737-200 aircraft and 220 employees serving Vancouver, Kelowna, Calgary, Edmonton, and Winnipeg. At the time of its entry into the Western Canada, all segments of the market were dominated by Air Canada and Canadian Airlines either directly or through their regional subsidiaries and independent partner airlines.

Service was extended to Victoria, Regina and Saskatoon later in 1996. In 1997, WestJet service to Abbotsford/Fraser Valley, Thunder Bay, Prince George, and Grande Prairie were added.

In July 1999, WestJet completed its Initial Public Offering of 2.5 million common shares. The capital raised from the offering was used for the purchase of additional aircraft, as well as the building of new Head Office and hangar facilities in Calgary.

By December 1999, Canadian Airlines was on the verge of bankruptcy. Sensing opportunity in Canadian Airlines' financial woes, WestJet announced that it would be extending its operations across Canada. Between March and June 2000 WestJet added service to the eastern Canadian cities of Hamilton, Moncton, and Ottawa with Hamilton as the hub.

The Air Canada/Canadian Airlines rivalry persisted until the buyout of Canadian in June 2000. Air Canada inherited a large inventory of different aircraft types and a heavy debt load. After June 2000, Air Canada commenced a route and equipment rationalization process. By October 200, the amalgamation of Air Canada and Canadian services was substantially complete.

In 2001, WestJet began service to Fort McMurray, Comox, and Brandon. Also in 2001, WestJet added its first four Next-Generation Boeing 737-700 aircraft. In 2002, WestJet added service to two new Ontario destinations, London and Toronto. In February 2002, the Corporation successfully undertook a second share offering yielding net proceeds of $78.9 million.

In January 2003, WestJet completed its coast-to-coast service plan by beginning service to Windsor followed by Montreal, St. John's, Gander and Halifax. It now operates 50 B-737 aircraft to 24 domestic destinations. WestJet celebrated its 28th quarter of profitability with its fourth quarter 2003 results.

In the Western Canadian regional market, Air Canada rationalized service under its regional subsidiary Jazz and low cost airline Zip Air. ZIP operates a fleet of 12 Boeing 737-200 aircraft. Air Canada has announced plans to transfer 20 Airbus A-320 aircraft to Zip by the end of 2004. Zip's existing fleet will be retired.

Airport Pairs

This paper examines WestJet's performance on the following western Canadian city pairs in which Air Canada[1] and WestJet compete head-to-head.

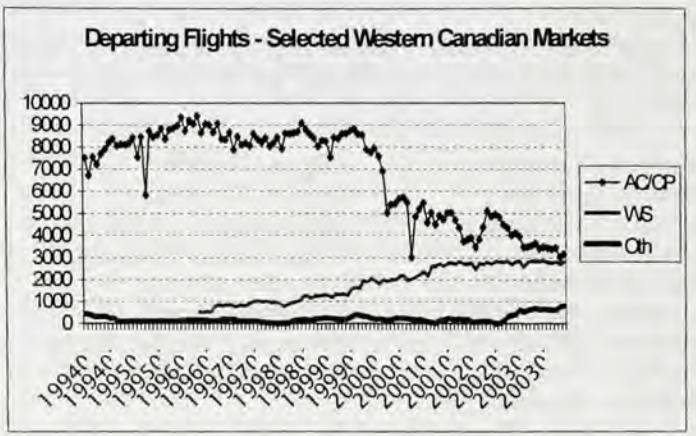
Edmonton –Vancouver
Calgary – Vancouver
Edmonton – Kelowna
Calgary – Kelowna
Vancouver – Kelowna
Edmonton – Saskatoon
Calgary – Saskatoon
Saskatoon – Winnipeg
Edmonton – Regina
Calgary – Regina
Regina – Winnipeg
Prince George – Vancouver
Prince George – Edmonton
Edmonton –Calgary
Edmonton – Grande Prairie
Edmonton – Fort McMurray
Edmonton – Peace River

Historical Air Carrier Performance
Departures

WestJet services were targeted at high volume Western Canadian origin/destination pairs. Their strategy was based on stimulating demand through low fares. The success of this strategy is clearly illustrated by dramatic increases in passenger totals at smaller airports following WestJet's commencement of service. For example, annual total enplaned/deplaned passengers at Kelowna grew by 70% following WestJet's entry in 1996. The passenger level doubled at Fort McMurray following their entry in 2001.

The growth in WestJet's departing flights at the selected sites is shown below:

[1] For definitional purposes, Air Canada will mean Air Canada, Jazz, Zip and all partners including CP after June 2000.



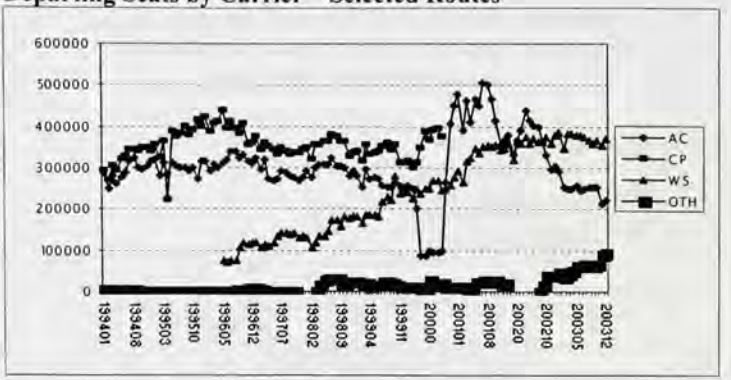
With the exception of the relatively small markets of Fort McMurray, Comox and Brandon, WestJet's Western Canadian route structure and schedule was essentially in place prior to the absorption of Canadian Airlines by Air Canada in June 2000. The restructured Air Canada-CAI operations momentarily peaked in late 2000. Since that time, Air Canada departures have retrenched to equilibrium with WestJet's departures. A recent upswing in other non-aligned carriers is noted during 2003.



Seats

The situation previously illustrated in departing air carrier performance does not translate into departing seats. The smaller average aircraft capacity of the Air Canada fleet equates to a lower system capacity vis-à-vis WestJet. As a result, WestJet now accounts for over 55 percent of departing seats on the selected routes.

Departing Seats by Carrier – Selected Routes



Fares

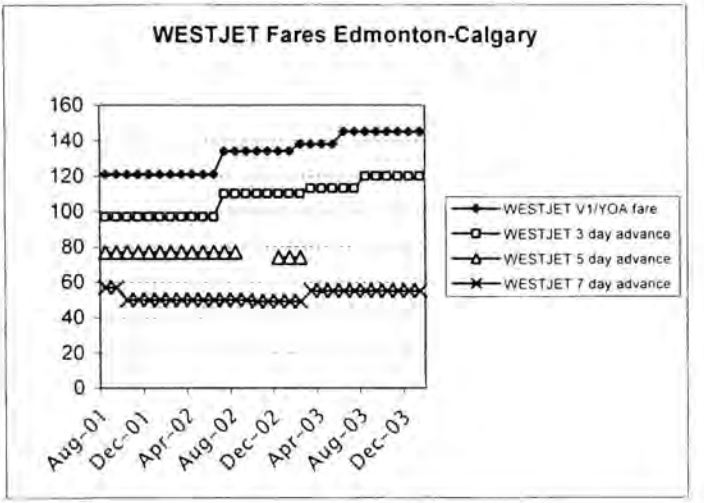
The traditional fare structure that was employed by Air Canada and Canadian Airlines incorporated high one-way economy ("Y") fares, complemented by a confusing array of status fares (groups, youth, accompanied children, seniors) and discounted excursion fares. Excursion fares were typically offered on a round trip basis and required advance purchase of 7 or 14 (and sometimes 21) days, as well as minimum stay requirements.

WestJet's fare structure[2] is less complex and incorporates fewer restrictions. WestJet offers one-way fares with advance purchase periods of 1, 3, 5 and 7 days. The lowest discount fares typically require 7 day advance purchase but last minute discount fares may also be available. Minimum stay requirements are not imposed. The success of WestJet as a price leader is reflected in Air Canada's adoption of a similar fare structure in 2001.

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[2] Analysis of WestJet's fares is limited to fares available after August 2001; prior to that date they did not file fares with Airline Tariff Publishing Company.

The graph below shows selected WestJet published fares between Edmonton and Calgary from August 2001 to December 2003. 1 and 3 day advance purchase fares have increased modestly but the heavily discounted 5 and 7 day advance purchase fares have been relatively stable.



While published fares have been relatively stable, a number of surcharges have increased the actual cost of flying. These include a surcharge of $10 (one way) imposed in 1998 to compensate for air navigation (NAVCAN) costs. In early 2002, this was increased to $11. This surcharge was restructured on July 30, 2002. The new structure differentiates based on trip length: $5 for journeys under 300 miles, $10 for 301 to 1000 miles; and $15 for longer trips. A similarly structured fuel surcharge was implemented in January 2003 with charges of $5, $7 and $10 for the respective trip lengths. An insurance surcharge of $3 was introduced on October 1, 2001. The impact of this on fare levels is shown below:



WestJet integrated their fuel surcharges into base fares in January 2004. A discount of $3 one way is offered for internet bookings. Air Canada's published fares and surcharges are similar. Air Canada has advertised web-only Fun, Latitude and Freedom fares since last summer; the levels appear to be similar to published fares.

From examination of published fares, it appears that the carriers have not substantially increased fares since August 2001. It is impossible to judge from published fares whether average fares are increasing or not because the airlines may leave fares unchanged but reduce the availability of discounts.

Fleet Comparisons and Efficiencies

Air Canada operates a variety of equipment, including 10 different models of aircraft. Maintenance of such a varied fleet may pose a significant cost burden. However, the public perception of efficiencies of WestJet's Boeing fleet in operating a common fleet of B-737-200 and their B-737-700 aircraft may be misplaced. Other than the name of constructor and model line, there are few mutual

efficiencies [3]. In effect, WestJet operates two different aircraft. Air Canada's fleet on the selected routes is 50 percent turbo-prop which generates an average aircraft seating of 79. Conversely, WestJet's all-jet equipment using B-737-200/700 has an average of 124 seats. For the routes selected, the two companies have reached a point of equilibrium in departures.

WestJet remains a western based and western focused air carrier. The majority of its flights are in the west and expansion into eastern Canada does not constitute a significant portion of its day-to-day operations. In January 2002, there were 376 departures per week from Thunder Bay east. There were 1,099 departures in the four western provinces. Calgary has almost as many WestJet Departures as all of eastern Canada. On non-WestJet routes in western Canada, Air Canada maintains a very large presence accounting for over 80 percent of total departures.

Aircraft cost data published by the US Department of Transport provides an interesting basis for comparing relative costs of Air Canada's turboprop equipment (Dash 8-100) and WestJet's 737-200. Based on U.S. airline data for the third quarter of 2002, turboprop direct operating costs averaged $32.71 per seat per hour. Regional Jets (under 125 seats) averaged $24.14, and jets between 125 and 150 seats averaged $18.35.[4] Cost for the 737-700 was estimated at $14.10 per seat per hour. While there was a wide divergence in cost between air carriers operating the same equipment, the overall cost structure

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[3] The only commonality between the 200 and 700 series is the diameter of the fuselage. Parts are not interchangeable. Manuals are different. There are separate type certificates required for each type from a maintenance perspective. In terms of flight training and endorsement from the pilot's perspective, the 200 series is different from the glass cockpit systems found in the 700 series so being checked out on the 200 does not allow you to fly the 700 series on the 200 endorsement.

[4] All costs in U.S. dollars.

indicates an escalating average cost per seat hour associated with smaller, turbo-prop equipment.

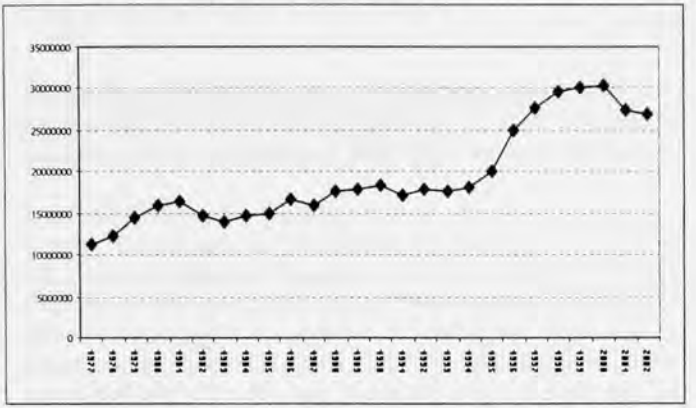
While the US experience may not be completely comparable to the Canadian air carrier sector, the cost differential is interesting. At these costs, comparing a 737-700 with a turboprop on the same city-pair, as is the case in many markets in western Canada today, the cost difference could be over $18 (CDN) per seat per hour. WestJet's 124 seat average aircraft should generate a better revenue return than Air Canada's 79 average seat aircraft. The cost advantage per seat per hour definitely shifts to WestJet. In spite of a lower load factor[5], if realized fares are similar WestJet would be more profitable. Air Canada indicated interest in obtaining new 70-100 seat aircraft in its 2003 Financial Report.

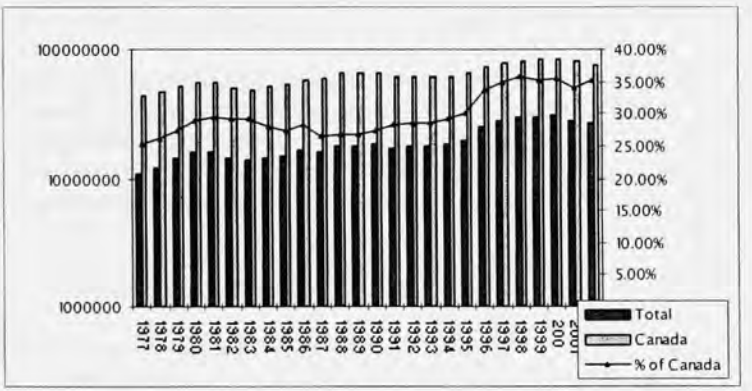
Passenger Statistics - Selected City Pairs - 1977-2002

It seems indisputable that WestJet's low cost service has stimulated demand in Western Canada. Over the 25-year horizon, passengers at the selected airports displayed an average annual growth rate of 3.6 percent compared to the 2.2 average at all Canadian airports. Most of this growth occurred after WestJet service began. By the end of 2002, this growth was concentrated in the Edmonton-Calgary-Vancouver triangle with Kelowna receiving considerable spin-off benefits in the same order of magnitude. Since the peak of 30.4 million passengers, there has been some retrenchment. The 2003 preliminary airport statistics for indicate growth in western Canadian passenger levels in the range of 4 to 5 percent.

[5] In the third quarter of 2003, Air Canada reported a system wide load factor of 79 percent. WestJet reports a January 2004 load factor near 69 percent.

Total Enplaned Deplaned Passengers at Selected Sites





Comparing the four western provinces to the national position, the share of national passenger traffic in the selected airports has increased from 25 percent in 1977 to 35 percent in 2002.

Conclusions

WestJet has introduced a competitive route and fare structure into the Western Canadian market. In doing so, it has opened the western Canadian air carrier arena to greater possibilities for the traveling public.

Air Canada has reduced capacity significantly on the routes analyzed in this paper. Departures have been reduced 42 percent by the end of 2003 vis-à-vis the January 2001 peak. For 2004, Air Canada is approximately level with WestJet departures. They have reduced seats by 56 percent since July 2001. WestJet offers 68 percent more seats than Air Canada on the selected routes. In late 2003 and into 2004, niche market carriers have re-emerged on thinner routes largely in competition with Air Canada partners. Almost exclusively, these are under 20-seat turbo-prop.

It remains to be seen whether there is potential for further growth in WestJet services in Western Canada. It may be that they have already penetrated all of the markets which are sufficiently large to support operation of their 120+ seat aircraft. There is an opportunity for both carriers to acquire twin engine jet equipment to serve thinner markets.

Air Transportation and the Economy in Atlantic Canada

Introduction and Background

This paper is based on a project undertaken by the Atlantic Canada Airports Association (ACAA). This industry association of 17 Atlantic Canada airports wished to identify the important linkages between air transportation and the economic opportunities in the Atlantic Canada Region. The focus of the research was to identify the economic importance of each of the 17 airports to their catchment area as well as the regional and national roles played by the Atlantic air transportation industry.

The project reached a number of conclusions concerning the economic importance of Atlantic Canada's airports and air transportation services.

1. Airports are essential partners in the economic development and well being of the communities and businesses that they serve and an important element in the national and international transportation network.

2. They are highly prized assets, contributing to a community's ability to attract new industry, and expand its trade around the world.

3. Air access is a key part of any development strategy whose goal is to provide high quality jobs and careers for the population, especially for youth, and offer the highest possible standard of living for its residents. A community with a viable airport and

good air access is literally on *The Map*. Every airport, regardless of size, contributes to the overall system: by expanding the air transportation network, providing feed, facilitating tourism, or by simply offering carriers and consumers more choices.

4. Airports encourage the retention and growth of the highly valued "knowledge worker" demographic, characterized as young, professional, well educated and mobile. An airport, and good air access, is vital to attracting this sought-after group, who represent not only high-tech workers and engineers, but also medical professionals, university professors and researchers.

5. Airports play a key role in the safety and security of Canadians and non-Canadians alike. They are staging areas for emergency response teams and equipment. Search and rescue, fire-fighting and medical evacuations are deployed efficiently and quickly, saving property and lives across Atlantic Canada. They are called on to safely land airplanes in distress or in peril; a role that was never more imperative, or more professionally and personally handled, than on September 11th, 2001.

6. Airports directly generate significant economic benefits. The seventeen airports studied handled more than 5.4 million passengers in 2002, and generated 8,100 jobs (Full Time Equivalents), with an estimated payroll of $284 million and over $900 million in economic outputs.

Over the past decade, airports have been turned over to local control, in part so that they might be more responsive to local needs. This has had a positive impact on how the airports conduct themselves. They are now better able to align their business plans with their communities' and businesses' air access needs. They are accountable to a local Board of Directors. They attract customers by providing the best possible service at the best possible price. Paradoxically, while airports have never been more important, at the same time, they have never been more beset. In recent years, airports have had to cope with a number of challenges, including:

- The acquisition of Canadian Airlines by Air Canada, and the subsequent reduction of domestic capacity
- The economic "stock meltdown" and loss of high-end business travel
- The terrorist attack of September 11, 2001
- The war with Iraq
- Severe Acute Respiratory Syndrome (SARS)
- Air Canada filing for bankruptcy protection under CCAA

Separately, each of these occurrences has had an impact on the air industry and airports. Taken together, they have led to a very precarious situation. Airport revenues are down, a result of lower passenger volumes and continued reductions in capacity. At the same time, costs are increasing, in part due to the need for enhanced security and safety measures. This situation has compromised planned capital expenditures at many airports, and for some smaller airports, their future viability is in question.

Methodology

The project focused on identifying the unique and critical economic roles that each airport plays in their communities and regions. The intent was not to take a traditional approach of focusing on the economic impacts resulting from the jobs and other expenditures involved in operating an airport and its air transportation services. Instead, the focus was on identifying the roles that the airports and air transportation services play in supporting the regional economy and the quality of life.

The individual airport reports are based on consultations in each community with the airport authorities, elected civic officials, business community representatives and various economic development organizations. These consultations identified the critical economic and social roles played by air transportation. In addition,

when available, quantitative information was collected to support the opinions and ideas expressed.

The results of the project were 17 individual and unique stories. The stories demonstrate how each airport has respond to the economic opportunities and priorities of its region. However, this paper also demonstrates that there are some common roles that all the airports are playing. While these roles are not necessarily exclusive to Atlantic Canada, they do demonstrate that efficient air transportation is critical to the economic future of the Atlantic Canada Region.

The project also included the development of a policy framework that would ensure the sustainability of the Atlantic Canada airport and air transportation system. The policy framework also identifies opportunities and initiatives that would strengthen the supporting economic roles of the air transportation industry and the ACAA. The policy framework is presented in a separate ACAA publication.

Atlantic Canada Air Transportation's New and Evolving Economic Roles

The importance of airports to Atlantic Canada is growing. The challenges presented by its terrain, maritime geography, weather and the wide distribution of its communities now are more and more directed towards air transportation services. Over the past ten years, scheduled passenger traffic in Atlantic Canada has increased by over 16 percent. This increased traffic is remarkable when comparing it to the population growth for the Atlantic Region of 2 percent over the same period.

The great distances between major centres and widely dispersed population of the region have resulted in the development of a number of hub airports. Halifax is the major hub airport, handling the largest volume of aircraft and passengers; 35 percent of the Halifax passenger traffic is connecting to other Atlantic Canada airports. Halifax is also the major Atlantic Canada international airport with

the greatest number of flights to the US and European destinations. St. John's also serves as a hub airport for Newfoundland and Labrador. Moncton has been developing a role as a hub by catering to discount and charter carriers.

Each Atlantic Canada airport has worked with the various air carriers to develop air service that is appropriate for its catchment area. The airports have developed both regional and national air services. In many cases the regional air transportation requirements have led to direct US and international air services.

Passenger service to the Atlantic Canada Region airports is provided by nine Canadian airlines operating scheduled domestic service, three international airlines providing scheduled international service, and three charter carriers.[1]

The "New" Economy

In the past, airports were sometimes seen as merely an adjunct to the transportation network, dwarfed by roadways, freight rail and maritime shipping, perched on the edge of town, unseen, and perhaps ignored, by residents.

At one time, this was not unreasonable. Roads, rail and marine were the most efficient and cost effective ways to move bulk freight: groundfish, coal and lumber. Canada and the provinces provide an extensive network of highways and roads. The shipping mechanisms were established, and it was simpler and easier to use what was already there. People could travel efficiently by road, because their trips were often hundreds, not thousands, of kilometres long. The travellers who used air as their main transportation system were in the minority, as were those high-end, perishable products that demanded the combination of speed and distance only air could provide.

However, even in the past, this view neglected to consider who those airport users were, and their impact on the local economy. Air users -

[1] Transport Canada Internet Site

mobile, highly educated, selling high-end services and products - are often the drivers of wealth. They are the 20% of the 80/20 rule: the "vital few". To put it another way, an economy trying to grow without them is akin to trying to start an engine without spark plugs.

The airport is an essential element in encouraging the retention and growth of this dynamic group, and the jobs and wealth it provides. For example, 70% of the market for Fredericton's knowledge-based industries is outside Atlantic Canada. These industries employ about 2,500 people in the region. If the airport were to close, it is estimated that it would result in a direct loss of 660 knowledge-based jobs and $84 million in economic output.[2] The loss would ripple down through the economy. The lucrative businesses would be fine: they would simply relocate to an area that could serve their air transportation needs. The people and supporting businesses of Fredericton would be the losers.

The same principle applies to all airports, regardless of size. For example, Cape Breton's unemployment rate fell to its lowest level in eleven years; despite the recent loses of both Devco and Sysco. Part of that was the economic boost the region received when Stream International announced its plans to establish a 900 person Customer Interaction Centre in Glace Bay. Other new businesses have sprung up in the region, including value-added wood products, and a current "hot" industry, marine bioceuticals. These gains would not have been possible without the Sydney Airport. As the Sydney officials reported, air service is one of the first criteria applied by businesses evaluating potential sites for relocation – the four and one half-hour drive from the Halifax Airport is not a reasonable substitute to the speed and ease of air service.

This shift represents far more than merely substituting one industry for another. For Sydney, and all of the other airport-based

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[2] Innes, J.D. Brander, J.R.G. and Rajendran, M, The Fredericton Airport and the Knowledge Industry in Central and Western New Brunswick.

communities in Atlantic Canada, the shift to air-reliant industries is a profound change in how wealth is created, who will be attracted to jobs and communities and what the future will be.

New Trade and Investment Patterns

It is the goal of every community, every province and the Atlantic Canada region as a whole to increase its economic activity by retaining and attracting businesses, investment and workers, stemming the tide of population exodus and creating a vibrant and diverse economy. Over the last 15 years a series of major events have come together which have transformed how this will be accomplished. The traditional sources of wealth for Atlantic Canada such as forestry, groundfish and mining are in decline. To respond, government, industry and colleges/universities began to work together to create a new economic model based on high-end, value-added products and services. Trade liberalization agreements[3] have opened new markets with hundreds of millions of potential customers who could be, quite literally, anywhere on the planet.

These factors lead to a new business paradigm: high-end businesses selling in global markets. These businesses rely on the air sector to deliver their goods and services speedily and efficiently. Airports are at the centre of this supply chain equation. If the airport is not there, or its services are inadequate, or if airlines are not delivering the right destinations, the formula fails.

Airports do not have to be large or distant from other airports or even offer scheduled services to be able to contribute to the success of a community. They simply have to be open for business. A good example is the airport in Summerside, PEI, which has no scheduled service and is 60 km away from Charlottetown International Airport. The airport, located in Slemon Park, an industrial complex, supports the corporate travel of such notable Atlantic Canadian companies as

[3] E.g. the North American Free Trade Agreement (NAFTA), the General Agreement on Tariffs and Trade (GATT) and the General Agreement in Trade in Services (GATS)

Irving, McCains and Humpty Dumpty. It also provides services and facilities for a burgeoning aerospace/transportation industrial cluster, which includes international brands such as Honeywell and CAE. The Summerside airport contributes to high-end tourism, attracting business conventions such as the Canadian Owners and Pilots Association and serving as a landing site for lucrative fly-in golf and adventure/eco tourists.

Most importantly, perhaps, in terms of the airport's contribution to Summerside's "success formula", the aerospace/transportation business cluster employs about 500 people, mostly in high-salaried, year-round and stable positions. Even better, most of these workers are "repatriated" Prince Edward Islanders and those who left seasonal jobs such as fishing or agriculture.

While the Summerside example might be easier to see, because of its relative size, its positive contributions are mirrored across Atlantic Canada. For example, the technical and executive staff involved in Newfoundland and Labrador's oil and gas industry are able to headquarter in St. John's because of the airport's ability to connect them not only within the province and to their facilities, but also to Halifax, the United States and overseas. If the air services were not in place, it is likely that at least some, if not all, the high-end jobs would relocate to Halifax, as a best-case scenario. Worst case, many of those jobs might not even stay in Canada.

Airports, and access, have also contributed significantly to foreign investment in the region. The Atlantic Provinces Economic Council (APEC) has determined that 75% of all foreign firms made their initial investment after 1990 – or post-FTA[4]. Perhaps surprising for some, forty-seven percent of these firms are headquartered in the South of the United States. While it is difficult to quantify how large a role that the airports have played, it is fairly obvious that without the airports, some of that long-haul investment simply would not have

[4] Atlantic Canada Economic Council (APEC), Atlantic Canada's International Trade in the Post FTA-era

been made, in part, because people would not get here to invest in the first place.

The community-based anecdotes are supported by the trade data.

- Exports of non-resource based manufactured products grew by forty percent between 1990 and 1999, up from 10.1% of total manufactured exports to 14.1%. This supports the contention that Atlantic Canada is developing new products outside of its traditional resource based industries.
- Demonstrating the growing value of airports, international trade in goods by Atlantic Canadian companies grew by 98% between 1989 and 1999. International trade in services was even more impressive, boasting a whopping 222% in growth over that decade, 78% better than the Canadian average.

The importance of air links and direct access to Atlantic Canada airports from major markets is increasing as demonstrated by such developments as:

- In 1992, Oregon represented 0.3 percent of Nova Scotia's exports. In 2002, Oregon is Nova Scotia's fifth most important export state, and represents almost three percent of the province's market.
- Prince Edward Island's fourth largest market in the United States is Florida, at just over five and a half percent of exports to the U.S. In 1992, the value was only half that, at 2.75%.
- Even though Newfoundland has no direct road access, and Labrador's is difficult, there have been equally impressive shifts in its trading patterns; Texas is its number two trade state, at 16% of all exports by Newfoundland and Labrador. New Jersey, the number one trader at almost 20%, was just over a tenth of that size ten years ago, at about 2.6% of Newfoundland's U.S. market.

Some of these shifts are simple to explain; Texas is a major client of Newfoundland and Labrador's oil and gas industry, for example. But

it is likely that at least some of the other gains are due to small and medium-sized businesses in Atlantic Canada able to take advantage of the airport/airline system to get their products and services into new markets.

Access to International Tourism

International tourism, while an export industry, merits special attention. There are two reasons for this. The first is that tourism relies totally on good, and competitively priced, access. Non-existent access, or access that is too complex or too expensive translates into reduced or non-existent tourism trips, regardless of how good the product or experience is. The second reason is that long-haul air tourists spend more and stay longer than those who travel by road. It is far more lucrative and productive to serve planeloads of tourists, rather than busloads.

Tourism traffic supports a wide range of local businesses such as accommodators, restaurants, museums, attractions and other facilities enjoyed by residents and travellers alike. Tourism dollars are tremendous generators of wealth and jobs, helping support jobs ranging from air traffic controllers to ecologists to fishermen taking whale watchers out to sea. The dollars are also spent on far more than trinkets. Icelandair's service to Halifax was estimated to have generated $14 million annually in new spending in Nova Scotia. Not only on souvenirs and hotel nights, but also thanks to the value of the Canadian dollar, on cars, audio video equipment and washing machines.

Moreover, good air access into Atlantic Canada benefits the entire country. Internationally recognized destinations such as L'Anse-aux-Meadows, Peggy's Cove, the Bay of Fundy, and the Anne of Green Gables site help draw thousands of tourists to Canada every year. The benefits are shared throughout Canada as the tourists proceed on to other Regions of Canada.

There are a number of lucrative travel markets that are particularly sensitive to the availability, quality and price of air service, including

meetings, incentive and convention travel, the cruise industry and packaged holidays. These groups require a combination of ease of access to destinations, competitive and attractive pricing and sufficient lift. If a destination cannot provide the right elements, the travel groups will seek out the destinations that can. Communities, including those in Atlantic Canada are in global competition for tourism business, with the proximity of the airport, and the availability of appropriate service as two key success factors.

Airports and Businesses

Airports are strategic business tools. Most companies require a proximate airport if they are seriously considering expansion or investment in an area. Many communities work diligently to ensure that they have all the right elements to attract business: an educated workforce, good schools and medical facilities, a competitive tax regime, and so forth. However, if they do not have air access, all of that effort may be wasted. It is conceivable that a community could get all the fundamentals right, but without an airport and at least the potential to grow air service, it would still lose out to a city or town that has better access to air service.

To complicate matters, the high-end businesses in Atlantic Canada that rely on air access to serve their markets are often relatively small in size. Generally, their demand alone is not large enough to create new air services, and they must rely, at least initially, on the air service that already exists. This leads to a "Catch-22" that many communities are caught in: small, but lucrative businesses cannot grow without air services, yet air services will not expand unless the businesses grow first. Unfortunately, this may have led to some businesses simply relocating to municipalities with better air access; an unrecoverable loss for the communities left behind.

Privately managed airports are key players in dealing with access issues, as they are strategic partners of both communities and carriers. In partnership with communities, they can determine the real air access needs of residents and businesses, by identifying potential air users, destination markets, capacity needs and other air travel

determinants. In partnership with carriers, they can determine which routes might be under-served, identify growth areas and help offset some of the risk associated with start-up services.

The Fredericton Travel Bank is an example of a strategic partnership between an airport, the business community and an air carrier. While Fredericton has reasonably good service within Canada, travellers to the United States had to hub via Halifax or Toronto. This was a costly waste of time for the engineering, IT and other exporting businesses in the region, whose most lucrative customers were in the U.S. or overseas. One way they worked around this situation was to drive to Bangor, Maine, and board a U.S. carrier there – an option that was used by as many as 25,000 travellers a year.[5] This was a better solution, but it was by no means good enough, as it added hours to their travel day, and substantially increased their cost of doing business. This "work around" also took passengers away from the Fredericton Airport.

These exporting businesses needed strategic and cost effective air service that flew directly into Boston and connected to other U.S. and international points beyond. The only way to ensure they received it was to do it themselves. Led by the Fredericton Airport Authority and the Chamber of Commerce, more than 250 enterprises banded together to create a $2.5 million Travel Bank – a monetary guarantee of a minimum level of spending on airfares. As a result, Fredericton businesses now have the non-stop service they need, provided by Delta Airlines.

Airports and Community Life

Trade opportunity and business growth are only two ways that airports support their communities. Another, equally important role, is the contributions that airports make to residents' quality of life. This is accomplished in several ways.

- Proximate and viable airports ensure that residents are connected to other communities and can travel easily to and from their

[5] The Globe and Mail, Tuesday, May 27, 2003

homes. This is nice to have, but not essential, to those who make only an occasional trip. However, the service is indispensable for those who travel long distances frequently, and for those for whom mobility is essential. For example, new demand driven by the large number of Newfoundlanders who are working in Fort McMurray, Alberta have helped create a new service between Fort McMurray and Gander/St. John's.

- Good air access, and the new business opportunities it provides, makes it easier to generate rewarding jobs in a smaller community. If they can be mobile, and the right opportunities are close to home, many Atlantic Canadians chose the best of both worlds, and stay in their home communities.
- Airports and air services enhance the quality of services that a community provides by supporting the recruitment and retention of professionals. These include medical professionals, who are literally, vital to the health of the community, and college and university professors, who play a critical role in helping the region adapt to and take advantage of new technologies and industries. Airports also support the recruitment of foreign students to Atlantic Canadian institutes, an important, and lucrative, segment of the student body.
- Airports serve as a backbone of the emergency response safety net. Proximate airports save lives, acting as "command and control" centres for search and rescue, firefighting, medical evacuations, and more. They also provide facilities for meteorologists, people whose importance, given Atlantic Canada weather, is invaluable.
- Each airport's individual contribution to safety in the overall air transportation system cannot be ignored. They are called on to safely land airplanes in distress or in peril, be a backup for an airport which has been closed unexpectedly, or even, as they did on September 11th, 2001, land dozens of planes safely in minutes in the name of national security.

Airports and the Transportation Network

Airports and air access are at times seen in competition with other modes. While this is true to a degree, it is far more accurate to

consider airports as a long-haul, strategic element within a region's larger transportation network. Arriving at an airport is only one leg of a journey. One of the main functions of an airport is to link passengers and freight to other modes, seamlessly connecting them to their ultimate destinations. The more effectively airports can accomplish this, the more useful to business and personal travel they become. Each component of our transportation infrastructure: roads, airports, railways, etc. complements the others, strengthens the network and provides productive and cost-effective ways to move people and goods to and from a region. Moncton, for example, is a multi-modal hub, and a major warehousing and distribution point. Seafood is the largest single cargo handled by the airport, a popularity which has been driven by Moncton Airport's ability to offer "just in time" air cargo services. Air cargo not only supports more traditional road or marine shipping, it also acts as a catalyst, opening new markets that cannot be reached by other modes.

Airport Economic Activity

The project included individual economic impact reports on seventeen Atlantic Canada Airports Association airports.[6] These reports identified and described the roles that each of the airports plays in supporting economic development and general quality of life in their communities and regions. These reports also estimated the direct economic impacts (expenditures, employment, taxation) resulting from the operation of the airports and their air transportation services. On a local and regional basis, these **annual impacts** are significant even without considering the wider supporting roles played by the airports in their regional economies.

- 8,100 full-time jobs
- $284 million payroll
- $909 million in operating expenditures

[6] In addition to the ACAA airports, the government of Newfoundland and Labrador operate 13 airports in Labrador and Transport Canada still operates two, which are at different stages of being divested to private operators.

- $40 million in capital expenditures

Components of the National and Regional Airport System

The seventeen ACAA airports form parts of the National Airport System (NAS) and the Atlantic Canada regional airport system. The NAS includes airports in all national, provincial and territorial capitals, as well as airports with annual traffic of 200,000 passengers or more. There are 26 NAS airports across Canada including seven in Atlantic Canada, Charlottetown, Fredericton, Gander, Halifax, Moncton, Saint John and St. John's. The ACAA regional airports include: Bathurst, Charlo, Deer Lake, Goose Bay, Miramichi, St. Leonard, Stephenville, Summerside, Sydney and Yarmouth.

The *Public Transit Commuter Accessibility Audit*

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Background

Over the past fifteen years, Canada's metropolitan regions have witnessed the widespread adoption of community planning policies rooted in the notion of sustainable transportation. Because these policies seek to promote travel on foot, by bicycle and on public transit in lieu of travel by private automobile, the importance of evaluating the quality of non-automobile transportation choices cannot be understated. If evaluations of pedestrian, bicycle, and public transit accessibility are not made part of routine transportation system quality assessments, it will be difficult to identify and eliminate potential obstacles and deterrents to travel by these modes. Furthermore, it will also be impossible to monitor whether progress is being made toward sustainable transportation goals and objectives. As one legacy of the automobile-oriented city, planners rarely have at their disposal any practical tools for evaluating levels of accessibility provided by modes of sustainable transportation. Where transportation system quality has been measured, the primary focus has been the measurement of automobile traffic speeds, congestion levels, and roadway capacities – in other words, how well demands for automobile transportation have been served. On the other hand, the needs of pedestrian, cyclists and public transit users have rarely been considered.

One area in which a tool for evaluating accessibility is sorely needed is within the context of public transit commuting. As part of their efforts to reduce levels of automobile-based commuting, municipalities across Canada have adopted a number of policies that

seek to encourage more commuters to travel by public transit. This brings to light two important issues that have yet to be thoroughly addressed in urban transportation research. First, if planners are to ensure that public transit represents a viable means of transportation to and from work, they require a systematic and consistent means of identifying any weaknesses or deficiencies in the infrastructure, facilities and services currently in place, so that barriers or deterrents to commuting by public transit may be identified and eliminated. A second and ensuing implication is that, before public transit accessibility can be evaluated within the context of the journey-to-work, planners require a clear understanding of what infrastructure, facilities and services are required by public transit commuters.

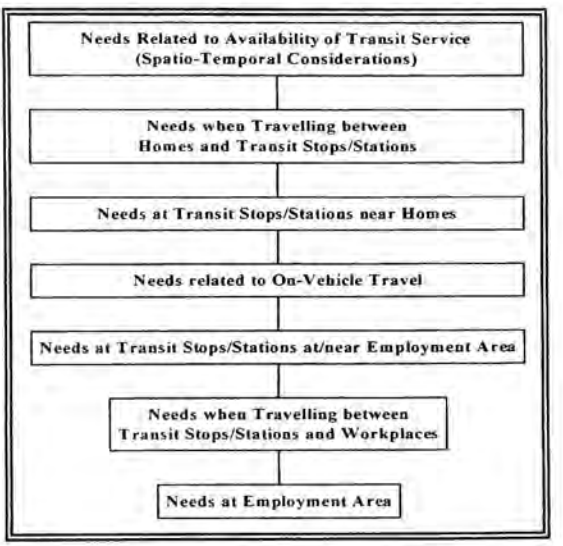
The purpose of this paper is to present the *Public Transit Commuter Accessibility Audit* (*PTCAA*), which has been created to address the need for a practical accessibility evaluation tool within the context of public transit commuting. The paper begins with a brief overview of the *Comprehensive Definition of Public Transit Commuter Needs*, created to formally outline the infrastructure, facilities and services required by metropolitan commuters in order for public transit to represent a legitimate transportation choice. This is followed by an outline of the six steps involved in conducting a *PTCAA*, which can be applied within the context of actual spatio-temporal commuter travel flows to evaluate the viability of commuting to a particular employment area by public transit. The paper concludes with a brief discussion of further research needs.

A *Comprehensive Definition of Public Transit Commuter Needs*

Before a tool for evaluating public transit accessibility to employment could be created, it was important to identify what conditions ought to be examined. Thus, the first research objective was to formally conceptualize public transit commuter needs in a way that reflected the broad sociodemographic characteristics and increasingly diverse spatio-temporal travel patterns of the contemporary metropolitan labour force. This resulted in the development of a *Comprehensive Definition of Public Transit Commuter Needs*, an early version of

which was first introduced in a previous CTRF conference paper.[1] Using these three data collection methods – a literature review, a commuter survey, and informal consultations with three sustainable transportation advocacy groups – it became clear that a broad range of infrastructure, facilities and services is required in order for public transit to represent a viable transportation choice for metropolitan commuters (Figure 1). Furthermore, it also showed that responsibility for addressing public transit commuter needs falls not only upon transit agencies, but also land use and transportation planners, private developers, and individual employers.

Figure 1
Classification of Public Transit Commuter Needs



The *Public Transit Commuter Accessibility Audit*

Once the needs of public transit commuters were formally conceptualized, the task of developing a tool for evaluating public transit accessibility to employment could be dealt with. At this point,

the research objectives were 1) to translate the individual public transit commuter needs identified in the previous stage into a series of representative indicators and 2) to devise a straightforward and practical accessibility evaluation framework by which current conditions could be measured and assessed.

Box 1
Steps in the *Public Transit Commuter Accessibility Audit*

Step One: Select employment area.
Step Two: Identify hours of work within employment area.
Step Three: Select residential subarea.
Step Four: Complete *PTCAA Checklist.*
Step Five: Complete *PTCAA Report Card.*
Step Six: Make recommendations for improvement.

Transportation researchers have identified several characteristics that must be incorporated into any accessibility evaluation tool if it is to have practical utility. First, it must be straightforward in order to ensure that its level of complexity does not deter potential users. Secondly, because planners are more interested in identifying specific obstacles or deterrents to travel by public transit, it should present results in disaggregate form rather than as a single index. Third, the tool should be flexible in terms of where and when it is applied so that planners can use it for different purposes. Fourth, it should contain a manageable number of indicators that can also be modified according to local circumstances. Finally, it should ideally involve the use of both qualitative and simple quantitative data collection methods in order to fully capture the essence of the public transit commuter's travel experience. Based on these suggestions, the six-step *Public Transit Commuter Accessibility Audit* was developed (Box 1). The tool is designed for application at the micro-scale level and within the context of actual spatio-temporal commuter travel flows. That is, it evaluates conditions between a particular residential subarea and a particular employment area with consideration for the hours at which commuters are travelling or working. Each step is explained below.

Step One: Selection of employment area.

The first step in conducting a *PTCAA* is to choose the employment area to which public transit accessibility will be evaluated. This can range from a single, stand-alone facility to a larger employment district composed of several workplaces. However, it is likely that planners would be most interested, at least initially, in evaluating public transit accessibility to locations delineated in local planning documents as major employment centres where public transit is expected to hold a large share of the journey-to-work modal split. A focus on this type of setting would provide an opportunity to ascertain not only whether the needs of public transit commuters are served, but also whether stated policies related to public transit commuting are achieving their intended impacts. Furthermore, although the selection of a larger employment area requires more extensive data collection and thus a greater expenditure of time and labour than if only a small employment setting was selected, these costs are balanced by the ability to evaluate public transit accessibility for a larger share of metropolitan commuters.

Step Two: Identify hours of work.

Once a particular employment area has been selected, the next step in the *PTCAA* is to determine as accurately as possible when workers are present at this location. This information – which must include both days of the week *and* times of day – is required in order to gauge whether or not public transit service is provided to and from the employment area when it is needed or may be needed. There are at least four potential methods for obtaining this information, including: a storefront survey; examination of origin-destination survey data; an employer survey; or an employee survey.

Step Three: Selection of residential subarea.

The third step is to select a residential subarea from which public transit accessibility to the employment area in question will be evaluated. This can include, for example, a traffic zone, a

neighbourhood, a census tract, or even a larger community comprised of several traffic zones or census tracts. A logical starting-point, however, would be to choose a subarea where many workers at the specified employment area currently reside, or would be expected to reside. At the census tract level, this information can be obtained in the form of "Place of Work" statistics collected every five years as part of the Census of Canada. Origin-destination surveys represent a second potential source. In these studies, a sample of households in each traffic zone is asked to indicate the workplace locations of all employed individuals. Thus, data can be used to determine which traffic zones are home to large proportions of individuals working within the employment area being examined. A third option might be to choose a metropolitan subarea that would be *expected* to house individuals working within the employment area. For instance, if an area has been designated as a "suburban downtown" and is intended to serve as a focal point for the employment activities of nearby residents, it would make sense to evaluate public transit accessibility from one or more surrounding communities.

Step Four: Complete PTCAA Checklist.

Once the employment area and residential subarea have been selected and hours of work at the employment area have been obtained, a spatial and temporal context for conducting the *PTCAA* has been established. The next step involves completion of the *PTCAA Checklist*, the most time-consuming and labour intensive part of the process. The structure of the *PTCAA Checklist* coincides with that of the *Comprehensive Definition of Public Transit Commuter Needs*. It is comprised of 94 statements, each of which reflects a public transit commuter need discussed in the previous chapter (Appendix 1). Accordingly, its completion begins with the collection of data related to the availability of transit service, which can be easily obtained from transit maps and schedules. Subsequent sections involve the examination of infrastructure, facilities and services found along the actual public transit journey between the selected residential subarea and employment area.

Although its primary intention is to be used in evaluating public transit accessibility to places of employment as it pertains to all seven dimensions, it can nonetheless be used to conduct less extensive evaluations, if desired. For example, where planners are simply interested in examining the infrastructure, facilities and services in place at transit stops and stations within a particular employment area, they can complete the *PTCAA Checklist* as it pertains to the dimension labelled "Transit Stops/Stations at/near Employment Area".

Completion of the *PTCAA Checklist* involves collection of both qualitative and simple quantitative data. In some cases, it may be possible to evaluate conditions simply by counting the number of locations where a particular type of infrastructure, or facility or service is located. For example, Statement #7 under "Transit Stops/Stations near Homes" reads: "Seating is provided at transit stops and stations." How accurately this statement reflects current conditions can be ascertained by determining the proportion of transit stops that have benches. In other cases, the evaluation of conditions is more subjective in nature. For example, Statement #3 under "Travel between Homes and Transit Stops/Stations" declares: "Travel routes between places of residence and transit stops/stations are aesthetically pleasing." Individual perceptions of "aesthetically pleasing surroundings" will clearly differ from one person to the another and therefore defies quantification. As a result, data entry on the *PTCAA Checklist* would be more qualitative than quantitative. In this case, the auditor may provide a textual description of the surroundings and perhaps also provide photographic supporting evidence.

Step Five: Complete PTCAA Report Card.

Once current conditions have been documented, the next step is to assign a "grade" to each statement based on the information gathered and, subsequently, to present these on the *PTCAA Report Card*. Five possible "grades" can be assigned to each statement: *A, B, C, DNA, or N/A*. An *A*-grade is assigned to those statements that are true or very close to being true. A grade of *B* should assigned in cases where the

statement is only partially true, therefore implying that public transit commuter needs are not *fully* served. Finally, the *C*-grade is used to reflect circumstances in which conditions are especially poor and the statement is completely, or almost completely, false. For example, if the data indicates that every street in a census tract has sidewalks, the statement reading "A *continuous sidewalk network* provides pedestrians with physical access to transit stops/stations" would receive an "A". If sidewalks were available on collector and arterial roads, but not on smaller streets, a "B" grade would be appropriate. Finally, if there *no* sidewalks were provided on *any* streets within the census tract, a grade of "C" would be assigned. Two further selections are also possible, however. Auditors can check "Data Not Available" ("DNA") if relevant data could not be obtained; for example, the question of whether sidewalks are adequately cleared of snow and ice could not be addressed if the *PTCAA* is conducted in the month of July. "N/A" is available for selection in cases where the statement is not relevant to the *PTCAA* being conducted. For example, questions related to the provision and quality of park-and-ride facilities would not pertain to census tracts from which commuters are not required to travel by car to gain access to public transit service.

It is of paramount importance that justification be offered for each grade assigned or for selection of the DNA or N/A options. Because an important function of the tool is to provide evidence of obstacles or deterrents to public transit commuting, deficiencies related either to the provision of infrastructure, facilities and services or to the availability of data must be explicitly identified. As a result, space is provided beside each statement for the insertion of relevant comments. An effective means of supporting findings related to unmet public transit commuter needs is through the use of photographic evidence. The inclusion of photographs demonstrating unsatisfactory conditions can make more evident to readers the problem(s) at hand, thus adding credibility to the report.

Step Six: Make recommendations for improvement.

Perhaps the most important task besides the compilation of accurate data is to communicate the *PTCAA* results and their implications, especially those concerning any weaknesses or deficiencies that have been identified. Ideally, the results of the *PTCAA* should be reported to *all* groups responsible for land use planning, transportation planning and public transit planning within the areas evaluated. Discussion of any planning implications should also make clear which statements could not be validated due to a lack of data, as this may provide the impetus for new data collection exercises.

Further Research Needs

The practical utility of the *PTCAA* was tested in the form of several case studies in the City of Ottawa. In each application, public transit accessibility was evaluated between two residential subareas and a major employment area. Although levels of accessibility varied considerably across the case study areas, each audit revealed significant obstacles and deterrents to public transit commuting that warrant further attention on the part of planners. These included convoluted route configurations, inadequate service frequencies, potentially dangerous transit stop locations, and aesthetically unpleasant pedestrian environments.

Despite this initial success, further research is required to improve the practical utility of the *PTCAA*. First, it must be modified to take into account concerns about the validity of the data obtained. The primary concern here is that many of the variables evaluated dynamic conditions, such as driver friendliness and the provision of a low-floor transit vehicle, that will vary considerably depending on when exactly the *PTCAA* is conducted. A second issue relates to the labour intensiveness of the auditing process. The numerous field observations require voluminous amounts of time. The risk is therefore that planning agencies may feel that the benefits of conducting a *PTCAA* may not outweigh the time commitment involved in collecting necessary data. A final and related concern is

the question of researcher bias. Although the *PTCAA* has been designed to reflect the socioeconomic diversity of the contemporary commuter population, there is the possibility that data collection will leave out important details due to the primarily qualitative nature of the process. For example, a young adult male's interpretation of what constitutes a safe or aesthetically pleasant walking environment may differ considerably from that of an elderly woman. Thus, an important issue that must be addressed in future research concerning the *PTCAA* is how to ensure that a diversity of viewpoints is reflected in the audit results and, more importantly, in the recommendations that follow.

Conclusion

As sustainable transportation principles are more widely incorporated into municipal planning policies, there is a growing need to create tools for evaluating the viability of non-automobile transportation choices. The *Public Transit Commuter Accessibility Audit* has been devised to address this need within the context of public transit commuting. This tool provides planners with a straightforward and practical tool for gauging the extent to which public transit represents a potential means of travelling between a selected residential subarea and selected employment area with consideration for the times when commuter travel actually takes place. Further research is required, however, in order to ensure that the tool can be applied within a reasonable time frame and to ensure that it provides a more accurate picture of actual conditions experienced by the diverse public transit commuter population.

Reference

[1] Fullerton, Christopher. 2003. "Evaluating Accessibility to Employment by Public Transit from the Commuter's Perspective," *Proceedings of the 38th Annual Conference of the Canadian Transportation Research Forum*, Ottawa, Ontario, pp. 721-735.

Appendix 1
Public Transit Commuter Accessibility Audit Checklist

Availability of Service

1. Transit service is available within the subarea.
2. Transit service is available at the employment area.
3. Transit service is provided directly between the subarea and employment area.
4. If transit service is not provided directly between the subarea and employment area, commuters must only transfer once in order to reach the employment area.
5. If commuters must transfer between transit vehicles, route schedules are efficiently coordinated.
6. Transit service is provided between the subarea and employment area on days when commuters travel.
7. Transit service is provided between the subarea and employment area before, during and after employees' workdays.
8. Transit service is provided between the subarea and employment area at convenient frequencies.

Travel between Homes and Transit Stops/Stations

1. Facilities and services required on a day-to-day basis are available between homes and transit stops/stations.
2. Commuters can travel directly between their homes and transit stops/stations.
3. Routes between homes and transit stops/stations are aesthetically pleasant.
4. Routes between homes and transit stops/stations are adequately lit between dusk and dawn.
5. Routes between homes and transit stops/stations are highly visible from adjacent buildings and by passing traffic.
6. A continuous sidewalk network provides physical access between homes and transit stops/stations.
7. Sidewalks are wide enough to accommodate pedestrians travelling in both directions.
8. Sidewalks are in good physical condition.

Appendix 1 (continued)
Public Transit Commuter Accessibility Audit Checklist

Travel between Homes and Transit Stops/Stations (cont'd)

9. Sidewalks are designed to accommodate the needs of wheelchair users.
10. Sidewalks are promptly cleared of ice and snow.
11. Sidewalks are effectively cleared of ice and snow.
12. Along collector and arterial roads, sidewalks are separated from vehicular traffic by buffers.
13. Travel to/from transit stops/stations is not hindered by obstacles such as parked motor vehicles or snowbanks.
14. When they must cross collector and arterial roads, commuters are provided with signalized road crossing s.
15. Road crossing signals can be activated by pedestrians.
16. Road-crossing signals include audible signals.
17. Commuters accessing transit stops/stations by bicycle are provided with clearly demarcated bicycle lanes.
18. Bicycle lanes are of an adequate width.

Transit Stops/Stations near Homes

1. Transit stops and stations are located on pavement.
2. Transit stops and stations are adequately lit between dusk and dawn.
3. Transit stops and stations are highly visible from adjacent buildings and by passing traffic.
4. Trash receptacles are provided at transit stops and stations.
5. Transit stops and stations are clean.
6. Effective shelter from the elements is provided at transit stops and stations.
7. Seating is provided at transit stops and stations.
8. Newspaper vending machines are provided at transit stops and stations.
9. Service information is provided at transit stops and stations.
10. Public telephones and emergency telephones or callboxes are available at transit stations.

Appendix 1 (continued)
Public Transit Commuter Accessibility Audit Checklist

Transit Stops/Stations near Homes (cont'd)

11. Public washrooms and baby change facilities are provided at transit stations.
12. Bicycle storage facilities are provided at transit stops and stations.
13. Convenience stores and/or vending machines are located at transit stations.
14. When commuters must access public transit by car, park-and-ride facilities are provided at transit stations.
15. An adequate supply of parking is provided at park-and-ride facilities.
16. Park-and-ride facilities are provided free of charge.
17. Park-and-ride facilities are adequately lit between dusk and dawn.
18. Park-and-ride facilities are highly visible by passing traffic and/or from adjacent buildings.
19. Park-and-ride facilities are security monitored.
20. Direct pedestrian access is provided between park-and-ride facilities and transit stops or stations.
21. Park-and-ride facilities are easily accessible by car from adjacent roadways.

Travel on Vehicle

1. Transit vehicles are universally accessible.
2. Route numbers and destinations are clearly visible.
3. Adequate seating is available on transit vehicles.
4. Commuters' personal safety and security is not compromised on board transit vehicles.
5. Transit vehicles are clean.
6. Transit drivers announce major stops, stations and intersections.
7. Transit drivers are friendly and helpful when asked for assistance.
8. Transit vehicles are equipped with bicycle racks.

Appendix 1 (continued)
Public Transit Commuter Accessibility Audit Checklist

Transit Stops/Stations at/near Employment Area

1. Transit stops/stations are located close to all workplaces in the employment area.
2. Transit stops and stations are located on pavement.
3. Transit stops and stations are adequately lit between dusk and dawn.
4. Transit stops and stations are highly visible from adjacent buildings and/or by passing traffic.
5. Trash receptacles are provided at transit stops and stations.
6. Transit stops and stations are clean.
7. Effective shelter from the elements is provided at transit stops and stations.
8. Seating is provided at transit stops and stations.
9. Newspaper vending machines are provided at transit stops and stations.
10. Service information is provided at stops and stations.
11. Public telephones are available at transit stations.
12. Emergency telephones or call boxes are provided at transit stations.
13. Public washrooms are provided at transit stations.
14. Baby change facilities are provided in washrooms at transit stations.
15. Bicycle storage facilities are provided at transit stops and stations.
16. Convenience stores and/or vending machines are located at transit stations.

Travel between Transit Stops/Stations and Workplaces

1. Commuters can travel directly between transit stops/stations and their workplaces.
2. Routes between transit stops/stations and workplaces are aesthetically pleasant.
3. Routes between transit stops/stations and workplaces are adequately lit between dusk and dawn.

Appendix 1 (continued)
Public Transit Commuter Accessibility Audit Checklist

Travel between Transit Stops/Stations and Workplaces (cont'd)

4. Routes between transit stops/stations and workplaces are highly visible from adjacent buildings and by passing traffic.
5. A continuous sidewalk network provides physical access between transit stops/stations and workplaces.
6. Sidewalks are wide enough to accommodate pedestrians travelling in both directions.
7. Sidewalks are in good physical condition.
8. Sidewalks are designed to accommodate the needs of wheelchair users.
9. Sidewalks are promptly cleared of ice and snow.
10. Sidewalks are effectively cleared of ice and snow.
11. Along collector and arterial roads, sidewalks are separated from vehicular traffic by buffers.
12. Travel to and from transit stops/stations is not hindered by obstacles such as parked motor vehicles or snowbanks.
13. When they must cross collector and arterial roads, commuters are provided with signalized road crossings.
14. Road-crossing signals can be activated by pedestrians.
15. Road-crossing signals include audible signals.
16. Commuters accessing transit stops/stations by bicycle are provided with clearly demarcated bicycle lanes.
17. Bicycle lanes are of an adequate width.

Employment Area

1. Facilities and services required on a day-to-day basis are available in the employment area.
2. Bicycle storage facilities are provided within the employment area.
3. Bicycle storage facilities are highly visible by passing traffic and/or from nearby buildings.
4. Cyclists are provided with shower and change room facilities at workplaces in the employment area.

HOW ENERGY CONSTRAINTS COULD ENSURE A MAJOR ROLE FOR TETHERED VEHICLES IN CANADA'S NEXT TRANSPORT REVOLUTION

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Introduction

After several false alarms, the prospect of major constraints on the availability of transport fuels is becoming more firmly entrenched. A consensus may be beginning to emerge that world *production* of oil, which now fuels 95 per cent of transport,[1] could peak during the next two decades (see Figure 1).[2] The production peak would echo the peak in worldwide oil *discovery*, which occurred in the early 1960s (see Figure 2).

Meanwhile, potential demand for transport fuels could continue to rise, driven chiefly by growth in economic and transport activity in China and other industrializing countries,[3] resulting in sharply elevated prices.

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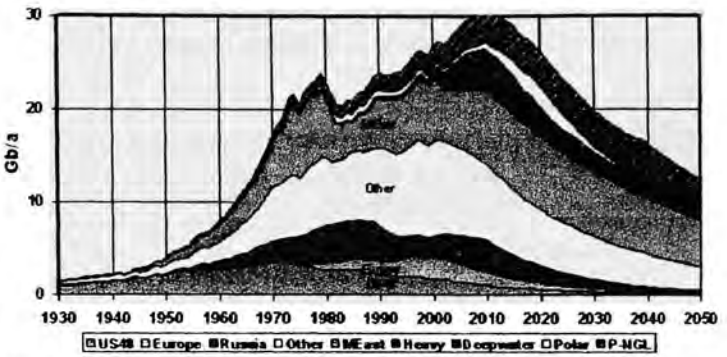


Figure 1. World production by region of regular oil and natural gas liquids, actual and estimated, billions of barrels per year, 1930-2050.[4]

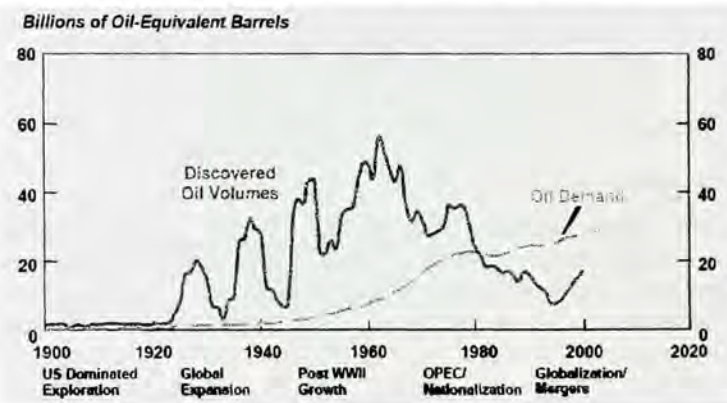


Figure 2. World discovery of and demand for oil, 1900-2000, and projected potential demand until 2020.[5]

The most promising alternative transport fuel is said to be hydrogen, whether for use in fuel cells or combustion engines.[6] However, North American production of natural gas—the source of about 95 per cent of hydrogen produced in the U.S.[7]—appears to have already peaked,[8]

resulting in large increases in wholesale and retail prices.[9] There is much natural gas in the Middle East, Russia, and elsewhere,[10] but major constraints on moving it between continents.[11]

Canada's vast size and extensive international trade make us more dependent on transportation than most affluent countries.[12] Without adequate preparation, Canada could suffer inordinately from greatly elevated fuel prices, whether for conventional transport fuels based on crude oil or for fuels required by emerging technologies, including hydrogen for fuel cells.

Accordingly, addressing potential constraints on the availability of transport fuels could well become a national policy priority, perhaps similar in importance to that of meeting the transport challenges posed by Canada's Kyoto commitment.

Among effective responses to potential energy constraints could be much wider use of tethered vehicles—i.e., electrically powered vehicles fuelled via rail or wire—including trains, streetcars, trolley buses, and even trolley trucks.

Tethered vehicles have three relevant advantages: (i) they can have remarkably low energy intensities; (ii) their primary fuels can include a wide range of renewable and non-renewable sources; and (iii) for the most part they involve familiar, tried, tested, and available technology.

They also have two major disadvantages: (i) they are confined to routes with appropriate infrastructure (i.e. rails and/or wires); and (ii) they rely on continuously available, centrally provided power.

The balance of this paper will discuss the advantages and disadvantages of tethered vehicles and show how they could and perhaps should be used more widely in Canada and thus become a significant feature of Canada's next transport revolution.

Energy use by tethered and other vehicles

The superior performance of tethered passenger vehicles with respect to energy use is illustrated in Table 1. In each of the three categories of vehicle, tethered vehicles show lower *operational* energy use.

Vehicle type	Fuel	Occupancy (pers./veh.)	Energy use (mJ/pkm)
Personal vehicles:			
SUVs, vans, etc.[13]	Gasoline	1.70	3.27
Large cars[13]	Gasoline	1.65	2.55
Small cars[13]	Gasoline	1.65	2.02
Motorcycles[13]	Gasoline	1.10	1.46
Fuel-cell car[14]	Gasoline	1.65	0.92
Hybrid electric car[15]	Hydrogen	1.65	0.90
Very small car[16]	Diesel	1.30	0.89
Personal Rapid Transit[17]	Electricity	1.65	0.49
Public transport between cities:			
Intercity rail (U.S.)[18]	Diesel		2.20
School bus[13]	Diesel	19.5	1.02
Intercity bus[13]	Diesel	16.8	0.90
Intercity rail (U.S.)[18]	Electricity		0.64
Public transport within cities:			
Transit bus (U.S.)[19]	Diesel	9.3	2.73
Trolleybus (U.S.)[19]	Electricity	14.6	0.88
Light rail (streetcar, U.S.)[19]	Electricity	26.5	0.76
Heavy rail (subway, U.S.)[19]	Electricity		0.58

Table 1. Energy use in megajoules per passenger-kilometre by various modes. Tethered modes are shown in colour.[20]

Overall (primary) energy use can be much greater than operational (secondary) energy use, according to how the energy is supplied. For example, electricity produced by a combined-cycle gas turbine generator requires expenditure of about 90% more primary energy in the form of generator fuel as is available in the secondary energy in the electricity.[21] Similarly, if hydrogen for a fuel cell is produced by electrolysis, the energy content of the electricity used is about 60% higher than the energy content of the hydrogen produced.[22]

With such conversion losses, it is important to consider the primary energy use; this is a better indicator of the energy burden. However, when the secondary energy—which provides the motive power—can be produced with little intermediate conversion, considerations of primary energy use are less important. Examples are gasoline produced from conventional oil and electricity from wind turbines.

Tethered vehicles also provide superior performance in freight transport. There are no electric freight trains in North America. The comparison in Table 2 is for Finland. Not shown are tethered versions of trucks, known as 'trolley trucks', which like trolleybuses are powered through an overhead wire. They are used extensively in mining and other off-road operations (see Figure 3). Data on energy use by trolley and regular trucks are not available; the difference is difference between the two is likely comparable to that shown in Table 2 for diesel and electric trains.

Vehicle type	Fuel	Energy use (mJ/tkm)
Truck	Diesel	0.45
Train	Diesel	0.20
Train	Electric	0.06

Table 2. Energy use by freight transport in Finland, in megajoules per tonne-kilometre.[23]

The particular features of electric motors that make them more efficient than comparable internal-combustion engines are: (i) higher torque at low speeds, thus requiring less fuel use and a smaller engine; (ii) smaller engines mean less weight to carry, also meaning less fuel use; and (iii) electric drive systems can have regenerative braking—motive energy is captured when decelerating rather than lost as friction heat—again resulting in energy savings.



Figure 3. Trolley truck operating at the Quebec Cartier iron ore mine, Lac Jeannine, 1970s.[24]

The low energy intensities of tethered vehicles, for passengers and freight, suggest that extensive use of them should be considered as part of the preparation for an era of energy constraints.

Tethered vehicles can use a variety of primary energy sources

Just about as important for sustainability as tethered vehicles' low energy intensity is their versatility in the use of primary energy sources. Any means of generating electricity for the grid is a primary source of energy for tethered vehicle operations. In this way, wind, sun (thermal and photoelectric), tide, falling water, nuclear fission, and combustion of fossil fuels and biofuels can all be energy sources for tethered vehicles.

As we move towards an energy future whose only certainty may be reduced reliance on fossil fuels, the ability to power transport by a wide variety of sources will be advantageous. Moreover, electricity is

the most convenient energy currency of many sustainable primary sources, including wind, sun (photoelectric), tide, and falling water.

Tethered vehicle technology is readily available (but there are opportunities for improvement)

Tethered electric vehicles have been in practical use for at least 120 years.[25] There were streetcars on Canadian streets before there were automobiles.[26] There has been continuous development of the technology as adoption of these modes has spread throughout the world, and as technical requirements have been enhanced (e.g., for high-speed trains).

Building on this well-established technology, there are many opportunities for further enhancement, especially in the matter of personal rapid transit (PRT, noted in Table 1). Because PRT could provide a convenient, affordable alternative to automobile use in low-density areas, it offers the opportunity to address what may be the most intractable of transport challenges.

Another major challenge concerns road freight transport, the fastest growing source of energy use and greenhouse gas emissions. It's possible to conceive of technological development that would allow any truck, and even any road vehicle, to draw motive power from overhead wires, replacing some of it during braking.

Tethered vehicles are restricted to powered routes

The most serious disadvantage of tethered vehicles is their infrastructure requirements. At a minimum, they require wires above existing roads, and the means to power them. According to the type of vehicle, they could also require new rails or other guideways.

A similar challenge confronted automobiles 100 years ago. They were mostly confined to summer travel on roads within urban areas. In 1910, the only paved highway in Canada was a 16-kilometre stretch from Montreal to Ste.-Rose. Present levels of route flexibility

took many years to develop. Indeed, an automobile was not driven across Canada until 1946, and the Trans-Canada Highway was not completed until the 1960s.[27] Today's automobiles and trucks may be even more confined to laid-out roads than those of a century ago, but the road system is extensive, reaching to most parts of southern Canada.

Widespread adoption of tethered vehicles for the next transport revolution could well involve continued use of the present road system, with the addition of powered overhead wires that can be shared by all. However, vehicles run more efficiently on rails or tracks than on roads, and energy constraints may favour trains and other vehicles confined to special-purpose rights-of-way.

Tethered vehicles require continuously available, centrally provided power

Toronto's streetcars and subway trains stopped during the blackout on August 14, 2003, but cars and trucks kept on rolling, at least for a time. Then they were stopped in traffic jams caused by non-functioning traffic signals and by line-ups at non-functioning gas stations.

It is nevertheless true that cars and trucks have some additional resilience compared with tethered systems because they carry their own fuel. However, both depend ultimately on heavily centralized systems of energy distribution.

Greater dependence on tethered transport systems would stimulate designs for greater resilience involving more distributed production and greater redundancy. These would in any case be likely features of a more sustainable system of energy supply.

Preparing for the next transport revolution

If we had a perfect political system, able to assess and respond to long-term risks and opportunities, we might well be busy now laying

down the infrastructure for an easy transition to predominantly tethered transport over the next few decades. Present political systems are more able to respond to emergencies. Thus, it could be a decade or two before the transition begins in earnest, too late for the transition to be painless.

If the next transport revolution will indeed be about tethered vehicles, what could be done today? Here are some suggestions:

- Confirm whether or not energy constraints will be severe and whether or not tethered vehicle systems offer the best opportunities for continued movement of people and goods.
- Plan a transition from what we have now to what we need to have in terms of energy supply, transport infrastructure, and vehicles.
- Conduct needed research, e.g., into PRT, trolley trucks, and overhead wire systems that can accommodate a range of users.
- Direct investments appropriately, e.g., towards light-rail transport rather than bus rapid transport and towards electric rather than diesel trains, because in each case the former will be more compatible with the next transport revolution.

End Notes

[1] According to Page 411 of International Energy Agency, *World Energy Outlook 2002* (IEA, Paris, France, 2002), 95.5% of the energy used for motorized transport worldwide in 2000 came from oil, i.e., 1,696 out of 1,775 million tonnes of oil equivalent.

[2] Part of the evidence of emerging consensus on the notion of a peak in world oil production during the period 2010-2030 is the authorship of the first *Nature* paper mentioned in Note 4 below, which comprises an academic and two industry specialists.

[3] According to the June 2003 issue of the *BP Statistical Review of World Energy*, available at the URL below, China passed Japan in 2002 to become the world's second major user of oil after the U.S.

Over the previous decade, use of oil in China had increased by 99%. Use of oil in Canada and the U.S. had increased respectively by 17% and 16%. Use of oil in Japan had declined by 3%.
1. http://www.bp.com/subsection.do?categoryId=95&contentId=2006480. Accessed Feb. 8, 2004.

[4] Figure 1 was taken from the Web site of the Uppsala Hydrocarbon Depletion Group at the first URL below. The figure suggests that production of liquid hydrocarbons suitable for conversion into transport fuels will peak in about 2012. Some estimates point to earlier peaks, e.g., in 2005, as projected in Deffeyes KS, *Hubbert's Peak: The Impending World Oil Shortage*. Princeton University Press, 2001. Others point to later peaks, e.g., in 2018-2023, as projected in White N, Thompson M, Barwise T, Understanding the thermal evolution of deep-water continental margins, *Nature*, 426:6964, 324-333, 2003. Extreme among the projections of later production peaks are those of the U.S. Energy Information Administration (EIA), which suggests production will continue rising beyond 2025 (*International Energy Outlook 2003*, Washington DC, 2003, available at the second URL below) and those of the International Energy Agency (IEA), which suggests oil production will continue rising until 2030 (*Energy to 2050: Scenarios for a Sustainable Future*. IEA, Paris, France, 2003). Energy constraints will arise from potential demand running ahead of actual production of liquid hydrocarbons resulting in high prices, *not* from depletion of all available oil. Put another way: "The world is not about to run out of hydrocarbons, and perhaps it is not going to run out of oil from unconventional sources any time soon. What will be difficult to obtain is cheap petroleum, because what is left is an enormous amount of low-grade hydrocarbons, which are likely to be much more expensive financially, energetically, politically and especially environmentally." (Hall C and four others, Hydrocarbons and the evolution of human culture. *Nature*, 426:6964, 318-322, 2003).
1. http://www.isv.uu.se/uhdsg/. Accessed Feb. 4, 2004.
2. ftp://ftp.eia.doe.gov/pub/pdf/international/0484(2003).pdf. Accessed Feb. 4, 2004.

[5] Figure 2 is from a presentation by Harry J. Longwell, Executive VP, Exxon Mobil Corporation at the Offshore Technology Conference, Houston, Texas, May 7, 2002, available at the URL below.
1. http://www.exxon.mobil.com/files/corporate/hjlslide3.pdf. Accessed Feb. 5, 2004.

[6] According to the International Energy Agency, "In the long term, perhaps the most promising path for virtually eliminating the direct use of petroleum fuels ... is the hydrogen fuel cell. Once all vehicles operate on hydrogen fuels, they will be potentially renewably fuelled (if a renewable source of hydrogen is developed), and will produce water as their only emission." (Pages 168-169 of *Towards a Sustainable Energy Future*, IEA, Paris, France, 2001). In January 2003, U.S. President George Bush announced the FreedomCAR and Fuel Initiative "to reverse America's growing dependence on foreign oil by developing the technology needed for commercially viable hydrogen-powered fuel cells", detailed at the URL below. Hydrogen can be used as fuel for internal combustion engines, but its use in fuel cells is said to offer "significantly greater potential" (see the second URL below).
1. http://www.eere.energy.gov/hydrogenfuel/. Accessed Feb. 8, 2004.
2. http://www.initiative-brennstoffzelle.de/en/ibz/live/nachrichten/detail/104.html. Accessed Feb. 8, 2004.

[7] According to Amory Lovins in *Twenty Hydrogen Myths* (Rocky Mountain Institute, 2003, available at the URL below), "U.S. hydrogen production is at least one-fifth and probably nearer one-third of the world total, is equivalent to ~1.8% of total U.S. energy consumption, and comes ~95% from natural gas at ~99% purity from steam reforming and associated cleanup processing."
1. http://www.rmi.org/images/other/Energy/E03-05_20HydrogenMyths.pdf. Accessed Feb. 8, 2004.

[8] For an informed view that North American natural gas production may have already peaked, see the presentation by Matthew Simmons, *The Natural Gas Riddle: Why Are Prices So High? Is a Serious Crisis Underway?* at the mini-conference of the International Association for Energy Economics, Houston, Texas, December 11,

2004, available at the URL below.
1. http://www.simmonsco-intl.com/files/IAEE%20Mini%20Conf.pdf. Accessed Feb. 8, 2004.

[9] The Alberta Gas Reference Price increased more than 3.5-fold between February 1999 and February 2003, from $1.90 to $6.83 per gigajoule (see the URL below). Over the same period, the price Toronto consumers paid for natural gas rose by about 70%.
1. http://www.energy.gov.ab.ca/gmd/gas/monthlyref.asp. Accessed Feb. 8, 2004.

[10] According to the International Energy Agency (see the source detailed in Note 1), North America was responsible for 31% of world natural gas consumption in 2000 but had only 5% of proven natural gas reserves (pp. 110 and 114).

[11] Natural gas can be economically shipped between continents as liquefied natural gas (LNG) when the wholesale natural gas price is above about Can$4.40 per gigajoule. Three difficulties impede rapid expansion of LNG imports: (i) a shortage of vessels designed to carry LNG; (ii) a shortage of terminals designed to receive LNG; and (iii) movement of LNG is regarded as hazardous. On the last point consider the following from Powers B, *Assessment of Potential Risk Associated with Location of LNG Receiving Terminal Adjacent to Bajamar and Feasible Alternative Locations*, at the URL below: "The US Coast Guard requires a two-mile moving safety zone around each LNG tanker that enters Boston Harbor, and shuts down Boston's Logan Airport as the LNG tanker passes by. ... These extraordinary precautions are taken out of concern for spectacular destructive potential of the fire and/or explosion that might result from a LNG tank rupture."
1. http://www.borderpowerplants.org/pdf_docs/lng_position_paper_june2002_english.pdf. Accessed Feb. 8, 2004.

[12] Figure 17 (Page 29) of *Measuring the New Economy: Trade and Investment Dimensions* (Organization for Economic Cooperation and Development Document No. TD/TC/WP(2001)23/FINAL, October 2001) sets out 1999 data on trade and GDP for 25 OECD and east European countries, at the URL below. Among the listed

countries, Ireland (125%), Hungary (110%), and The Netherlands (86%) had trade as a higher share of GDP than Canada (72%).
1. http://www.olis.oecd.org/olis/2001doc.nsf/LinkTo/td-tc-wp(2001)23-final. Accessed Feb. 8, 2004.

[13] The data in this row are derived from the electronic version of *Energy Use Data Handbook* (Ottawa, Ontario, Natural Resources Canada, June 2003), available at the URL below.
1. http://oee.nrcan.gc.ca/neud/dpa/handbook_tables.cfm?Text=N&PrintView=N. Accessed Feb. 6, 2004.

[14] The fuel-cell-car data are for the 2004 Honda FCX subcompact, as posted by U.S. Department of Energy at the URL below.
1. http://www.fueleconomy.gov/feg/fcv_sbs.shtml. Accessed Feb. 6, 2004.

[15] The data for a hybrid gasoline-electric car are those for the 2004 Toyota Prius midsize car, as posted at the URL below.
1. http://www.fueleconomy.gov/feg/hybrid_sbs.shtml. Accessed Feb. 6, 2004.

[16] The data for the 'very small car' are those for Volkswagen's Lupo 3L, a two-seater-plus diesel car available only in Europe and described by the manufacturer as the "first 3L vehicle in production" (see Klaus-Peter Schindler, *The future of the Diesel engine in passenger cars*. Presentation at the 7th Diesel Engine Emissions Reduction Workshop, Portsmouth, Virginia, August 2001, at the first URL below). Manufacturer's energy-use data are given here, i.e., 2.99 litres/100 km, equivalent to 0.89 mJ/pkm for an occupancy of 1.30 (this author's estimate). In Slide 10 of the cited presentation, a rate of 0.75 mJ/pkm is given for "average rate of occupation" "in urban traffic under 75 km", which suggests an average occupancy of 1.54 or higher. Testing of the Lupo 3L by Transport Canada indicated highway fuel use of 3L/100 km and city fuel use of 3.8L/100 km (*Advanced Technology Vehicles Program, 2001-2002 Annual Report*, Road Safety and Motor Vehicle Regulation, Transport Canada, January 2003, at the second URL below).
1. http://www.osti.gov/fcvt/deer2001/schindler.pdf. Accessed Feb. 7, 2004.
2. http://www.tc.gc.ca/roadsafety/atvpgm/reports/annual/atvp0102.pdf. Accessed Feb. 7, 2004

[17] Personal Rapid Transit (PRT) is a generic term for concept systems comprising fully automated small vehicles carrying 1-6 passengers running on guideways at, above or below ground, providing direct origin-to-destination service. A useful review of these and other innovative technologies can be found at a Web site maintained by Jerry Schnieder of the University of Washington, at the URL below. The energy use shown in Table 1 represents the average of several developers' estimates.
1. http://faculty.washington.edu/jbs/itrans/. Accessed Feb. 7, 2004.

[18] There are no electrically powered intercity trains in Canada, and so U.S. data are provided for this type of vehicle. Amtrak's Northeast corridor is the only electrified part of the intercity rail system in the U.S. About 2.63 billion passenger-kilometres (pkm) were performed in this corridor in 2000 and about 6.34 billion pkm in the rest of the system (this author's estimates from various sources, notably Report No. GAO/RCED-96-144 by the U.S. General Accounting Office, *Northeast Rail Corridor: Information on Users, Funding Sources, and Expenditures*, 1996, at the first URL below, and Table 9.12 of Davis SC, Diegel SW, *Transportation Energy Data Book 23*, Oak Ridge Tennessee: Oak Ridge National Laboratory, 2003, at the second URL below). According to Table A.16 of the second source, 470,170,000 kilowatt-hours of electricity and 94,968,000 U.S. gallons of diesel fuel were used respectively to provide this service.
1. http://ntl.bts.gov/data/rc96144.pdf. Accessed Feb. 11, 2004.
2. http://www-cta.ornl.gov/data. Accessed Feb. 11, 2004.

[19] The data in this row are derived from data on U.S. systems provided by the American Public Transportation Association (APTA), available at the URL below. (Data on Canadian systems in the source cited in Note 13 are not provided by mode. However, in aggregate they seem roughly comparable to the APTA data.)
1. http://www.apta.com/research/stats/. Accessed Feb. 7, 2004.

[20] The sources for the estimates in Table 1 are in the corresponding end notes. The table shows *end* or secondary energy. As noted in the text, primary or full-cycle energy use can be much greater.

[21] For generator efficiency see, for example, Wei A, *Technologies for Next Generation Turbine Systems*. Presentation at the Turbine Power Systems Conference and Condition Monitoring Workshop. Galveston, Texas, February 2002, available at the URL below.
1. http://www.netl.doe.gov/publications/proceedings/02/turbines/wei.pdf. Accessed Feb. 7, 2004.

[22] For the efficiency of electrolysis, see Page 171 of Committee on Alternatives and Strategies for Future Hydrogen Production and Use, National Research Council, *The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs*. (Washington DC, National Academies Press, 2004), available at the URL below.
1. http://books.nap.edu/books/0309091632/html/index.html. Accessed Feb. 7, 2004.

[23] The freight transport data in Table 2 are from the source at the URL below. In Finland, electric freight trains appear to use less than one third of the operational energy per tonne-kilometre (tkm) used by comparable diesel freight trains, which in turn use less than half of the energy used by trucks. Note that the report energy use by Finnish trucks (0.45 mJ/tkm) is very much lower than the use estimated even for heavy Canadian trucks in the source detailed in Note 13 (2.41 mJ/tkm). However, the Finnish and Canadian sources present similar estimates of energy use diesel freight trains (respectively 0.20 and 0.25 mJ/tkm).
1. http://www.ecotraffic.se/pdf/et.pdf. Accessed Feb. 7, 2004.

[24] The trolley truck photo is at the URL below.
1. http://hutnyak.com/Trolley/trolleyphotos.html. Accessed Feb. 8, 2004.

[25] See, for example, the URL below.
1. http://mikes.railhistory.railfan.net/r066.html. Accessed Feb. 10, 2004.

[26] Filey M, Howard R, Weyerstrahs H, "*Passengers Must Not ride on Fenders*", Toronto, Ontario, Green Tree Publishing Co., 1974)

[27] Nichol J, *The All-Red Route* (Toronto, Ontario, McArthur and Co., 1999).

Understanding the Travel Behaviour of the Rural Elderly

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1. Introduction

A number of trends related to elderly drivers, when considered in concert, serve to identify a building crisis particularly for those who live in rural areas. It is well documented that because of the 'Baby Boom' cohort, not only are the numbers of elderly on the rise, but the proportion of North American's population over 65 years of age will dramatically increase over the next two decades. These demographic shifts, coupled with exceedingly high accident rates among this age group, have elevated the pressure for jurisdictions to consider more proactive re-licensing practices for seniors.

The issues are particularly problematic for those seniors living in rural areas as they typically have limited transportation alternatives other than driving their own automobiles. In fact, research has shown that the rural elderly tend to retain their driver's license longer than their urban counterparts, yielding accident rates that are the highest among any age group (Hildebrand and Myrick, 2001). It is a crucial first step to develop a better understanding of the travel behaviour of this group so that the most appropriate proactive strategies can be pursued.

Traditionally, travel behaviour was documented through the use of either written trip diaries or personal interviews to collect trip-by-trip data over a two to three-day period. These techniques rely on the participant to either mentally recall or manually record trip-making, often resulting in under-reporting as trips (particularly short ones) are often forgotten or omitted. A further difficulty is that traditional travel surveys only provide limited dimensions of exposure to the risk of an

accident; typically expressed simply in terms of kilometres of travel coupled with end origin and destinations. Distances traveled by road class, traffic volume, operating speeds, time of day, and specific route choice are all important variables not usually captured through conventional analyses.

Over the past few years, there have been significant advances in travel data collection methods, particularly with the proliferation of Global Positioning System (GPS) technology. New compact GPS units, combined with more comprehensive Geographic Information Systems (GIS), allow for convenient presentation and analysis of GPS-collected travel information. GPS and GIS resources have been shown to complement the traditional survey methods currently employed by researchers. With improved accuracy and functionality, GPS and GIS have the ability to accurately quantify the older driver travel habits and ensure the survey captures a complete record of trip-making behaviour. These detailed travel data can form the basis of a valuable planning tool for the formation of public policy and the development of alternative public transportation services.

This paper synthesizes the results of a study that was undertaken that had two broad goals established to address some of the previously noted issues.

- To develop and test a GPS-based methodology for data collection, presentation, and analysis of automobile trip data with minimal involvement/disruption of participants;

- To collect precise and comprehensive travel data on older drivers (65 years and older) in New Brunswick for the purposes of comparing urban and rural travel patterns.

Geographically, the study was limited to the census subdivisions of the New Brunswick counties of York, Sunbury, and Queens. Participants for the study were composed of solicited volunteers 65 years of age and older. Although the study was conducted using a 'convenience' sample, efforts were made to include participants representing equally both sexes, all elderly age cohorts, and both

urban and rural areas. Automobile travel habits of the participants were tracked throughout a minimum two-day period. The survey time period was extended beyond 48 hours when scheduling and equipment permitted.

2. Background

Given the prevalence of reduced driving abilities among the elderly, there has been much discussion in the literature regarding mandatory relicensing, or the introduction of driving restrictions. Policies vary widely by jurisdiction ranging from automatic renewal to required medical checks, road or written tests, to automatic revocation at an age threshold (Deschenes, 2004). There are many differing opinions regarding an appropriate strategy. For example, Lange and McKnight (1996) suggest that retesting be confined to an older age group and initiated when doctors, police, or family provide evidence of the driver's decline in ability. The loss of an elderly person's license has substantial implications for them and their dependents particularly in areas where public transit services cannot counter the convenience of the private automobile (Taylor, et al. 2001). The rural elderly suffer a larger drop in absolute mobility when driving is no longer possible, because public and private services are limited or absent in rural areas (Rosenbloom, 1988).

Carp (1988) associates the well-being of an elderly person with the satisfaction of two categories of needs: those activities that precipitate independent living, and needs that give positive quality of life or "higher-order" needs. He defines "higher-order" needs (such as social interaction, usefulness, recreation, and religious experience) as not being essential for living, but are necessary for the well being of the person. Other studies have referred to these dichotomies as mandatory and discretionary activities or needs. A 1978 travel diary study of able-bodied elderly in Lawrence, MA showed that 38.1 % of all vehicle trips related to the satisfaction of higher order needs, which was less than the 61.9% of trips for essential needs, but significant nevertheless (Slavin and Jacobson, 1985).

Both necessity and "higher-order" needs can be difficult to satisfy if the person does not own a private vehicle. An elderly person in a rural area is further restricted where the automobile is often the sole means of personal transportation. When an older person ceases driving, it is usually the "higher-order" needs trips that are most adversely affected. A study of focus groups of those over 70 years of age in Maine and Florida found that older people who ceased driving concentrated their trips on life maintenance activities, often at the expense of recreational trips (Burkhardt, 1999).

The rural elderly are particularly dependent on the private automobile. A 1996 survey by Stamatiadis et al. (1996) of 155 people in rural Kentucky found that the automobile accounted for a total of 83.2% of all trips being taken as either a driver or passenger. In the Lawrence study, 66% of all trips were taken in an automobile, with 58.4% of those trips as a driver and 35.6% as an automobile passenger (Slavin and Jacobson, 1985). Hildebrand and Myrick (2001) found that the rural elderly retain their licenses longer than their urban counterparts presumably because often no alternative to the private automobile exists. Consequently, accident rates were found to be much higher for the rural elderly.

The travel behaviour of an elderly person as described in several recent studies can be generalized in the following manner: a typical elderly person has independence and social needs that require mobility, and the most prevalent means of mobility is the private automobile. It becomes more likely that as a person ages, they will suffer effects that reduce physical and cognitive abilities, making the use of the private automobile difficult or dangerous. Consequently, one would need to switch travel modes to maintain mobility, or compromise independence and social needs. The rural elderly are especially prone to losing mobility because rural mobility is secured predominately with the private automobile.

The current study was conceived based on the need for more detailed research on the travel behaviour of elderly drivers, and the successful application of GPS and GIS to recent travel surveys. The mapping of traveled routes collected by GPS onto a GIS base map has been shown

to aid in prompted recall, and GPS as a travel diary has been shown to reduce respondent burden. It has been discussed that self-reported methods can result in missed trips and trip link rounding, therefore GPS promises a more complete description of vehicular trip-making.

The most prevalent elderly driver research investigates elderly driver accident characteristics, yet the "measures of exposure" have been limited to average kilometres traveled. GPS will provide added dimensions to exposure, in terms of kilometres of travel on different speed, class, and volume of roads, and different times of the day for travel. In addition, trip purposes can be determined from prompted recall interviews, providing better understanding of vehicle use for life maintenance and higher order needs.

3. Methodology

To satisfy the first study goal, several tests were undertaken to identify the best practices for the administration of a GPS travel diary survey based on the target population. These tests identified: the GPS receiver to be used, means of power supply, installation and configuration practices, and data presentation methods. The study was structured to allow for some variance in terms of equipment location, post-test interview approach, test period timing, and test duration, all of which were monitored and best practices identified. The specified constants for the data collection included: trackpoint sampling frequency, power supply methods, base mapping, and geographic location.

In anticipation of a GPS study of older drivers, several assumptions were made. The first was that many of the potential participants would be unfamiliar with the technology and require some orientation with the equipment. The second was that based on this unfamiliarity, the use of active data collection as defined by Wolf et al. (2001) would be burdensome to the participants. The third assumption was that most participants might not be comfortable permitting the GPS unit to be powered by the vehicle battery, particularly during the colder survey months. The fourth assumption was that many potential participants would treat this study with some skepticism and regard it

as an evaluation of their driving capabilities rather than an analysis of travel characteristics. Based on these initial assumptions, test methods were developed to address these potential concerns, with hopes of maximizing participation.

There are two major manufacturers that produce off-the-shelf GPS units: Garmin and Magellan. After preliminary tests with the GPS V and the Etrex Legend models, it was found that both unit types were suitable for the data collection needs. The Etrex Legend from Garmin is smaller and less expensive than the GPS V, yet has similar features necessary for this study. It can record 10,000 data location points, and its point sampling rate can be manually altered (thereby extending the sample period). It has a one second continuous update rate, a GPS accuracy of < 15 metres (3-5 m with differential corrections), a velocity accuracy of 0.05 m/s steady state, and can operate from temperatures of -15°C to 70°C (Garmin, 2002). This unit also costs half the price of a GPS V, approximately $300 CDN. The GPS V's built-in road maps and trip navigation is the major difference between the two units. Functionally, these extras were unnecessary for the study.

In order to maximize trackpoint memory, while achieving data precision, an "automatic" interval setting, with "medium" resolution was used. Points were sampled at 15-20 second intervals while the vehicle was in motion, and at a higher rate when the vehicle was making a complex maneuver, such as making a sharp turn. Few or zero points were sampled while the vehicle was stationary. Three initial tests were conducted with this setting on the GPS units, and it proved precise enough to determine trip starts, routing, and trip ends from the collected data.

ESRI's ArcView GIS 3.3 was chosen primarily because of researcher familiarity and the availability of appropriate base maps in ESRI format.

A study criterion required participant GPS data collection durations for at least 48 hours, with 72 hours being preferable. The most convenient power supply for this purpose is the vehicle's battery,

however, some vehicles do not provide outlet power when the ignition is in the 'off' position. Because of this, an external 12V power pack was utilized for the study.

Following the collection of the GPS data, an interview (either telephone or in person) was arranged where the subject could participate in stated-adaptation surveys and add critical information regarding each trip link, such as purpose or the presence of passengers. However, before the interviewer could undertake this step, it was necessary to transform the data from raw numerical information to graphical geographic representations of the trips.

Points tracing the vehicle's travel paths were delineated on the GIS base mapping using a graduated colour legend to represent varying travel speeds (organized in 20 km/h intervals, from 0 – 120 km/h). This made it easier to identify stops due to traffic control devices or short drop-off trips.

To satisfy the study's second primary goal (i.e., to develop a comparison of elderly rural and urban travel behaviours), the collected data were reviewed and compared to information from traditional travel diaries, or survey studies of older drivers. This ensured that the information collected through this study offered an improvement on existing travel data. Some of the key findings are presented in the following section.

4. Study Findings

A total of 39 elderly subjects participated in the pilot study. Data collection varied from two to four days depending on equipment availability and scheduling. Data collected for two participants were excluded from analysis because of extreme travel circumstances. For example, it was discovered that one subject was a part-time door-to-door salesperson. The net result was that 43 person-days of travel data were collected for the rural elderly, while 45 person-days were gathered describing urban seniors. Because of this sampling method, noted differences between urban and rural elderly drivers in this study cannot be expressed with statistical significance. However, general

trends and averages are discussed, along with marked differences noted between the two groups. Urban and rural participant data were normalized by expressing travel per participant-day, so that general comparisons could be made. This information provides valuable insight into senior travel behaviour not identified by written trip diaries, and aims to demonstrate the applicability of the data collection on a larger scale.

Most of the participants were between the ages of 65 and 75 years of age. Of the three women younger than 65 years, all were 64 years old and the spouses of older male participants. Six rural and five urban seniors over the age of 75 participated. The results are summarized in Table 1.

Table 1: Distribution of Participants

	Rural		Urban	
Age	Male	Female	Male	Female
< 65	0	2	0	1
65-75	8	4	8	4
>75	3	4	5	0

4.1 Trip Characteristics

This section presents an analysis of the collected data, and employs various descriptive terms. For clarity, these terms are defined below:

- **Trip (or round trip)**: Travel characterized by participants leaving their Home, performing a task or series of tasks, then returning Home. A trip is composed of a series of trip links.

- **Trip link (or link):** The one-way path connecting an origin and destination. A trip is composed of a minimum of two trip links: Home (origin) to Desired Location (destination), and Desired Location (origin) to Home (destination).

- **Trip chain**: Refers to a minimum of two trip links in series, where sequential trip link destinations are not Home, but another Desired Location.

4.1.1 Trip Frequency

When trip frequencies were analyzed, it was found that urban seniors engaged in, on average, 2.1 trips per day, while rural seniors performed 1.7 trips per day. As the data in Figure 1 show, there is a fair degree of variability in the survey data.

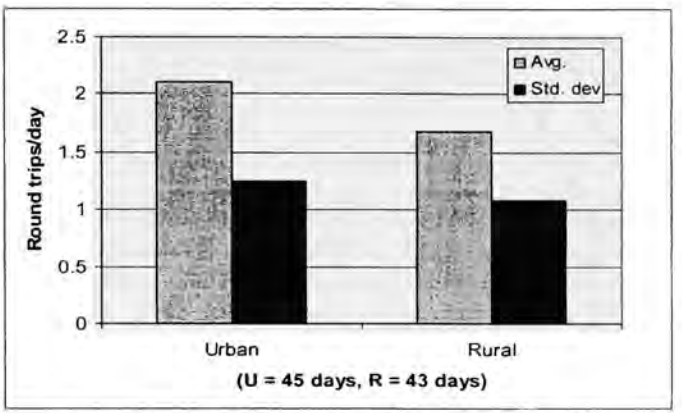


Figure 1: Average Number of Round Trips per Day

4.1.2 Trip Chaining

Trip frequency cannot be considered in isolation of the number of stops or activities included in each link. Trip links refer to the one-way path connecting the nodes of an origin and destination. A chain refers to sequential trip links. Consequently, a round-trip with one destination would consist of two trip links, one being to the destination, and the other the return segment. Figure 2 contrasts the

number of links per trip for both rural and urban seniors. The frequency of simple two-link trips for urban seniors was 1.68 times higher than for rural seniors, and remained generally higher for three and two-link trips. Conversely, rural seniors had a higher proportion of trips with five or more links. When compared with the data presented in Figure 1 that show rural seniors perform fewer round trips per day, it is not surprising to find that they chain more activities together during each trip. This is most likely because they live further away from their desired destinations.

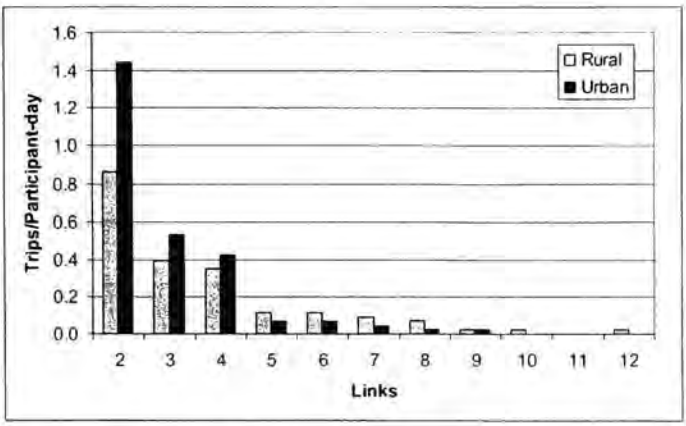


Figure 2: Frequency of links per trip

4.1.3 Trip link length

Urban seniors had a higher frequency of trip link lengths less than 10 km (1.87 times the rate of rural seniors); however, rural seniors had 1.86 times the urban rate of trips less than 1 km. This frequency of shorter trip links by rural seniors may suggest that they use their vehicles for tasks that urban seniors would complete by other modes or that they are more likely to string together multiple stops in a single trip where those in urban areas would use multiple trips. Figure 3 shows that very few of the urban seniors drove further than 10 km in a

trip link. Rural seniors experienced high rates of trip links greater than 20 km, accounting for almost one-fifth of all of their trip links. As most rural participants lived greater than 20 km away from urban centres in the study area, this was not unexpected.

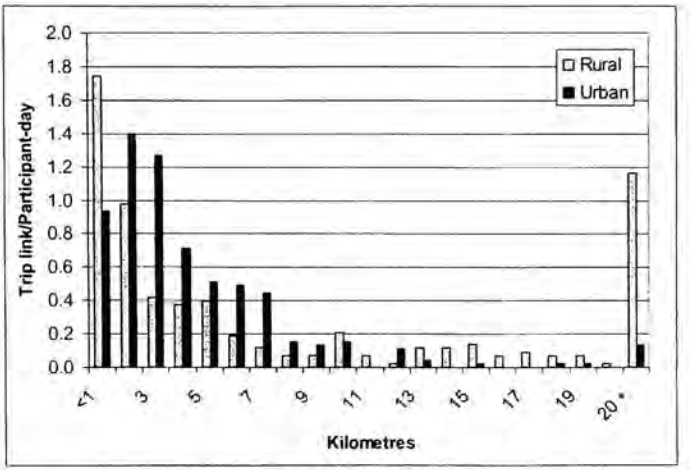


Figure 3: Trip Link Lengths

4.1.4 Trip Start Times

There are several similarities in trip link start frequency patterns between rural and urban seniors, as the data show in Figure 4. In contrast with younger age groups, there are very few trip links started prior to 8:30-9:00 am, and frequency patterns follow similar patterns through much of the day. A major difference observed is the higher trip link start frequencies for rural seniors versus urban seniors from 10:00 am to 1:00 pm and 6:30 to 7:30pm. These data suggest that overall rural seniors in this study performed their trips approximately one to two hours prior to those of the urban seniors. Finally, it is important to note that trip-making is much more curtailed after 7:30 pm among the rural elderly. This is consistent with difficulties the

aged have with vision after dark and the predominately non-illuminated conditions in rural areas.

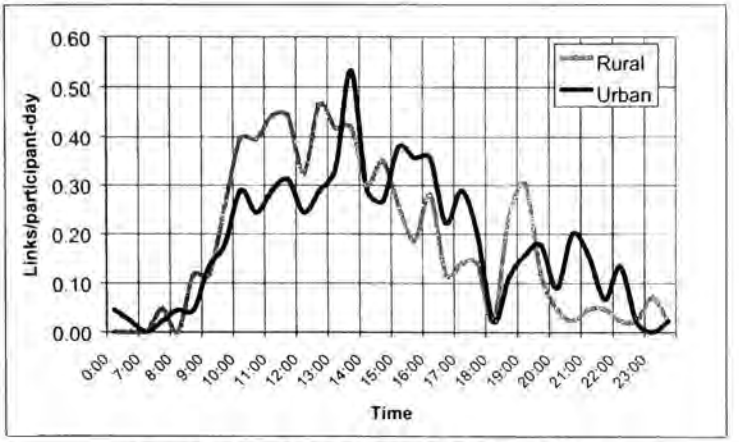


Figure 4: Rural and Urban Trip Link Starts

4.1.6 Passenger Trips

Rural seniors traveled with one or more passengers during 39% of their trips, compared to 24% of the urban seniors. For the rural senior, 6% of all trips involved two or more passengers compared to only 2% of trips among the urban elderly. These trends are important because it has been shown that some seniors tend to compensate for diminished capabilities through the use of 'co-piloting'. The findings may also reflect a reliance among seniors to travel with friends or family when they discontinue driving.

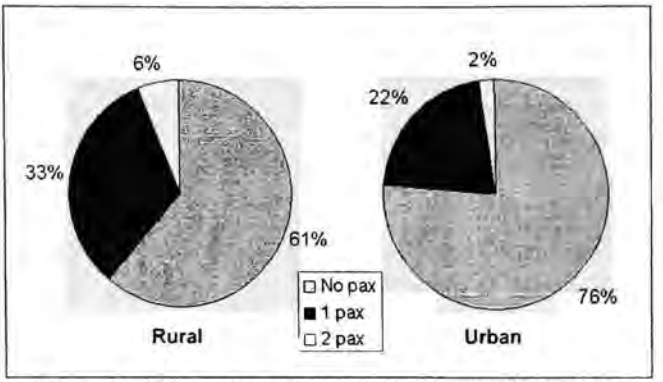


Figure 5: Proportion of Elderly Trips with Passengers

4.1.7 Trip Purpose

Trip purposes were garnered from the interview that followed the GPS survey. Various responses to trip purpose were recorded, and then assigned into two broader categories consistent with Carp (1988), and further subdivided based on frequency of participant responses:

Life Maintenance – trips associated with maintaining life including:

- Shopping (groceries, convenience, hardware, etc)
- Personal errands (mailing a letter, banking)
- Vehicle errands (fueling up, vehicle maintenance)
- Work
- Medical related (visiting a doctor, buying prescriptions)

Higher order - trips associated with well-being including:

- Social trip (visiting, recreation, pleasure drives)
- Pick up/drop off (shuttling trips)
- Dining out
- Lending vehicle
- Errands for others
- Volunteer work
- Church/educational

Excluding return trips, life maintenance and higher order needs trips were split nearly evenly for both rural and urban seniors. The most frequent life maintenance trip for both groups was shopping, followed by personal errands, as depicted in Figure 6. Urban seniors had a higher frequency of shopping trips; however, this may be due to their proximity to shopping venues and lessened propensity to chain activities together. Rural seniors had a higher incidence of personal and vehicle errands. As rural seniors were shown to drive further than their urban counterparts, trips for fuel were more common. Urban seniors had a higher incidence of medical related trips.

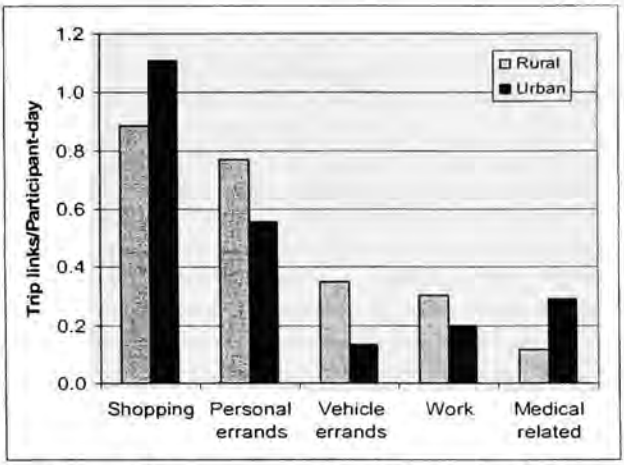


Figure 6: Frequency of 'Life Maintenance' Trips

The most frequent higher order trips were social-related, as shown in Figure 7. Interestingly, rural seniors performed 1.56 times as many social trips as their urban counterparts. The second most frequent trip-making for both groups was passenger pick-up/drop offs. There was a slightly higher incidence of dining out for rural seniors. The less frequent trips included loaning of their vehicle, running errands for others, volunteer work, and church/educational. It is likely that the number of church-related trips would be more frequent if the sample had not concentrated mainly on weekdays.

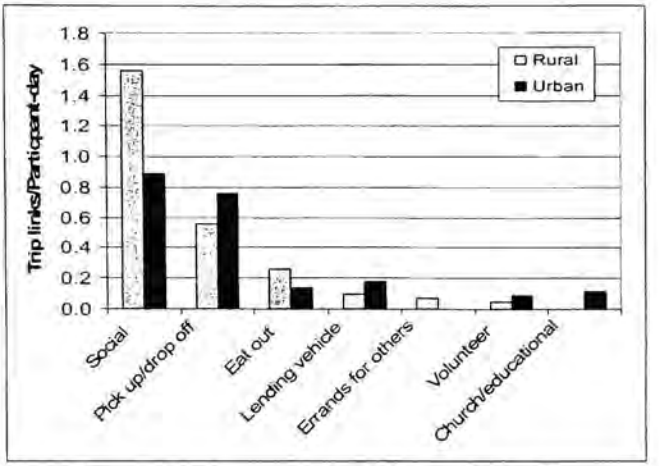


Figure 7: Frequency of 'Higher Order' Trips

4.2 Measures of Exposure

The data presented in Table 2 summarize study findings regarding variables that can be used to describe exposure including total daily travel time, daily distance traveled, and average link speed. It is clear that for those seniors living in rural areas, their travel needs result in increased exposure regardless of the metric used. Although the results are not presented in this paper, an increased level of detail is possible where other factors such as road class, speed limit, time of day (and corresponding traffic volumes), number of intersections (by control type), etc. can be detailed for each respondent using the GIS base mapping in combination with the GPS data. These kinds of variables are extremely important when one evaluates accident involvement rates by comparing to other age cohorts.

Table 2: Summary of Elderly Driver Exposure Estimates

	Rural	Urban
Daily Travel Time	1:05 hours	0:43 hours
Daily Distance Traveled	63 km	24 km
Average Link Speed	45 km/h	30 km/h

5. Discussion

The methods employed in this survey were very time consuming. Although installation of the unit and orientation with participants usually took just a few minutes, interviewer transit times were much longer when engaging rural participants. Post survey data processing was the most time consuming task, taking two hours on average per participant. Nevertheless, the richness of the data collected provides an opportunity for policy-makers to explore the impact of alternative transportation services. Furthermore, a much more valid comparison of accident involvement can now be made given added dimensions of driver exposure.

Although the results are not presented in this paper, elderly subjects were asked to explain how they might alter their trip-making in light of different hypothetical restrictions on their driving licenses (e.g., no night driving, no driving on high speed roads, license revoked, etc.). The ability to review plots of their recent trip-making with a GIS interface proved very valuable with both recall and strategizing adaptations. Anecdotally, the majority of participants were not concerned if under one scenario they were not permitted to drive at night; however, nearly every participant, both urban and rural, would consider themselves severely affected if they could not drive at all. Urban seniors were able to identify alternate means of transportation they could take, such as the bus or taxi, but rural seniors indicated they would need to rely more on family members or even relocate to an urban area.

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Characteristics of Weekend Travel in Calgary

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INTRODUCTION

The analysis of urban travel demand has focussed almost exclusively on weekday patterns of behaviour, mostly on weekday peak periods and on the AM peak period (or peak hour) in particular. By implication, the estimation of the user benefits and community and environmental impacts associated with transportation policy alternatives has been limited to consideration of weekday and weekday peak-period conditions. But people also travel in their cities on weekends, enjoying the benefits of such travel and contributing to externalities – and congested conditions sometimes arise at such times. A more complete analysis of the implications of urban transport policy options would include consideration of weekend conditions, taking account of the differences in the patterns of such travel demand – with its different purposes, directions, times and volumes.

This paper describes an investigation of weekend travel patterns in Calgary undertaken as a prelude to the development of a model of weekend travel for use in the analysis of the weekend-related implications of potential policy alternatives.

CALGARY HOUSEHOLD ACTIVITY SURVEY

A survey of personal activity patterns and associated personal travel, called the 'Household Activity Survey' (HAS), was undertaken in the Calgary Region in late 2001 and early 2002 in order to obtain data required for the re-calibration of the Calgary Regional Transportation model. A total of just over 8,400 interviews were conducted with households, covering all trips over 100m made on specified 'survey days'. This included – by design – approximately 2,200 interviews where the survey day was a weekend day. The resulting sample provides indications of the nature of weekend travel in terms of generation rates, purposes, mode use and patterns in time and space. Some of these indications are presented and discussed below, in comparison with the corresponding elements of weekday travel. As such, this provides some insight into a little-known yet significantly large component of urban travel.

WEEKEND TRAVEL CHARACTERISTICS

Trip Generation by Purpose: Figure 1 compares the distributions of trip purposes for weekdays and weekends. Consistent with expectations, on weekends there is relatively less trip-making between home and work and school and relatively more trip-making between home and shopping and other activities.

Figures 2, 3 and 4 show the numbers of trips by purpose and person category for weekdays, Saturdays and Sundays. The same scale is used in Figures 2 through 4, allowing direct comparisons among the indications in all three Figures.

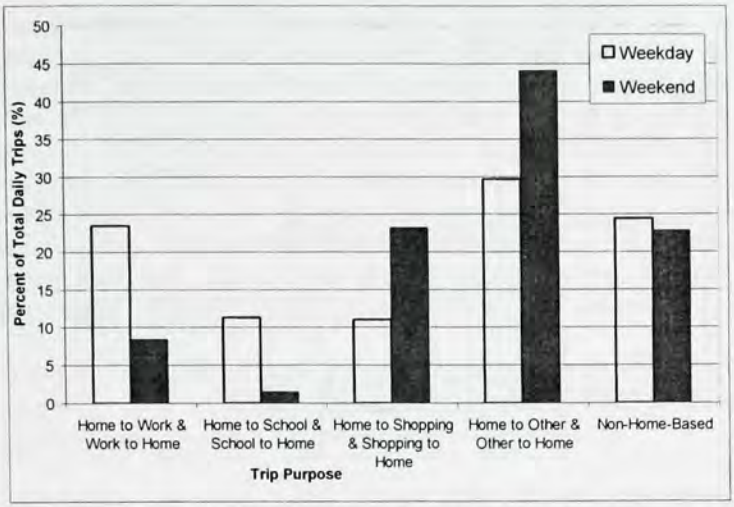


Figure 1: Distributions of weekday and weekend trip purposes

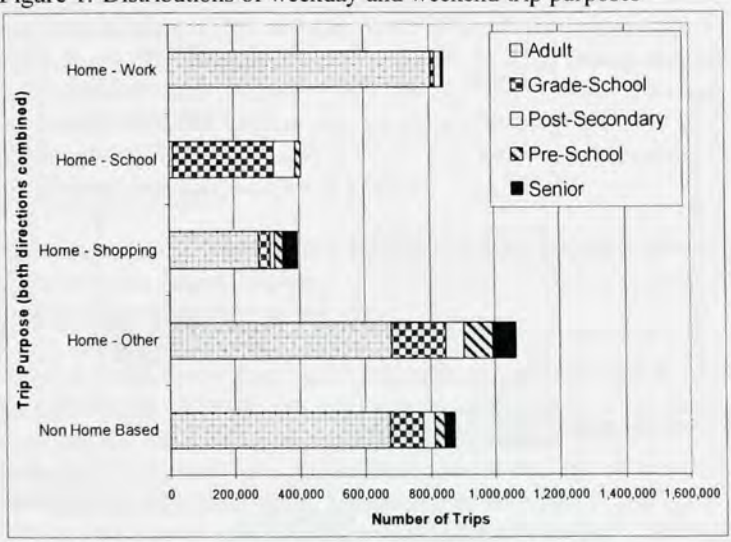


Figure 2: Numbers of weekday trips by person and purpose

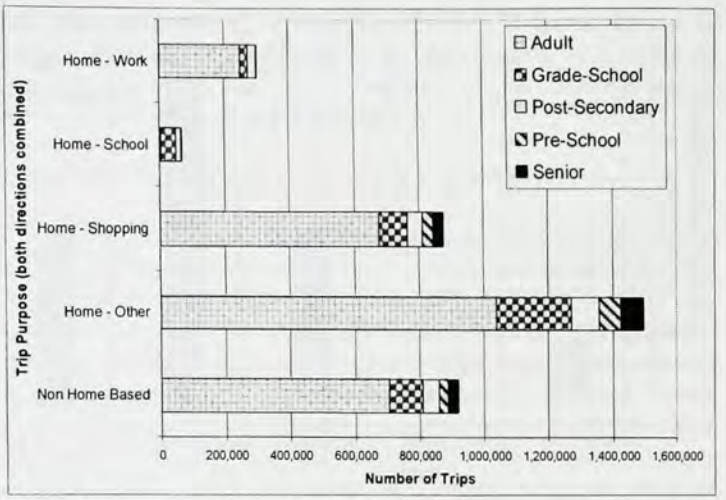


Figure 3: Numbers of Saturday trips by person and purpose

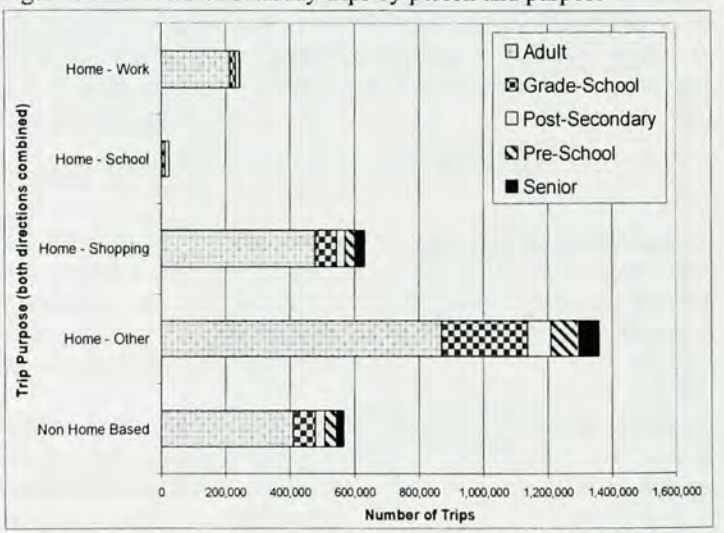


Figure 4: Numbers of Sunday trips by person and purpose

The greatest number of home-other trips (which includes both the home to other and the other to home directions) are made on Saturdays, when almost 40% more home-other trips are made than on weekdays. The number of non-home-based trips is about the same on Saturdays as on weekdays. The numbers of home-work trips on the weekends are only about 25 to 30% of the number on weekdays. Adults tend to dictate the patterns on all days for all purposes except home-school. Grade-school children dictate the patterns for home-school trips, and also contribute somewhat to the patterns for other purposes.

Home to Work Trips: Figure 5 shows the distribution of trip lengths and Figure 6 shows the distribution of mode use for home to work trips on weekdays, Saturdays and Sundays.

Trip lengths tend to be shorter on weekends, with relatively greater proportions for the very shortest distances in particular. This is consistent with the notion that the greater amount of weekday work by the primary 'bread-winners' in households is employment that has been selected with relatively less concern about travel distances, whereas the weekend work is more casual and part-time work by other family members that has been selected with relatively more concern about travel distances from home locations.

The comparatively low and then high proportions for the 4 to 6 km and 6 to 8 km ranges, respectively, for Sundays is likely due to small sample size and resulting sample error.

There is a shift away from transit and park and ride use and to more auto passenger and walk use for home to work travel on weekends, with slightly more auto passenger and walk use on Sundays. The proportions of transit use on weekends are about half of those for weekdays, going from about 10% to 5% of all home to work trips. The proportions of auto passenger approximately double. The auto driver proportion actually drops slightly on Sundays.

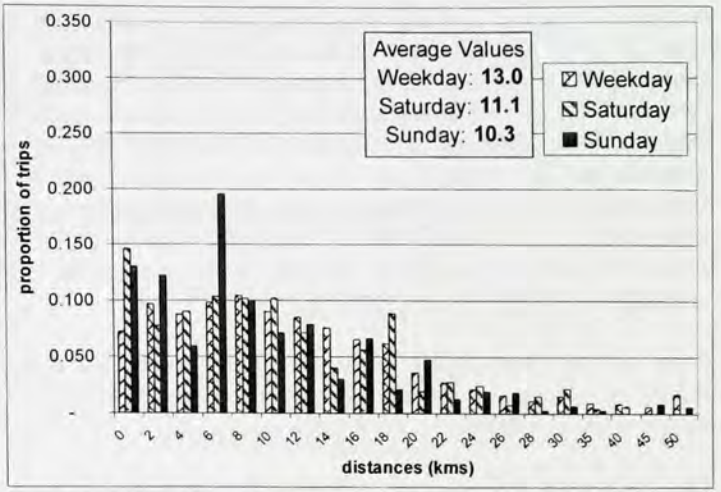


Figure 5: Distribution of trip lengths for home to work trips

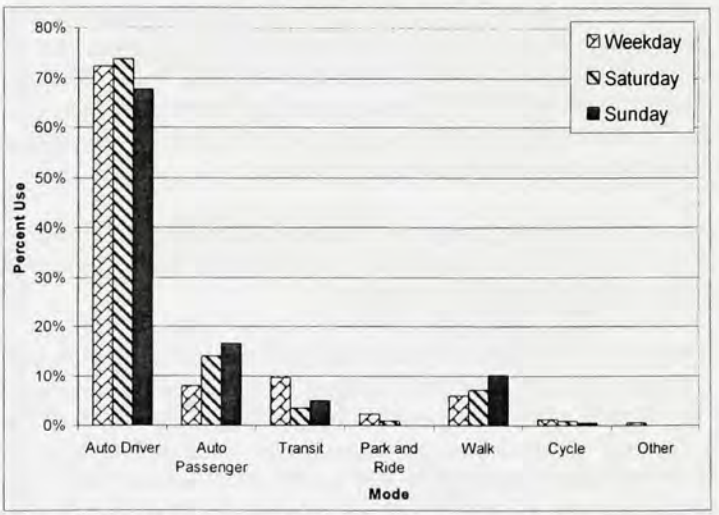


Figure 6: Distribution of mode use for home to work trips

Home to Shopping Trips: Figure 7 shows the distribution of trip lengths and Figure 8 shows the distribution of mode use for home to shopping trips on weekdays, Saturdays and Sundays.

Relative to weekdays, home to shopping trips tend to be somewhat longer on Saturdays and slightly shorter on Sundays. Saturdays tend to have greater proportions of their trips in the longer distance ranges, beyond 10 kms. Weekdays tend to have the greatest proportions in the 2 to 8 kms range. This is consistent with the idea that households have a tendency to make their more extensive shopping 'expeditions' on Saturdays in particular.

The proportion using the auto driver mode for home to shopping trips goes down somewhat on weekends, whereas the proportion using the auto passenger mode goes up by similar amounts on both Saturday and Sunday. It may be that this is reflecting an increase in the amount of family group travel for shopping activities on weekends.

There is a small increase in the proportion of trips using walk on weekends. There is also a decrease in the proportion of trips using transit on weekends, going from about 3% on weekdays to about 1% on both Saturdays and Sundays, which is slight in aggregate but large in relative terms. There is virtually no use of park and ride and cycle at any time.

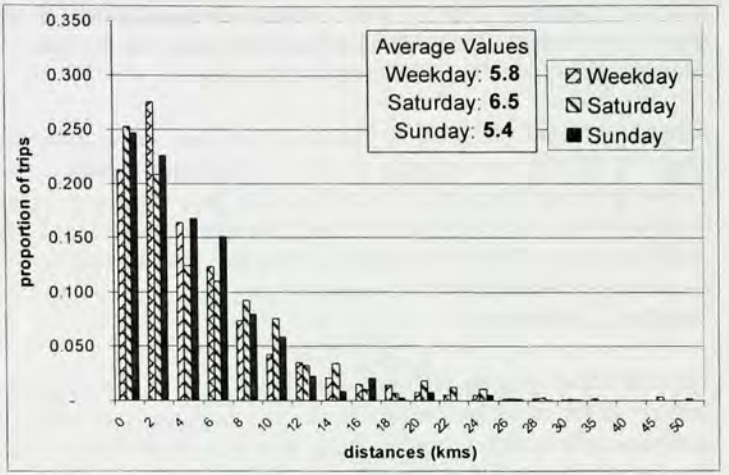


Figure 7: Distribution of trip lengths for home to shopping trips

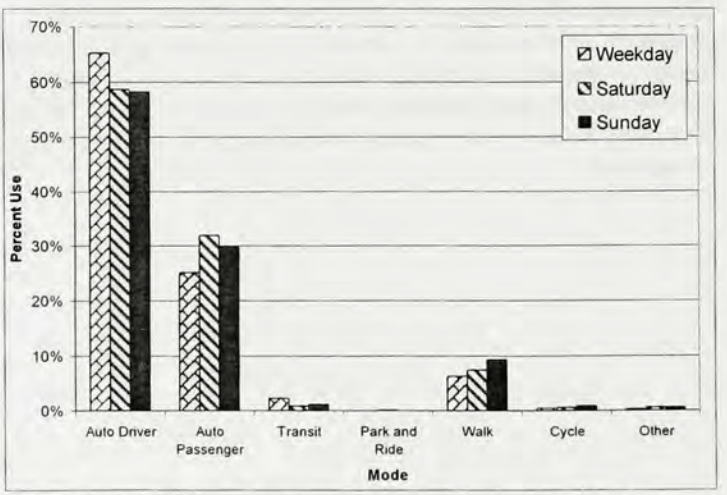


Figure 8: Distribution of mode use for home to shopping trips

Home to Other Trips: Figure 9 shows the distribution of trip lengths and Figure 10 shows the distribution of mode use for home to other (non-work and non-shopping) trips on weekdays, Saturdays and Sundays.

Home to other trips tend to be quite a bit longer on both Saturdays and Sundays than on weekdays. The average trip length goes from 6.7 kms on weekdays to 9.0 kms on Saturdays and 8.9 kms on Sundays, an increase of almost 35%. There is a large proportion of very short trips on weekdays: almost 30% are less than 2 kms in length, compared to about 20% for weekends. The proportions are greater on weekends, particularly on Sundays, for almost all distance ranges greater than 6 kms.

The proportion of home to other trips by auto driver drops on the weekend, moreso on Sundays than on Saturdays. The proportions using transit and walk also go down on the weekend. The shifts for walk are comparatively large. The proportion using walk on Sundays is about half of that on weekdays. It is the auto passenger that increases on the weekend, again, moreso on Sundays than on Saturdays. The patterns in transit use proportions on weekdays and weekends for home to other trips are very similar to those for home to shopping trips: the comparatively small proportion of use on weekdays is reduced even further on Saturdays and Sundays.

The shifts in trip lengths and mode use proportions outlined above are consistent with the idea that households tend to travel more as groups to more wide-ranging 'other' (non-work and non-shopping) activities on the weekends, with perhaps even a bit more group travel on Sundays than on Saturdays.

There is a slight increase in the proportion of home to other trips by cycle on Sundays, which may be the result of a more recreational element to the 'other' activities on Sundays in particular.

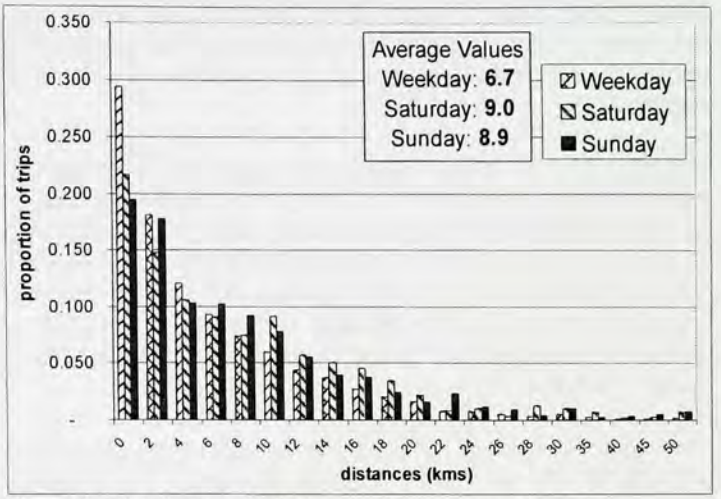


Figure 9: Distribution of trip lengths for home to other trips

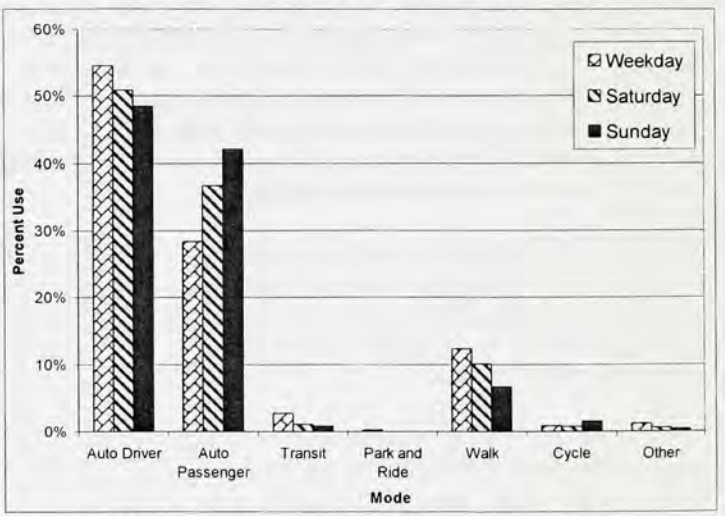


Figure 10: Distribution of mode use for home to other trips

Home to Other Trips: Figure 11 shows the distribution of trip lengths and Figure 12 shows the distribution of mode use for non-home-based trips on weekdays, Saturdays and Sundays.

Similar to the situation with home to other trips, non-home-based trips tend to be longer on both Saturdays and Sundays than on weekdays. In this case the average trip length does not increase quite as much, particularly for Saturdays: going from 6.4 kms on weekdays to 7.8 kms on Saturdays (a 22% increase) and to 8.4 kms on Sundays (a 32% increase). The proportion of very short non-home-based trips is very large on weekdays: about 32% are less than 2km in length, compared to less than 20% on Saturdays and 15% on Sundays. The proportions are greater on weekends, particularly on Sundays, for almost all distance ranges greater than 2 kms.

The proportion using auto driver decreases a bit on Saturdays and a little more than a bit on Sundays. The proportion using walk falls dramatically, from almost 20% on weekdays to about 4% on Saturdays and about 3% on Sundays. The proportion of non-home-based trips using auto passenger more than doubles, from about 18% on weekdays to about 36% on Saturdays and more than 40% on Sundays.

The much larger proportions of very short distances and of walking mode use on weekdays likely reflect, among other things, the large quantity of workplace-based personal travel, largely at noon around lunch, that is much more prevalent on weekdays. The dramatic shift to auto passenger on weekends is similarly consistent with the notion that there is much more wide-ranging, family-based group travel with multiple-stop tours on weekends, building on the ideas expressed above concerning home to shopping and home to other travel.

The transit use proportions display a very similar pattern to the patterns they displayed for home to shopping and home to other travel. And, again, there is virtually no park and ride or cycle use at any time, with the exception of just a very slight bit of cycle use on Sundays.

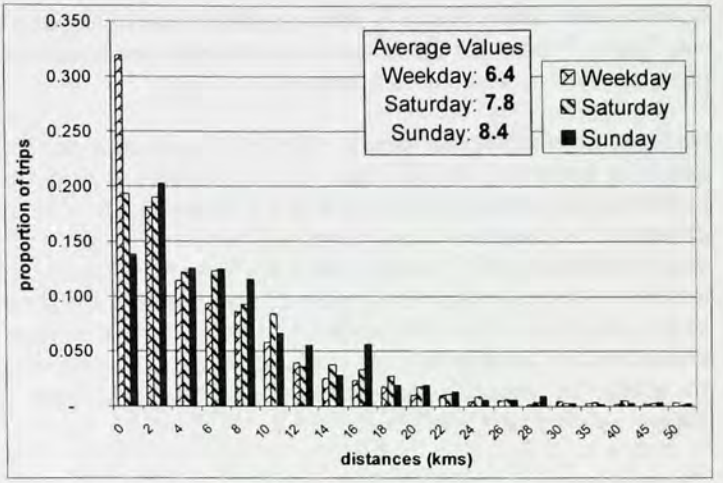


Figure 11: Distribution of trip lengths for non home based trips

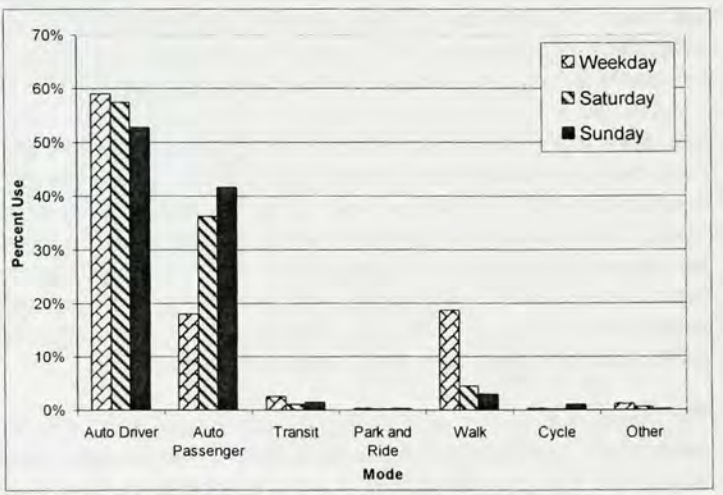


Figure 12: Distribution of mode use for non home based trips

The Household Activity Survey collected information about personal activity patterns along with personal travel. This information about activity patterns helps put travel behaviour into context, aiding in the interpretation of the travel patterns that are observed.

Figure 13 compares the average times spent on different categories of activities on weekdays, Saturdays and Sundays.

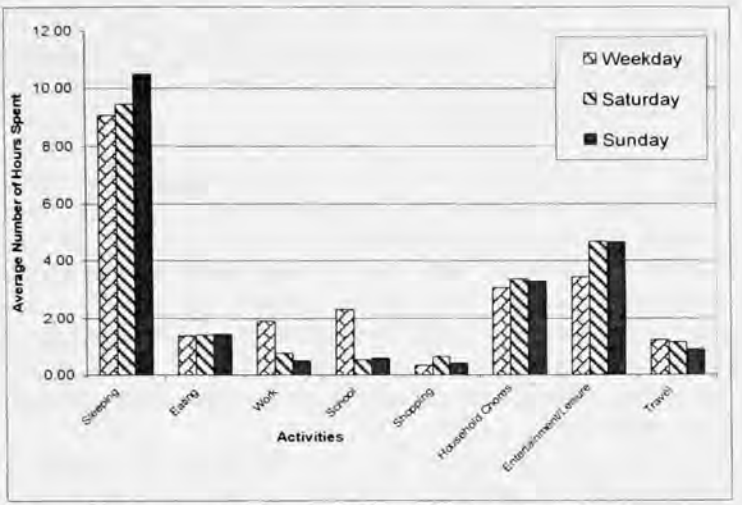


Figure 13: Average times spent on activities by all persons

The time spent on work and school activities drops dramatically on Saturdays and Sundays. School activities also tend to shift in nature and location, from in-school to in-home, homework-related pursuits. This is consistent with the reductions in quantities of home-work and home-school travel on weekends identified above.

The time spent on shopping increases on Saturdays in particular – consistent with the ideas expressed above about more extensive wider-ranging, group-oriented shopping 'expeditions' being undertaken on

Saturdays. The time spent on household chores, entertainment/leisure and sleeping also increases on weekends. This reduces the amount of travel outside the home and shifts travel to other entertainment/leisure activities outside the home, as observed above. The time spent travelling is slightly lower on Saturdays and more substantially lower on Sundays, consistent with increased amounts of time spent at home.

RESULTING TRAFFIC VOLUMES

The overall result of the patterns of travel on Saturdays and Sundays is less travel and different sorts of travel to different places at different times compared to weekdays.

Figure 14 displays the 24-hour roadway traffic volumes on weekdays, Saturdays and Sundays that typically result at specific locations. These volumes are consistently somewhat lower on Saturdays, and more substantially lower on Sundays. But the greater amounts of home-shopping, home-other and non-home-based travel with greater proportions of auto use can lead to higher traffic volumes on weekends than on weekdays at some locations at some times of the day, particularly on Saturdays near large shopping and recreational centres, which is common in Calgary.

CONCLUSIONS

Data collected in Calgary has indicated the travel patterns and associated activity patterns occurring on Saturdays and Sundays, and has allowed these patterns to be compared with those for weekdays. Main findings are that on weekends, compared to weekdays, there is:

- more travel for shopping and recreational/entertainment purposes;
- less travel for work and school; and
- various shifts in mode use, primarily from public transport to car passenger, consistent with more travel by larger groups.

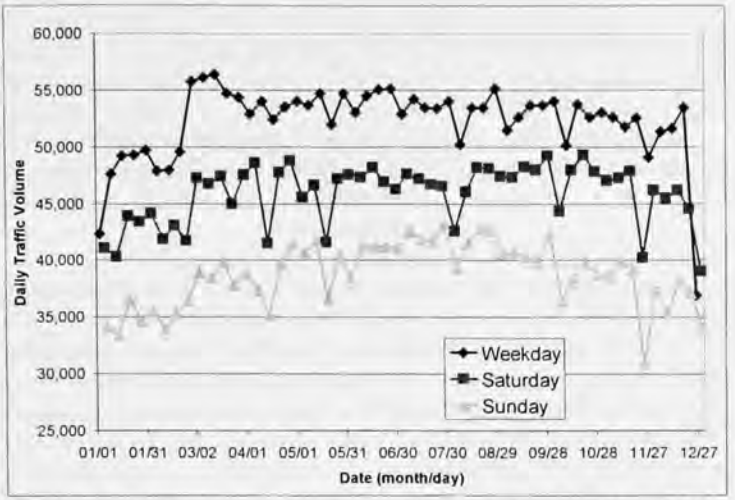


Figure 14: Traffic count volumes on 16th Ave at Deerfoot Tr in 2001

Thus, while the overall amount of travel is less on weekends, it is still possible that at times traffic flows and congestion around shopping and recreation areas can be greater on weekends than on weekdays.

Differences in the activity patterns giving rise to the differences in travel patterns were also considered. The findings regarding activity patterns are largely consistent with general perceptions about the differences between weekdays and weekends for households, and help explain the differences in travel patterns.

The results presented here expand our understanding of travel patterns, particularly those occurring on Saturdays and Sundays, but also, by contrast, those occurring on weekdays too. The directions (+ /–) of the differences between weekdays and weekends are all as expected – and perhaps could have been anticipated correctly *a priori*. But the work reported here has also provided insight and clarity into the magnitudes, rather than just the directions, of such differences.

Methodology and Tool for the Canadian Shippers to Support a Sustainable Freight Transportation System

Introduction

Stockholm, 1972, Vienna, 1985, Rio Summit, 1992, Kyoto Protocol, 1997... The international awareness about environmental issues is still maturing. Actions have gone from isolated and limited initiatives to a world-wide recognition of ecological problems among which figure the climate changes and their economical, social and environmental consequences. The increase in fossil energy consumption was identified as one of the major issue to address in the decades to come (United Nations, 1992). The countries that ratified the Kyoto Protocol initially committed to reducing their greenhouse gas emissions (GHG) by 5,2 % from the 1990 reference levels. Hence, the most polluting industrial sectors were grouped together under the term "Large Industrial Emitters" [1] (LIE) and several international and national strategies were put forward e.g. trading emissions rights, access to compensations, international licences. A compendium of procedures supported by extensive scientific research was negotiated in order to develop viable and reliable environmental alternatives.

One may ask: What about the transportation sector? Although excluded from the priorities negotiated at Kyoto, people and goods transportation remains at the heart of the GHG production. In Canada alone, the transportation sector accounts for a quarter of the total GHG emissions in 2000, that is 179 megatonnes of CO_2 equivalent (Environment Canada, 2002). During the 1990's, the transportation sector "contributed" 27,9 % of the additional

[1] The LIE include three sectors: thermal electricity, oil and gas, as well as mining and manufacturing.
(http://www.climatechange.gc.ca/french/publications/offsets/keyelements_html).

119 megatonnes of GHG emitted in Canada. Furthermore, of the additional 33,2 megatonnes, two-thirds were attributable to freight transportation (Environment Canada, 2003). Notwithstanding these numbers, nothing concrete was developed to modify the current modal transportation practices in Canada. The promotion of complementarities and/or shifts between transportation modes hardly went beyond the stage of good political intentions.

Considering the above, Maritime Innovation and Robert Hamelin & associés shared their expertise to propose methodological principles that could underlie a decision-making tool with regards to sustainable freight. This project stems from the hypothesis that because of their decisions capacities with regards to modal transport, shippers are in command when it comes to sustainable freight. Thus, the aforementioned tool proposes the basis for a GHG emissions calculation system related to freight transportation and developed specifically for shippers.

In the first part of this paper, we emphasise the results of a literature review pertaining to methodological principles already developed to promote modal shifts aimed at a reduction of GHG. Then, the computerised calculation system components are discussed along with a proposal for a transportation database and the development of a cartographic interface by means of a geographical information system (GIS). Lastly, the identification of incentive measures and their implementation, underline the importance of governmental commitment in the stimulation of a true sustainable development for the transportation sector.

From the Canadian Situation to the European Achievements: Overview of the Main Policy Trends Related to Sustainable Modal Transportation

Although far from being exhaustive, the international literature review about the complex problem of sustainable freight, has brought to light several diversified methodological approaches. Furthermore, it appears that at present time, the focus of the debate lies between

two industrial poles represented by North America and Europe. Since they are subjected, each at their own scale, to dictates of changes in the modal approaches, the most innovating solutions originate from transportation policies and practices developed on both sides of the Atlantic.

Straight off, it is necessary to specify that the literature review has concentrated on initiatives supporting transfer practices and complementarities between transportation modes. Research were limited to political frameworks originating from several multidisciplinary studies related to the environmental, economic, social, tax or regulation aspects of freight transportation. If one restricts even more the geographical field of analysis, it is accepted that Canada and the European Union do not necessarily have the same framework of modal practices development (Transport Canada, 2003, European Community, 2001, European Conference of Ministers of Transport, 2000).

In the Canadian context, one can refer to a first series of consultations which were undertaken as early as 1996 by Transports Canada, in order to develop public transportation policies under a more ecological philosophy[2]. At the time, the promotion of cleaner transportation alternatives was considered from a variety of perspectives: tariff, tax, technology or regulations. Following the

[2] *Ressources Futures Internationales*, 1996. *Le rôle de Transports Canada dans la promotion du virage écologique chez les transporteurs et les exploitants*. Document de discussion n° 2 préparé pour Transports Canada. 35 pages.
Ressources Futures Internationales, 1996. *Les subventions au transport : leurs répercussions sur l'environnement*. Document de discussion n° 5 préparé pour Transports Canada. 41 pages.
IBI Group, 1996. *Inclusion des coûts pour l'environnement dans la tarification du transport*. Document de discussion n° 7 préparé pour Transports Canada. 37 pages.
Marbek Resource Consultants, 1996. *Réduction des effets du transport sur le changement climatique et sur les autres problèmes liés aux émissions*. In : IBI Group, 1996.
Marbek Resource Consultants, 1996. *Réduction des effets du transport sur le changement climatique et sur les autres problèmes liés aux émissions dans l'atmosphère : Projet de stratégie de Transports Canada*. Document de travail. 36 pages.

creation of the *Transportation Climate Change Table* in 1998, a second series of consultations has led Canadian authorities to produce a document entitled *Transportation and Climate Change : Options for Action*. Several initiatives in favour of a change in transportation practices were put forward, one of which was the Freight Sustainability Demonstration Program (FSDP), granted with 4,5 million dollars over the period 2001-2006. To date, this remains the one and only tangible program representing a real opportunity in the modal change of practices towards cooperation/complementarities/shift modal projects aimed at GHG reduction.

As for Europe, one has to recognise that the approaches go further than those recommended at the present time in Canada. The density of traffic between the various Member States, within a more restricted geographical area, commands different modal promotion programs (Vickerman, 2002). With the counter-productive glutting of its main motorway axes, and even of its railway network, Europe of the 15, and soon of the 25, is undergoing a backlash in transport (European Community, 2003). The long surface corridors of freight transportation are becoming saturated under the double constraint of physical limitations (crossing of mountain passes for example) and the traffic density in large industrial and manufacturing areas like the German Ruhr region or the north of Italy. Space limitations have prevented building new terrestrial infrastructures, and, by the same token, have stimulated transfer and/or combinations between modes. Thus, the combined rail-road transportation brought road trailers onto trains. The new river services carry on with the development of the historical and natural network of inland transport. The future *motorways of the sea* should take off the road, millions of trucks and absorb the predicted growth of the freight exchange needs by 2010 (SSSV, 1999).

From the consequences of physical saturation and land pressure, national and community level authorities argue about, economic "counter-productivity", social dangerosity, social costs, and environmental effects. They support innovative ideas and programs,

to the advantage of transfer/ complementarity between modes (Liechti, 2002). The Pilot Actions for Combined Transport (PACT) programs represent this will for changes, with a first part (1992-1996) which was more of a pilot experiment intended to ensure the development of a second part (1997-2001). This European fund of subsidies promotes the development of combined transportation solutions within the European Community. The definition of the Pilot Actions for Combined Transport (PACT) is as follows:

> "*PACT aims at increasing the use of combined transportation by financially supporting original commercial initiatives in the field of combined transportation services. Increased use of combined transportation is regarded as a means of making transportation systems more sustainable* ". (translation).

The philosophy of PACT rested on the leverage action expected from the initial public fund injection to support more environmentally sound transportation practices. This financing was to generate a multiplier effect with a ten-fold increase of the public outlay through contributions from the proponents of alternative modal solutions. On the whole, 92 projects were implemented, representing 30 million euros. Results were unsatisfactory with nearly a third of the projects failing due primarily to economic and logistic difficulties to launch new transportation modal services. Simplification of the procedures and image improvement of the "clean" modes were added to deficiencies of the infrastructures in place and to the gaps of connection between two modes, such as the combinations rail-river or sea-river.

However, the European Community learned lessons from PACT and persists in its effort to promote a sustainable freight, while launching the new Marco Polo intermodal program. The ambition remains clear:

> "*By year 2010, contribute to the shift of a volume of goods corresponding to the predicted international road*

freight growth towards other means of transportation". (translation).

The tools and approach are refined with namely, the need for the proponent of a new "clean" service to demonstrate the number of tonne-kilometres that he targets to take off the road. Thus, 500 tonne-kilometres taken off the road are worth 1 euro. The objective consists in financing modal transportation projects and reward proponents who can make the scientific demonstration of the total number of tonne-kilometres shifted towards clean modes. Twelve billion tonne-kilometres remains the 2010 objective with European budgets which will be defined according to the success of the program[3] (CEC, 2003).

The methodological tools developed in *Marco Polo* take for granted that GHG reduction will result from a shift in transportation practices from the most polluting modes to the least polluting. Such option had already been considered by Canadian consultants back in 1999. They showed the merits of complementarities and modal shifts for the sake of the environment[4]. The demonstration rested on 5 case studies pertaining to the busiest freight corridors in Canada. However, neither systematisation nor automation of the modal shift process had been proposed.

Towards a New Approach...

This paper is meant to examine, from an original point of view, the functional opportunities of a real sustainable transportation system. First of all, the basic premise supposes that shippers can truly modify the modal organisation of transportation while considering the environmental factor. In the manner of north European avant-garde

[3] 75 million euros for the period 2003-2006.

[4] Delcan, 1999, *Assessment of modal integration & modal shift opportunities - Final Report.* Prepared for Freight Sub-Table - Transportation Issue Table. National Climate Change Process. 85p.

initiatives[5], large shippers and manufacturers are vested with some decision-making power in the organisation of their products pre- and post-routing networks. Consumers that are better informed and show greater awareness regarding the consequences of production and transportation practices of finished products are imposing increasing pressure on some of the shippers.

Consequently, a decision-making tool allowing the selection of the most ecological options of transportation based on the environmental results must be available to the shippers. The latter are responsible for the choices of transportation, which they generate. Thus, the objective of this process is to promote logistic choices of transportation taking into account the environment.

In this context, the development of **a GHG emissions calculation system related to freight transportation** proves to be interesting since it offers to the shippers a genuine **decision-making tool supporting the choices for sustainable freight** (Alix and Fournier, 2003). Four objectives are set:

- to affix a quantifiable value on the GHG emissions resulting from choices in modal transportation;
- to develop a data-processing tool allowing for the calculation of GHG emissions for all terrestrial and maritime transportation modes;
- to identify incentive measures to support the most effective modal combinations which can be initiated by the authorities;
- to make the approach profitable by ensuring the shippers of a financial or tax return because of their positive modification of transportation practices.

[5] Let us note the *Business Leaders Initiative on Climate Change* (BLICC) which gathers six international companies in favour of a change for a sustainable society and which promote actions as regards to transportation such as the transfer of cargo liner on trains (*DHL by rail and Ikea Rail AB*) or the *green logistics*.

Stakes and Challenges of the Method

In order to meet the aforementioned objectives, a five-step plan of action was initiated.

1. An international literature review aimed at collecting and compiling information with regards to air pollution generated by various terrestrial and maritime transportation modes. It is imperative to reach a scientific consensus with reference standards listing the energy performances of the transportation facilities as well as their GHG emissions. The calculations would be based on energy/tonnage/distance consumption such as kilojoule/tonne/kilometre. The current data are far from being alike and stem from various as well as complex methodologies. Consequently, the analyses will initially take the results of North-American research and simply compared them with those produced by the European and Japanese research institutions. For example, Environment Canada and Transports Canada do generate general comparison data for the pollution produced by various ground transportation modes according to their "intensity" (Table 1).

This first step of the plan of action also forces a technological watch in order to integrate, within the shortest lapse of time, ever going changes in equipment and transportation practices in North America.

Table 1
Freight Transportation in Canada and GHG emissions – 1990-2000

	1990	2000
Road Transportation		
GHG Emissions in Mt of CO_2 equiv	27.7	43.7
Shipping Activity per tonne-kilometre (billion)	74.7	165.1
Intensity – GHG per g of CO_2 equiv.	370.4	264.7
Railway Transportation		
GHG Emissions in Mt of CO_2 equiv.	6.9	6.5
Shipping Activity per tonne-kilometre (billion)	235.9	320.5
Intensity – GHG per g of CO_2 equiv.	29.2	20.2
Maritime Transportation		
GHG Emissions in Mt of CO_2 equiv.	5.0	5.1
Shipping Activity per tonne-kilometre (billion)	53.4	38.7
Intensity – GHG per g of CO_2 equiv.	94.6	132.0

Source : Environment Canada, GHG Department

2. Compiling information on road, railway and maritime equipment in North America, in an interactive database, will then be achieved. A simplification by class according to the energy performance levels of each equipment will have to be validated. Of course, a series of transportation parameters will be taken into account, e.g. the mean velocity on the route, the weight and volumes transported, the topography or the maritime currents.

Compatibility and comparability of all these qualitative data will be determined using calculation formulas of equivalence between transportation units of each mode selected. A 20-foot container, a railway wagon, a road trailer or the hold of a dry bulk coaster will have to be presented in equivalent units.

3. Then, the whole freight and equipment movement will be integrated in a flexible and convivial map support. In addition, the integration of the North-American map stock will be undertaken with the digitalisation of all the important infrastructures of ground transportation. Route modelling will be carried out using either postal codes of the origin and destination points, or geographic references, e.g. city, street.

Moreover, to facilitate the shipper's task, an interactive information system regarding the main transportation infrastructures located at the modal shifting points, has to be developed. Information on harbour equipment or availability of lifting gear at the railway siding is essential for the optimal structuring of the multimode routes.

4. The fourth step puts the shipper directly to contribution. Thus, the latter must initially establish an environmental assessment of its current and past choices of transportation. For this, he must track down all of his transportation practices to establish a preliminary assessment which will be used as a reference standard. The available data processing system will allow for the formatting of all of his transportation practices into a total of GHG equivalents, representing Year 1, the reference.

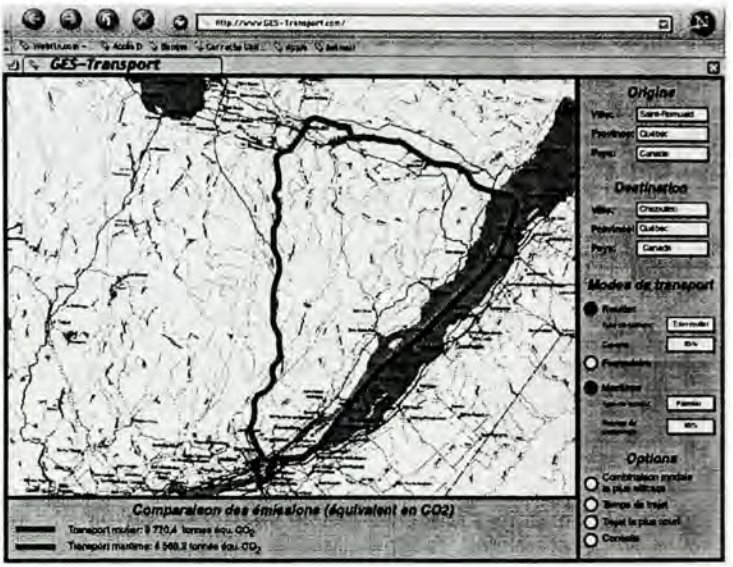
Then, the system will allow the shipper to select the transportation mode or the modal combination based on availability of the existing equipment. Various options leading to the chosen alternative, will be offered to him, among which the search for:

- the most effective modal combination in terms of GHG emissions
- the fastest modal combination
- the shortest modal combination.

To that effect, and according to its industrial, logistic, economic and environmental goals, he will be capable to simulate modal routes in just a few minutes. Then, he will have the freedom to choose the most

adequate transportation combination knowing that the software will propose straightaway the best environmental solution. His transportation options will be, to some extent, simulated, with priority given to the least GHG-emitting modal combinations.

Example of Graphic Interface and its Results



Source : Robert Hamelin & associés

5. Finally, the fifth and last step of the plan of action is crucial since it conditions the feasibility of such a process. One can affirm that nothing will change in the transportation practices without an economic, financial or tax incentive system. Most of the shippers will most certainly not modify their transportation practices if there is no payment obligation and especially, if they do not find an economic, financial or tax interest to it.

Consequently, the fifth step takes into consideration the market value of one tonne of CO_2 equivalent. This existing value could be exchanged for example, according to the Chicago Stock Exchange quotations. Based on this market, several rewarding systems for good modal practices can be suggested.

Direct subsidies payment to the shippers is a first option, once the environmental assessment of their transportation practices have been calculated and validated. Another option is the creation of fiscal profits calculated from the data compiled on the computerised GHG emissions calculation system and analysed by expert civil servants.

A third option could take the form of a transportation emission permit with the possibility of trading permit between industries based on their choices of transportation. The geographic limit of the permit trading area would be imposed by the responsible authorities (of provincial scale to the transnational recognition) supporting the aforementioned principles. .

The fourth option, which does not exclude in any way the preceding ones, would be a distinction, like an environmental certification, acknowledging good shipping practices. The shipper could develop marketing strategies focusing on the environmental management of its transportation activities as a promotional tool with his clients. His business would therefore have to be awarded an environmental certification given by an accredited organism.

Conclusion

As a decision-making tool, **a GHG emissions calculation system related to freight transportation** is not meant to penalise any mode in any way. This software will have to be user-friendly and as less restrictive as possible. The large shippers remain the main targets of the system without excluding the logistic integrators and NVOCC (*Non-Vessel Operating Common Carrier*), the large manufacturers or the retail companies. The objective is to reach structural changes in the arrangement and organisation of the modal combinations of freight transportation. These same changes will become one of the logistic solutions with a view to reduce the total GHG emissions of the transportation sector.

This initiative was developed for a North American context, which does not exclude in any way its applicability to other industrialised groups, such as the European Community or the Japanese archipelago. The solutions to environmental problems become a whole market in itself.

Though, the present reflexion raises several questions. How can the Canadian shippers be supported by the use of such a software package in their competing and strategic positioning throughout the world-wide market? Also, how can such an initiative be put forward without the commitment of authorities?

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HOW A TRANSPORT FUTURES ASSESSMENT COULD FACILITATE CANADA'S NEXT TRANSPORTATION REVOLUTION

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The Canadian Transport Futures Assessment outlined below, shortened here to 'Transport Futures', seeks to provide a new analytical approach that can contribute to improving future private and public sector decision-making about mobility options in Canada. By developing analytical methods and perspectives that can better accommodate the effects of economic, political, and technical discontinuities that are emerging to influence 21st century transport systems, Transport Futures will offer decision-makers the ability to make better informed choices than could otherwise arise from extrapolation of past trends and the extension of prior relationships among economic, demographic and other factors commonly considered in transportation planning.

Such new analytical perspectives can help reduce the likelihood that unanticipated events will leave transport providers and government

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agencies caught unprepared by sudden shifts in demand and changing expectations, as occurred following the terrorist attacks of September 11, 2001, and the SARS outbreak of 2003. Better understanding the dynamics of change in an uncertain future can pay dividends by improving the transport industry's overall capacity to adapt quickly.

A changed balance of opportunity and risk

The new analytical approaches will need to accommodate higher levels of uncertainty about the nature and implications of future threats to Canadian society, and to the transport sector that serves it, than those to which we have been accustomed. At the close of the 20th century, the range of risks facing Canada appeared relatively clear and manageable through an established set of strategies that relied upon known techniques. Just a few years later, not only has uncertainty about the extent of such risks expanded dramatically, but our collective understanding of how best to manage previously unknown risks, and respond to sudden new threats, is also in a state of flux.

In particular, the longstanding relationship between risk and opportunity that is found within the strategic paradigm of government and industry appears open to change. Past understandings of how to make effective decisions about transport options assumed a direct relationship between risk and opportunity. Precautions and mitigation measures to deal with risk could be pursued against a known (or knowable) cost, so that clear trade-offs between the benefits and costs of risk management options could be formulated. Today, considerable uncertainty about both the nature of risk and the scope for opportunity in the transport sector throws the longstanding relationship between risk and reward into some doubt.

This elevated level of uncertainty, and its influence on the relationship between risk and opportunity thus warrant greater levels of vigilance and innovation in Canadian transportation research. Transport Futures, as outlined below, could improve the capacity for strategically managing the relationship between opportunities and risks produced by transport activity over the coming decades.

New opportunities presenting a different calculus for transport planning efforts can be expected to arise from at least three dynamics, all increasingly apparent. First, the widespread adoption of intelligent transport systems offers considerable potential to improve productivity and enhance the safety and security of people and goods in motion. Second, new kinds of organization are emerging to provide mobility in innovative ways and with lower costs than previously considered possible. They range from new low-cost air carriers to third-party logistics providers to local car-sharing cooperatives. What these diverse organizations have in common—and what separates them from traditional entities that have provided much of Canada's 20th century mobility—is their ability to catalyze new configurations of transport inputs, notably labour, technology, and energy, and translate them into high-value mobility outputs. Third, consumer preferences for more flexible, healthy, and active lifestyles—reflective of Canada's more diverse and worldly population—could create new niches in the marketplace for transport innovations.

Previously deferred problems

As new opportunities emerge, challenges from the unsustainability of established transport trends create pressure to deal with previously deferred problems. One problem is that transport's energy demands could outstrip the supply of low or moderately priced hydrocarbon fuels before substitute fuels are readily available.[1] Another arises from the ways in which transport development has influenced spatial configuration, enabling 'sprawl' to become a prominent feature of the North American built environment.[2] Many costs of such low-density development have been deferred. Dealing with them will necessitate new regulations on, and/or ways of charging for, urban transport. The spatial challenges include the fiscal costs of renewing extensive infrastructure and the health and social costs arising from 'auto-dependent' lifestyles. A third challenge arises from Canadian transport's production of environmental pollution that exceeds the absorptive capacities of local and global ecosystems, harming much life.[3] Children, the elderly, those living near well-used transport routes and terminals, and others bear a disproportionate burden of adverse health and social effects.[4]

Integrating insights through four stages of analysis

Dealing with such an array of opportunities and challenges calls for incorporating a broader accumulation of knowledge into analytical efforts than has often been the case in transport analysis. The conceptual core best suited to creating both intellectual integration and analytical innovation is grounded in the social sciences, whose disciplines will provide an intellectual foundation for Transport Futures. Such an approach does not seek to bring much that is 'new' to considering transport issues and options, but it does seek to forge new connections among numerous perspectives that have often been pursued in isolation from one another, and thereby draw new insights.

Most studies of transport and its impacts make use of a subset of social science tools and techniques. Engineers use the economic technique of benefit-cost analysis to evaluate design options for new transport infrastructure and to assess the prospects of new technology.[5] Health researchers use geographic information systems in modelling the effects of aviation and road traffic on morbidity and mortality.[6] The relationships between transport research and social science analysis are bi-directional, bringing economists, geographers, political scientists, psychologists, and others who study transport into contact with particular aspects of engineering, scientific, and health-related research. Much of this useful combination of disciplinary perspectives and methods is unstructured. It thus yields only a partial approximation of the synergy that could emerge from integrating economic, geographic, historical, political, and sociological techniques for understanding transport activity and its impacts. Transport Futures will pursue just such an integration through a truly collaborative framework that will inform four stages of analysis.

Stage 1: Identifying the factors and forces with potential to reshape Canada's transport future

Making the most of future opportunities and effectively managing future risks demands a good understanding of how key 'drivers' of change can be expected to influence Canada's transport sector, and

society as a whole. Transport Futures will begin by identifying and carefully assessing such drivers. They include energy availability, the deployment of new technology, urbanization and demographic factors, and the impacts of environmental pollution on global climate and local public health, among others. Future rates of urbanization and macroeconomic growth will also be considered. These drivers will be used to construct plausible, but intentionally different, scenarios for Canada's transport future, focussing on the period 2010-2030. The resulting scenarios are not intended to yield direct insights into future transport outcomes. Rather, they will provide a base from which to identify the likely opportunities and risks that could emerge in the event that particular change drivers do come to exert a major influence on the transport sector. The scenarios will generate their greatest value by enabling the estimation of alternative outcomes and impacts in subsequent stages of this assessment.

Stage 2: Estimating transport activity and resulting impacts

Economic, social, and behavioural research methods will be used to estimate transport activity levels (movement of both goods and people) for each scenario produced during Stage 1, chiefly through the application of models that forecast travel behaviour, time use, market development, material consumption, and the dynamics of supply-chain management. The activity estimates for each scenario will be used to quantify the resulting impacts of transport in several ways. For example, ecosystem integrity impacts will be developed through estimating the greenhouse gas emissions generated by transport activity. Human health impacts will be highlighted through projections of local and regional air and water pollution by substances known to affect mortality and morbidity. Impacts that pose unusual risks to children and other vulnerable groups will receive special attention.

Stage 3: Understanding the economic, social, and spatial outcomes

This phase of analysis will form the heart of a successful Transport Futures investigation. It aims to generate an integrated view of the outcomes produced by transport activity levels associated with each different scenario. These outcomes would be presented in terms of

economic prospects, social cohesion, and ecological integrity. Economic considerations will include assessment of the implications of the chosen transport futures for the economic well being of Canadians. Socio-behavioural considerations will include the interactions of transport development and land-use arrangements, and the implications of different futures for social structure and equity. Ecosystem integrity will be measured by using cumulative environmental impact assessment techniques. The economic and social outcomes will be integrated with measures of ecological integrity and human health impacts to provide an overall indication of the sustainability associated with each scenario, and provide a basis for initial identification of associated opportunities and risks.

Stage 4: Identifying policy options that can best enable opportunities and mitigate risks in tomorrow's transport options

Here, the resource, technological, and other driving forces that were first identified in Stage 1 will be shown to exert considerable influence over the direction of Canada's transport future, by creating distinctive sets of opportunities and risks that form boundaries for possible outcomes. Economic and political choices made within these boundaries can enable both the successful pursuit of future opportunities and the effective management of future risks, just as they can frustrate success in such efforts. To facilitate future decision-making by government and industry, this phase of Transport Futures will elaborate the governance structures and economic instruments, such as pricing and fiscal policies, that can facilitate the attainment of desired outcomes and the avoidance of unpalatable risks. The nature of governing arrangements needed to realize opportunities and minimize risks will be explored for each scenario. These will include matters of regulation and deregulation, institutional arrangements, and the relationships between governments and markets in influencing transport activity.

Implementing the Transport Futures project

The disciplinary scope and analytical ambition of Transport Futures makes this project a good candidate for the "Major Collaborative Re-

search Initiatives" (MCRI) program of the Social Sciences and Humanities Research Council of Canada (SSHRC). The MCRI provides up to $2.5 million over five years to support innovative interdisciplinary analysis based in the Social Sciences. To date, close to 40 researchers at 14 Canadian universities have joined colleagues in Australia, Britain, the Netherlands, and the United States to participate in developing this research program. Further development work will continue through the summer of 2004, with the prospect of research starting in 2005 and continuing through 2009. The project will disseminate findings in the form of working papers, research reports, and policy briefings that will benefit from the feedback of an advisory committee, which will include government, industry, and labour representatives.

Transport Futures presents a training opportunity

A research effort that seeks to advance Canada's future transport opportunities should give priority to developing the skills needed to turn desired transport options into reality. Canada's post-secondary educational institutions lack the capacity for training a sufficient number of professionals needed to plan, develop, and manage our future transport needs.[7] Aside from a very few universities that graduate a handful of transport professionals each year, Canada's post-secondary institutions lack the critical mass of faculty to offer a comprehensive academic program in transport.

Transport Futures will build capacity in transport education by supporting students in several ways. First, all participating researchers will be expected to include graduate, and, where appropriate, undergraduate assistants in their research teams. The resulting flow of funds to students would significantly expand the very limited academic support that is currently targeted toward transport education at Canadian universities. Such funding opportunities are a necessary component in attracting students into transport studies. Second, by participating in research that yields insight into Canada's future transport options, students will be exposed to innovative analytical techniques and gain problem-solving skills well beyond what they could acquire from courses otherwise available to them.

Third, Transport Futures will offer students the opportunity to learn from faculty at universities across the network by supporting student exchanges among participating institutions, enabling students to acquire knowledge that would not be accessible at their home institution. Such exchanges could lead to common course offerings in which students at universities across Canada could enrol in transport courses offered by faculty at another institution and participate by videoconference and other distance-learning methods. Fourth, one or more participating researchers will coordinate internship placements with industry and government agencies in Canada's transport sector for students who have participated in this assessment.

The analytical strategy behind transport futures

There are basically three ways to approach the future. One is to do little in the way of serious strategic assessment, and then muddle along, exploiting opportunities and putting out fires as they occur. Another is to define a clear set of goals and work out the best or several ways of reaching the goals. The third is to identify several ways in which changes *could* unfold, select the most attractive of these, and figure out how to increase the likelihood of desired changes or decrease the possibility of undesired changes, or both. Each approach has merit, but the third approach, involving development of several *scenarios* of the future, may have the strongest analytical power. This is because it acknowledges a range of possible outcomes, and explicitly considers the set of *plausible* circumstances that could give rise to such outcomes. Through carefully analyzing the interplay among 'drivers' of change and the key choices available to decision-makers in industry and government, understanding is gained of how a transport system could be guided towards one, rather than another, of the futures.

Transport Futures is a scenario study. Scenario-based assessments have been used by governments and businesses when seeking to build their understanding of, and readiness to deal with, uncertain futures. Royal Dutch Shell pioneered "scenario planning" techniques in the late 1960s and used them to attain superior performance following the

1973 oil shock.[8] National governments—e.g., Norway and Singapore—have relied upon scenario-based assessments to inform their industrial and natural resource development strategies.[9] In Canada, scenario-based assessment techniques have been used to create economic development strategies for Ontario's financial and information technology sectors.[10]

As noted above, several scenarios will be identified in Stage 1 and analysed carefully in Stage 2. The scenarios will be heuristic devices. There will be no commitment to them except as tools to understand how transport systems in Canada might unfold and how transport trajectories can be influenced by strategic choices that may be available to industry and government.

The next transport revolution

How do the participants in Transport Futures see Canada's next transport revolution? The honest answer is, we don't know yet. That is why we want to undertake Transport Futures. Moreover, agreement among Transport Futures' participants now or at the end of the process may well be unlikely, except for agreement as to the value of the process in identifying opportunities and risks and how they might be addressed.

The present authors, instigators of Transport Futures, agree with the premise behind this year's CTRF annual conference, that a third revolution in transport may be needed. We agree too that information technologies will likely be a strong element in shaping what emerges from the revolution. However, we do not believe that IT is, in itself, the factor that will drive change. As noted above, we would give as much or more prominence to at least three other factors:

- Transport's energy demands, which could outstrip the supply of low or moderately priced hydrocarbon fuels before substitute fuels are readily available.

- Canadian transport's production of environmental pollution that exceeds the absorptive capacities of local and global ecosystems, harming much life.
- The dysfunctional impacts of transport on urban form, and the need to cover resulting deferred infrastructure and other significant costs.

Accordingly, we believe that the third transport revolution will generate transport systems that are more energy efficient, land conserving, and environmentally benign than present systems. Information technology will likely facilitate each of these advances. For example, IT can facilitate dramatic increases in the efficiency with which vehicles are used, by matching rides and by matching loads. They will reduce the number of vehicles on the road, thus lessening overall energy use and environmental impacts. IT can help curb sprawl by providing better information about development options and their transport implications.

Thus, we share the conference organizers' view that the third transport revolution could be more about the way in which new information—rather than new motive power—propels the planning and practice of how goods and people will move around Canada in the years to come.

End Notes

[1] There are various estimates of when worldwide production liquid hydrocarbons suitable for conversion into transport fuels will reach a peak. The authors consider the work of the Uppsala Hydrocarbon Depletion Group to be the most authoritative. It suggests that production will peak in about 2012. It is available at the first URL below. Some estimates point to earlier peaks, e.g., in 2005, as projected in Deffeyes KS, *Hubbert's Peak: The Impending World Oil Shortage*. Princeton University Press, 2001. Others point to later peaks, e.g., in 2018-2023, as projected in White N, Thompson M, Barwise T, Understanding the thermal evolution of deep-water continental margins, *Nature*, 426:6964, 324-333, 2003. Extreme among the projections of later production peaks are those of the U.S. Energy Information Administration (EIA), which suggests production will continue rising beyond 2025 (EIA, *International Energy Outlook 2003*, available at the second URL below) and those of the International Energy Agency (IEA), which suggests oil production will continue rising until 2030 (IEA, *Energy to 2050: Scenarios for a Sustainable Future*. IEA, Paris, France, 2003). Energy constraints will arise from potential demand running ahead of actual production of liquid hydrocarbons resulting in high prices, *not* from depletion of all available oil. Put another way: "The world is not about to run out of hydrocarbons, and perhaps it is not going to run out of oil from unconventional sources any time soon. What will be difficult to obtain is cheap petroleum, because what is left is an enormous amount of low-grade hydrocarbons, which are likely to be much more expensive financially, energetically, politically and especially environmentally." (Hall C and four others, Hydrocarbons and the evolution of human culture. *Nature*, 426:6964, 318-322, 2003). The most-discussed substitute for hydrocarbon transport fuels is hydrogen, for use in fuel cells. A recent authoritative report suggests that little can be expected from this option before 2029. See *The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs*. (Washington DC, National Academies Press, 2004), available at the third URL below.

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[2] For documentation on the challenges posed by sprawl and the contribution of transport, see the 'sprawl' section of the Web site of the *Planning Commissioners Journal* at the first URL below. For relevant data on Canada's five largest urban regions in relation to 47 other affluent urban regions, see Issue No. 7 of the *Sustainable Transportation Monitor* (Toronto, Centre for Sustainable Transportation, October 2002), available at the second URL below.
1. http://www.plannersweb.com/articles/sprawl-articles.html, Accessed Feb. 8, 2004.
2. http://www.cstctd.org/CSTadobefiles/STM7%20English.pdf. Accessed Feb. 8, 2004.

[3] For a brief account of the scope of impacts of transport on the environment and thus potentially on human and ecosystem health, see Section 4.8.2 of *Human Activity and the Environment 2000* (Ottawa: Statistics Canada, Catalogue No. 11-509-XPE, June 2000).

[4] For an account of the vulnerability of children to transport's impacts see Issue No. 9 of the *Sustainable Transportation Monitor* (Toronto, Centre for Sustainable Transportation, December 2003), available at the first URL below. Also see material prepared in connection with the workshop 'Sprawl: The Impact on Vulnerable Populations' held by the Department of Environmental Health of the University of Cincinnati, available at the second URL below.
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2. http://www.eh.uc.edu/epc/EPC%20accomplishments.asp, Accessed Feb. 8, 2004.

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Modelling Potential Changes in Demand for Freight Transportation in Atlantic Canada Due to Climate Change Impacts

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Introduction

This research is aimed at analysis of potential climate change impacts on demand for freight transportation in Atlantic Canada through its links with other sectors of the regional economy. The main idea of the study is to model climate change impacts as productivity shocks in relevant sectors of the regional economy and then trace consequences of these shocks for demand for freight transportation on the basis of computer simulation. This paper defines the research methodology, approach and the preliminary analysis of the freight transportation demand in Atlantic Canada.

At large, the likelihood and severity of climate change impacts mainly depend on the extent of global temperature increase. Temperature increase may, in turn, cause secondary impacts such as sea level rise, global hydrological patterns change, and general human health degradation. These impacts are usually discussed at a wide-ranging, global level. Examples of studies, dedicated to specific sectors of national economies, are rather scarce and mostly focused on agriculture and water habitats. The regionalism approach is almost undeveloped considering all impacts at a national scale.

Analysis of the existing practices in North America, particularly in U.S. and Canada (for example, Government of Canada Action Plan 2000 on Climate Change), has revealed that the main focus in the relationship between climate change and transportation had been on reduction in greenhouses gases (GHG) by transportation followed by evaluation of climate change impacts on transportation infrastructure. These two are direct cause and effect of climate change, both coming from supply side in an economic sense.

Less attention has been given to indirect effects of climate change that come through changes in demand for transportation. This study is dedicated to these indirect effects. It recognizes that freight transportation is produced to meet demand for transportation by other sectors of an economy which means that demand for freight transportation is derived or factor demand. Therefore, the objective is to analyze potential climate change impacts on demand for freight transportation in Atlantic Canada through its links with other sectors of the regional economy. The ultimate goal is to model climate change impacts as productivity shocks in relevant sectors of the regional economy and then trace consequences of these shocks for demand for freight transportation on the basis of computer simulation.

In this regard, three problems must be solved: (i) identification of potential impacts of climate change in Atlantic Canada in wide range, (ii) identification of sectors of regional economy affected by these potential impacts, and (iii) establishing links between transportation and affected sectors. This paper briefly discusses all three and presents preliminary analysis of the demand for the freight transportation in Atlantic Canada, generated by the major export/import industries of the region.

Potential climate changes

According to the U.S. Environmental Protection Agency (1990), increase in carbon dioxide emissions, and atmospheric levels of water vapour supplemented by geophysical and biogenic feedback will

result in a potential warming of between 1.5° and 5.5° C. In Atlantic Canada it is projected that over the next 100 years temperature will rise by 3°-4° C.

Global warming will also cause sea level to rise and hydrologic cycle to change. Models developed by the International Panel on Climate Change (IPCC, 1995) show average increase in sea level between 20 and 86 cm by 2100 with 50 cm considered as most likely. Total loss from a one-meter rise was estimated to be between US$270 and US$475 billion (Titus, 1991). Sea levels rise will have significant implications for Atlantic Canada. Potential consequences include erosion of soil, infrastructure damage, shifts in population density, changes in flows of freight transportation, changes in consumption patterns and others.

In addition, global warming will cause changes in the hydrologic cycle. The hydrologic cycle traces movement of water among the oceans, atmosphere, land and vegetation, and ice caps and glaciers. Scientists agree that significant warming will intensify the global hydrologic cycle and have major impacts on regional water resources (IPCC, 1990). The increase in temperature could increase average global precipitation from 7 to 15 percent (U.S. Congress Office on Technological Change, 1990). Precipitation will increase at high latitudes and decrease at low to middle latitudes. As well, the potential for more-intense or longer-lasting drought will increase. This means that water-dependent activities such as agriculture are likely to be greatly affected by a change in hydrologic patterns (Innes and Kane, 1995) or hydrologic changes are likely to cause changes in production and consumption activities. Transportation systems, particularly for freight, must adapt to these changes.

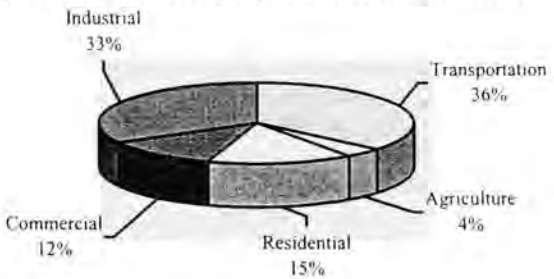
Climate change will also increase the precipitation patterns potentially causing droughts, and frequency of extreme weather events such as thunderstorms, tornados, hailstorms, floods, and heat waves. In general, it is expected that rainstorms will be less frequent and more severe, and the dry periods will last longer. Other problems that are likely to result from climate change include increased risk of

fires, pests, and disease to farms and forests, and damage to water and wetlands.

Sectors affected by climate change

In 1999, the Environment Canada estimated that Canada's transportation sector accounted for 36 percent of total GHG emissions (see Figure 1). In the same year, road transportation accounted for about 77 percent of total GHG related to transportation. Rail emitted almost 8 percent for the same period. Therefore, the total emission of the GHG from the surface transportation is as high as 85 percent of all GHG emission of the transportation industry. It has been estimated that by 2020 total transportation demand could boost up to 50 percent of its 1990 level. This way it will have further aggravating impact on GHG emission as a primary cause of the global climate change.

Figure 1. GHG Emission by Economic Sectors in 1999



Source: Transport Canada, 1999

The Atlantic region as a whole accounts for 6 percent of the heavy and mid-size truck fleet of Canada (Transport Canada 2001). Heavy truck is predominantly tractor-trailer combination with a separated power unit and cargo area whereas mid-size one is a straight truck with its integrated power unit and cargo area. The freight road transportation, especially interprovincial and transborder movement are mostly represented by these two categories of trucks.

The volume of rail transportation in Atlantic Canada accounts for over 11 percent of all Canadian National Railways' total traffic (Transport Canada 2000). Although the share of Atlantic's road and rail freight traffic is relatively small on the national scale the impacts of global climate change can be very substantial for the entire eastern Canada. However, as it was already mentioned, this comes from the supply side of the transportation industry.

Consequences of climate change impacts on demand for freight transportation can be traced through productivity shocks to the sectors of regional economy the most affected by the climate change. Therefore, it is necessary to identify these sectors first, and then rank them in terms of the generated volume of freight transportation.

The Atlantic Canada economy relies heavily on export/import activities. The economic strength of the region lies in traditional Canadian export industries such as lumber, paper, minerals, and agriculture. Atlantic provinces also provide refined petroleum, hydroelectricity, and natural gas. Among the top export activities that generate the largest demand for freight transportation are refined petroleum; lumber, wood and wood pulp; iron ore and scrap; newsprint paper; coated and treated paper; transport equipment, and frozen fruit and vegetables. Import to Atlantic Canada is even more important economic component. Crude oil, motor vehicles, machinery, technology and consumer goods dominate the region's import composition. The top import activities include fertilizers, construction materials, road motor vehicles and chassis, and agricultural products. Predominantly these sectors of regional economy generate the highest demand for freight transportation in Atlantic Canada and, once affected by climate change impacts, will cause changes in demand patterns for freight transportation over time.

This study is limited to land-base surface transport, which is defined as rail and highway transport. The demand for air freight in Atlantic region is not substantial enough to be counted. For years the share of air freight in the total tonnage transported into and out of Atlantic Canada has not been higher than 1 percent. Only in 1998 it was

slightly over 1 percent (Brander 2000). Overall importance of water transport in the region has been declining: its share in the regional freight transportation dropped from 33 percent in 1991 to 28 percent in 1998 (Brander 2000). The analysis of the marine freight going through Atlantic Canada's ports though still handling the significant volume of 63 million tonnes is beyond the scope of this research.

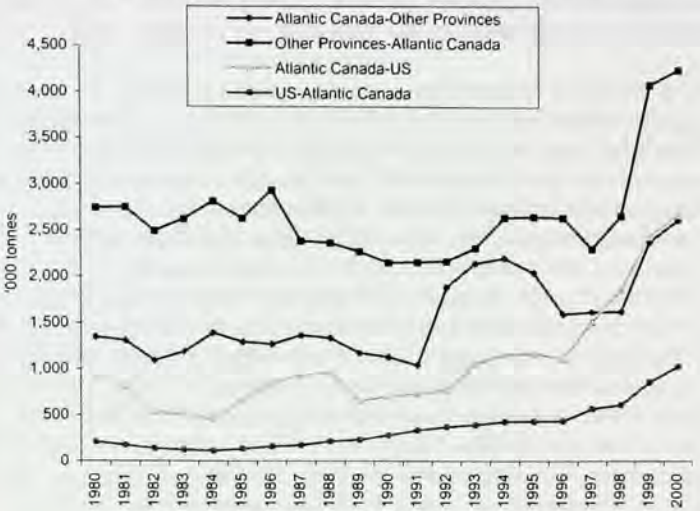
It is necessary to note that some explanation is needed to interpret changes and sharp short-term fluctuations in regional transportation flows that have occurred over the last two decades. No single factor can explain these changes. In addition, the interregional flows of freight transportation, reported by the Statistics Canada, were not consistent from year to year, yielding larger probability of error. The situation is also complicated by the fact that beginning in 1989, the Statistics Canada stopped reporting the total tonnage hauled by private trucking companies considering this as private information. Therefore, in order to estimate the trucking demand, the use of approximation procedure became inevitable. In this study, the approximation was based on the fuel consumption rate, fuel costs and total distance, hauled by both for-hire and private trucking companies. The study excludes marine imports and exports, which are usually treated as if they had their origin or destination in the region in which the railways picked up or delivered the freight at a port.

Over the study period for rail from 1980 to 2000, the volume of transportation by the regional export industries almost doubled. The largest increase of 288 percent in the volume of transportation by rail is reported by the regional industries exporting their commodities to the international markets, predominantly to the U.S. (see Figure 2).

The largest increase in transportation volumes occurred at the beginning and then at the end of the1990s. It is worth mentioning that the survey approach, used for collecting the statistics data, has been changing over time contributing to the inaccuracy of the reported data with respect to the interprovincial rail flows. However, the southbound trans-border movement for rail has always been reported

correctly making it a consistent indicator for estimating the actual demand.

Figure 2. Rail Transportation in Atlantic Canada



Source: Statistics Canada, Rail in Canada, various issues

Overall Atlantic Canada - US rail traffic increased by over 150 percent during the study period. In both absolute and relative terms, the demand for rail transportation in Atlantic region grew steadily with a higher increasing rate beginning in the mid-1990s. The strongest growth for the rail was transportation to the U.S. North Central and South regions.

The volume of freight trucking has been growing at a different rate over 1984-2000. Atlantic industries have generated a substantial demand for inbound trucking. The consumption of various commodities from other provinces almost tripled in Atlantic Canada, which is not surprising since Atlantic region has negative trade balance with the rest of the country. At the same time southbound

export activities of the Atlantic economy increased by over 200 percent whereas the incoming traffic remained relatively stable over time. This reflects the faster growth in international trade especially with the U.S. Given this pattern, it is possible to conclude that the regional economy is highly dependent on the international trade making the demand for trucking a crucial component.

Figure 3. Freight Trucking Transportation in Atlantic Canada

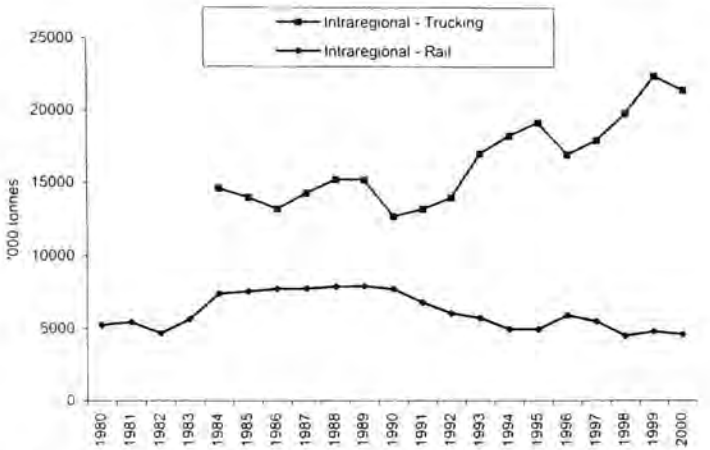


Source: Statistics Canada, Trucking in Canada, various issues

Intra-provincial trade of commodities accounts for the most of Atlantic Canada trade. In the trucking sector, it has increased from 14.5 to 20.5 million tonnes annually from 1984 to 2000 (see Figure 4). The situation with the rail demand is more complicated. Rail connection between the Atlantic Region and the rest of North America exists only in New Brunswick and Nova Scotia. Rail tracks were removed from Prince Edward Island and Newfoundland. Rail service to both provinces is performed through multi-modal transportation via Moncton and Halifax.

Because of its specific nature, in general rail transportation is not competitive with the trucking over the short-distance haul. However, rail, having experienced increase in total tonnage after the deregulations in 1980s, has been yielding its intra-provincial market share to trucking since early 1990s.

Figure 4. Trucking and Rail Transportation in Atlantic Canada



Source: Statistics Canada, Trucking in Canada and Rail in Canada, various issues

Having discussed the existing demand for freight transportation in Atlantic Canada through transportation flows, it is essential to define the research strategy to connect freight rail and trucking with the rest of the regional economy. The following principle underlies the proposed approach regarding links of transportation with other sectors. Freight transportation is produced and consumed in a transportation network. Transportation network is indispensable component of regional economy along with other sectors. Since freight transportation is an important input in production of different goods and services in other sectors of regional economy, it can be directly incorporated in production functions of different

commodities by priority sectors of regional economy. Demand for freight transportation by priority sectors then follows as derived factor demand.

On supply side, freight transportation is provided by transportation companies who try to meet the demand by priority sectors. In doing so, the providers of transportation create demand for required factors of production such as transportation labour and capital in other sectors of regional economy, called in economic literature secondary markets (sectors). This is how freight transportation is incorporated in the regional economic system.

This framework allows us to consider freight transportation as an integral part of an economic system, which consists of the transportation network, network users, transportation service providers and the various economic activities surrounding the network. Therefore, any change in the productivity of regional industries will have an immediate effect on the transportation demand.

Methodological aspects

Further steps in this research will include the development of a regional growth model. Priority sectors such as petroleum and coal, newspaper and ground paper, lumber and wood and food products will be described on the basis of production functions in which transportation will be incorporated as an input. The growth model will be designed on the basis of state-flow relationships between relevant economic variables over time to capture linkages between different sectors of the regional economy and transportation. As theoretical background for the model, Romer's (1996) growth model in combination with the RICE model (Nordhaus and Yang, 1995) will be used. In the designed model, transportation will be represented by earlier developed dynamic model of transportation network (Yevdokimov, 2001).

After the growth model is complete it will be converted into Vector Autoregression. Demand for freight transportation will become a component of the VAR. Then VAR will be estimated based on historical time-series data described in this paper according to methodology developed by Sims (1980) and refined by Enders (1995). Climate change impacts will be then imposed as productivity shocks that affect production functions in respective priority sectors. Since demand for freight transportation is a component of the VAR, changes in demand will be obtained as a result of the VAR after-shock dynamics.

Consequences of the climate change impacts as productivity shocks over time will be traced on the basis of Impulse Response Functions. Estimation methodology and inference are described in Enders (1995) and extended by Yevdokimov (2001) for large environmental impacts. The dynamics of consequences of climate change impacts as productivity shocks is as follows:

- a productivity shock or combination of shocks affect production function in relevant priority sector;
- since freight transportation is an input in the production function, demand for freight transportation as factor demand is affected directly;
- supply of freight transportation adjusts according to the cost minimization subject to the new demand;
- demand for inputs to produce freight transportation changes according to the adjustments in supply of freight transportation;
- new allocation of resources between priority sectors and secondary markets (sectors) changes flows in regional economy;
- new allocation affects priority sectors again and a new cycle begins.

Modelling of the productivity shocks represents a problem of itself. Some of them are permanent or long-lasting shocks. In a mathematical sense, they are autoregressive in nature with increasing intensity. Other shocks are temporary imposed in specific time

periods with varying frequency, intensity and duration. Therefore, first it will be necessary to classify all potential climate change impacts described above as permanent and temporary shocks, collect information on intensity and duration of these shocks based on the existing and emerging literature, and then choose functional forms to mathematically describe these shocks. Examples of econometric specification of different shocks are presented in Enders (1995).

Conclusion

This paper describes the preliminary stage of the research that is a part of a larger project entitled "Modeling sustainable transportation network". In that project, sustainability of the transportation network is modeled through its links with economy, society and environment. In this regard, the study presented in this paper explores linkages of the sustainable transportation network with the regional economy and environment. Consequently, understanding of the demand for freight transportation in Atlantic Canada based on time series analysis over the last two decades becomes crucial.

The time-series analysis showed that if the impact of the cyclical pattern of development is eliminated, the demand for freight transportation as measured through transportation flows has been growing remarkably over the last 20 years. Freight transportation in Atlantic Canada is an integral component of the regional economy. It is linked to other components of the economy in two ways: (i) regional economic activities generate demand for transportation; (ii) transportation, in turn, generates demand for commodities produced in other sectors of the economy as well.

Once these linkages are understood and described in the form of the dynamic state-flow relationships, it will be possible to trace the impacts of the global climate change on the demand for freight transportation as productivity shocks in priority sectors of the regional economy.

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CANADIAN PIPELINE TRANSPORTATION IN THE NATURAL GAS INDUSTRY?

Joseph Monteiro*

Introduction

The pipeline transportation industry was a consequence of the development of the oil and natural gas industry in the early 1940s and 1950s.[1] Pipeline transportation today accounts for a substantial portion of all freight ton-miles by various transport modes, despite the fact that it is not given the same treatment as conventional forms of transportation. In recognition of its potential, the Chairman of the Canadian Energy Pipeline Association in July 2000 stated "The Canadian pipeline industry faces a bright future marked by continued growth and investment."[2]

In this paper, Part I examines pipeline transportation in the natural gas industry. Part II reviews the regulations that existed in the mid 1980s and in 2000. Part III examines a typical analysis used in pipeline applications. Part IV describes the activities of the Competition Bureau in pipeline transportation and Part V reviews the initial impact of deregulation in the natural gas industry on pipeline transportation. Finally, a few concluding remarks are made.

I. Pipeline Transportation in the Natural Gas Industry in Canada

a) The Early Development and Growth of Pipelines in Canada

Pipeline transportation in Canada is relatively new compared to the more conventional forms of transportation. Pipelines are used to transport: natural gas; crude oil; and other oil products.

Pipeline transportation of natural gas began in Western Canada in the mid 1950s. The first three pipelines in the natural gas industry were: the Trans-Canada Pipeline (TCPL), the Westcoast Transmission Line (WTL), and the Alberta Gas Trunk Line (AGTL). Since, the 1950s the pipeline industry in Canada witnessed rapid growth, particularly after deregulation of the natural gas industry in 1985. Today, the natural gas pipelines serving Canada have increased in number from the initial three to ten. Pipeline transportation of crude

oil can be traced to a somewhat earlier period i.e., the 1940s to the early 1950s. The first three major crude oil trunklines were the Interprovincial Pipe Line (IPL), the Transmountain Pipeline, and the Montreal-Portland. Today, the crude oil pipelines serving Canada have increased in number from the initial three to twelve.[3]

b) The Importance of the Canadian Pipeline Industry

Pipeline Transportation vs. Other Forms of Transportation: The significance of pipeline transportation vs other forms of transportation can be seen in the magnitudes in table 1. These statistics indicate that pipeline transportation is a significant component of the Canadian transportation system both in terms of freight ton miles and revenue, a fact obscured by the little attention paid to it in conventional transportation literature.

TABLE I - Freight Ton Miles and Revenue by Transportation Mode (1999)

	Rail	For-hire Truck	Air (m)	Pipeline Oil (m)	Pipeline Gas
Freight ton Miles	299 (b)	158.66 (b)	2, 378	91, 188	192, 732 (b)
Freight Op. Revenue (m)	7, 217	2, 390	1, 238	1, 380	6, 957

Source: Statistics Canada, Catalogue Nos. 11-210-XPB, 57-205-XIB, 55-201-XIB, 51-206-XIB and Transport Canada Annual Report 2000.

Transportation by Major Pipeline Category: The importance of various categories of pipeline are shown in table II in terms of kilometres and tonne kilometres. These statistics reveal that transportation of natural gas is substantially greater than transportation of crude oil and oil products combined.

TABLE II - Pipeline Transportation (kilometres and tonne kilometres) (m)

	1980	1985	1990	1995	2000
Crude Oil (km)	122, 142	99, 065	89, 239	93, 423	77, 471
(tonne km)	103, 090	83, 620	75, 322	78, 859	65, 392
Oil Products (km)	18, 409	21, 939	32, 533	29, 737	29, 701
(tonne km)	14, 012	16, 706	24, 769	22, 642	22, 616
Natural Gas (km) b	86, 716	104, 878	153, 676	238, 787	259, 626
(tonne km) (b)	63, 302	76, 446	112, 450	174, 314	189, 527

Source: *Canadian Economic Observer*, Statistics Canada, Cat. No. 11-210-XPB, 2001, p. 86.

Pipelines in Natural Gas by Distance: The natural gas pipeline distance statistics are shown in table III. The data over the period 1985-

2000 indicates that for transmission (which is basically transport) it has increased by 44%. If distribution is also considered, the results for it are even more impressive indicating an increase of 68%.

TABLE III - Natural Gas -Pipeline Distance (kilometres)

	1985	1988	1992	1996	2000
Transmission	56342.8	59286.6	69918	76410.7	81339.6
Distribution	125398.4	153503.7	178374	192751.5	210677

Source: *Natural Gas Transport and Distribution*, Statistics Canada - Cat. No. 57-205-XPB.

Natural gas pipeline distance by Province for 2000 is shown in table IV. The statistics reveal that Alberta, Saskatchewan and Ontario

TABLE IV - Natural Gas -Pipeline Distance, by Province in 2000 (kilometres)

N.B	N.S	Québec	Ontario	Manitoba	Saskatchewan	Alberta	B.C.
430	361	1535	14513.9	4440.3	17720.4	35324.7	7014.3

Source: *Natural Gas Transport and Distribution*, Statistics Canada - Cat. No. 57-205-XPB.

account for approximately 43%, 22% and 18% of the natural gas pipeline by distance in Canada.

Revenue of Pipelines in Natural Gas: The revenue of the natural gas pipelines for transport is shown in table V. The revenue for 2000 is $8.9b, a substantial increase of 1,261% from its revenue in 1985.

TABLE V - Natural Gas Transport Systems ($ m)

	1985	1988	1992	1996	2000
Canada	658	1, 120	5, 063	6, 018	8, 959

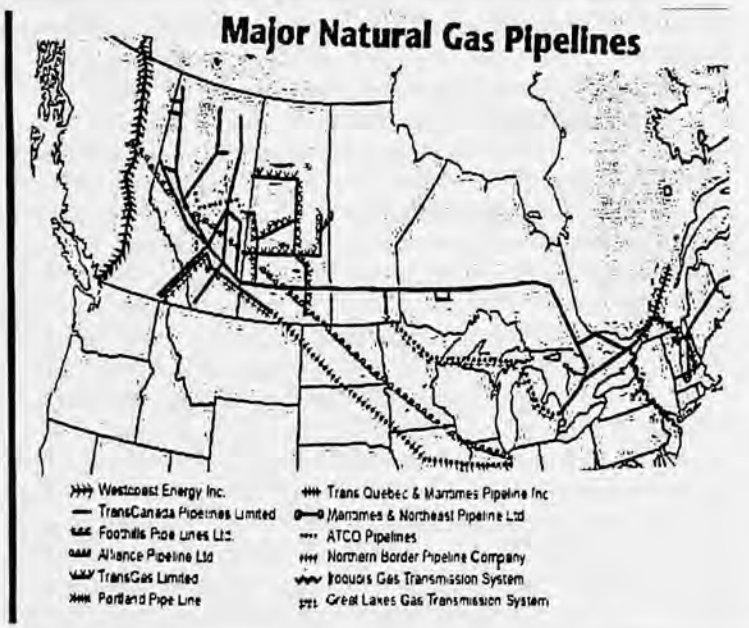
Source: *Natural Gas Transport and Distribution*, Statistics Canada - Cat. No. 57-205-XPB.

In sum, the above statistical information provides an indication of the significance and composition of the pipeline transportation industry indicating that pipeline transportation is an important component of transportation and that natural gas transportation is far more important than crude oil. Further, Alberta, Saskatchewan and Ontario account for a large proportion of the natural gas pipeline by distance in Canada.

c) The Markets Served by the Natural Gas Pipelines

Unlike other transportation carriers which are not tied to any

specific geographic market, pipelines in Canada typically serve specific geographic markets. In brief, the intraprovincial carriers are: Westcoast (in B.C.), ATCO (in Alberta), *TransGas* (in Saskatchewan), Trans Québec Maritimes i.e., *TQ&M* (in Québec), and Maritime & Northeast Pipeline Ltd. i.e., *M&N* (in the Maritimes); the interprovincial carrier is: TCPL; and the interconnecting carriers or carriers to the US are: Alliance Pipelines Ltd., Alberta Natural Gas Pipeline (i.e., *ANG/Foothills*), Foothills, Portland Pipeline, Northern Border Pipeline Company, Great Lakes Gas Transmission System, and Iroquois Gas Transmission System. This is graphically shown in the map hereafter and described verbally in greater detail in the footnote.[4]



II. Regulations in the Natural Gas Pipeline Industry

a) Federal Regulations in the mid 1980s and in 2000

Regulations for the removal of natural gas in Alberta can be traced to the late 1940s.[5] Before 1975, both export and domestic prices were negotiated between buyers and sellers. The resulting price was deemed to be below the competitive level. As a result, the Alberta and Federal governments intervened setting the price of gas under the terms of the National Gas Pricing Agreement of 1975 which remained in effect for nearly 10 years.[6]

Thus by the mid 1980s, the major facets of economic regulation were: 1. the price of natural gas at the initial point of delivery to the pipeline transporter was set by the Agreement; 2. the tolls for transportation service were regulated and set by the National Energy Board (NEB); and, 3. the resale price to the distributors by the pipeline transporter was regulated by the setting of 'city gate' prices.

After deregulation was introduced in 1985, the NEB continued to have the power to authorize natural gas exports. It uses a market based procedure to assess the merits of an export licence application. Further, interprovincial and international pipeline construction falls within its jurisdiction. In addition, interprovincial and international pipeline costs continue to require approval by the NEB and local distribution costs continue to be regulated by provincial boards/commissions/directly by a provincial government. In regulating pipeline rates, the prov. authorities and the NEB must ensure that rates are just and reasonable.[7]

Tolls were initially regulated on the basis of Cost of Service (i.e., COS) which was considered to work well for a number of years. However, in the 1980s, gas producers began to indicate that COS regulation did not provide effective incentives for pipelines to seek out efficiencies and reduce costs. In 1988, the NEB responded by establishing guidelines (i.e., rules under which the parties can negotiate settlements) which resulted in cost savings. These guidelines were updated in 1994. Other initiatives included: a workshop in 1993 hosted by the NEB on incentive regulation to improve the COS methodology; a multi-pipeline hearing in 1994 to determine the cost of capital for all major pipelines under its jurisdiction for a multi-year period; and a

Price Driven Efficiency Proposal by the producing sector.

These initiatives led to a move for incentive regulation schemes and one such settlement was between TCPL and its shippers for the period 1995-2000. It is based on a revenue requirement that mainly consists of three envelopes: one incentive envelope; one with costs that flow-through to revenue requirement; and one to account for non-routine adjustments (p. 24). The pipeline has an incentive to minimize on costs in the incentive envelope since net savings or overruns here are shared equally between TCPL and its shippers. Other costs not included in this envelope flow through to shippers as they would under COS regulation. While the settlement has determined levels for revenues and tolls, the NEB must still arbitrate on toll design issues and whether tolls are just and reasonable and not unjustly discriminatory. Since tolls continue to account for a large percentage of delivered price (2-3 times the actual cost of gas in 1997), the cost of transportation or transportation tolls continues to attract great attention.

b) Provincial Regulations

Intra provincial regulations also exist besides federal economic regulations indicated above. In BC, Alberta, Saskatechewan, Manitoba and Ontario which have most of the pipelines: entry i.e., intraprovincial construction of pipelines, approval of sale, tariff filing and tariff approval (for common carriers) are required. The requirements for starting a pipeline can be quite consuming as seen in the recent Arctic pipeline down the Mackenzie valley.

c) Should Regulations Be Changed?

Should the rate setting methodology be further fine tuned? There may be a case for costs in the incentive envelope to be changed as there is an incentive for the pipeline to reduce costs since net savings are shared. For example, providing the pipeline additional share of the net savings for further increases in efficiency. Another regulation that deserves consideration is whether the public interest criteria should explicitly introduce considerations of competition/efficiency.

III. Typical Economic Analysis Used in Pipeline Applications

In this section, a brief description of the economic analysis used in

a typical pipeline application case will be reviewed, however, first the economic characteristics of pipeline transportation are indicated.

a) Economic Characteristics of Pipeline Transportation

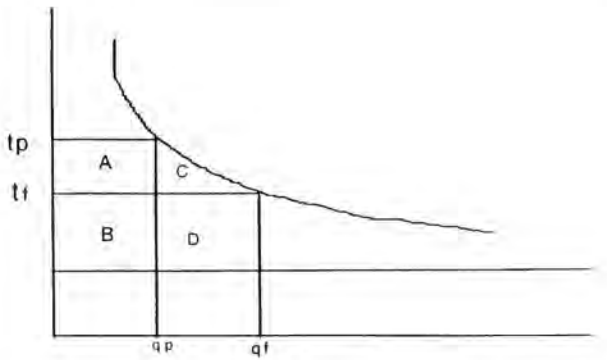
Transportation of natural gas by pipelines is subject to scale economies, as fixed costs are much larger than variable costs over most ranges of output. Besides these economies, it is worthwhile noting that due to the mathematical properties of a cylindrical space, an increase in the diameter of a pipeline leads to a proportionately larger output or flowthrough that can occur.[8] There are however no economies associated with length of the pipeline. Given these economic characteristics and a large element of monopoly power that exists in natural gas pipeline transportation, a monopolist would choose output that is less than socially efficient. The appropriate pricing remedy for such situations that has been advocated is a two-part pricing scheme: setting per unit price where the long run marginal cost is equal to average revenue; and recovering the deficit from a fixed levy on transporters.

b) Typical Economic Analysis in a Pipeline Application

In the economic analysis in one of the applications for entry, it was pointed out that the benefits from increased competition for pipeline services depend on (i) the impact on tolls from competition; (ii) how the increase in netbacks translates into increased production (the elasticity of supply with respect to lower tolls); and (iii) the gross profits from incremental production.[9]

The benefits can be easily seen in the diagram hereafter. The lower tolls of the new applicant (tf) leads to an increase in output (qf - qp). Assuming costs are the same for both the existing transporter and the new entrant, the welfare changes are shown by the total surplus C+D (the benefits from entry and competition). If the present value of this exceeds the capital costs and the present value of any increase in operating costs, then entry is efficient[10] implying that the application be approved. In calculating the benefits, the elasticity of production, the time horizon over which the benefits flow and the discount rate used in calculating the present value are all important. The smaller the

proportion of transport cost in the total price of the product, the lower is the expected elasticity. Similarly, the longer the time horizon (i.e., 20 years instead of 10 years) and the lower the discount rate, the larger will be the benefits.



IV.The Competition Bureau Activities Related to the Natural Gas Pipeline Industry

The Competition Bureau activities related to the natural gas pipeline industry have basically been concentrated in the area of advocacy with a few mergers and other civil and criminal cases.

Advocacy: Over the period 1983-2000, sixteen interventions were made in the natural gas industry (see Table VI). To implement deregulation brought about by the Agreement, cooperation of the provincial regulatory authorities was needed, since the latter regulated distributors in the consuming provinces and production in Alberta. The Bureau made several interventions to remove the restrictions on competition in the marketing of natural gas. The focus was on contract carriage and self-displacement, and later on regulatory changes.

1. *Focus on Natural Gas Toll Applications in matters such as Contract Carriage and Self-displacement* (2, 4, 5 and 6).

On issues of contract carriage and self-displacement the Commissioner was concerned that regulations and toll design restrict

access to transportation service by industrial users. He held that retention of a tariff provision prevented independent shippers from displacing sales of natural gas in TransCanada's traditional eastern markets. He also indicated that the Board should first amend the tariff provision to prevent the incidence of a disproportionate recovery of transportation costs from new buyers. Second, any change in access provisions should not penalize new buyers (through carrying charges). The NEB decision provided for payment of less than a proportionate share of carrying charges by new sales.

On toll setting for long term contract carriage, the Commissioner argued that brokers and groups of end-users should have access to the distribution systems to ensure the most effective and efficient means of bringing buyers and sellers of gas together in order to create a competitive market in natural gas. Where the distributor competes, he should do so through separate affiliates which would be unregulated and which would contract for transportation service with the regulated distributor. If the distributor undertook both activities, such sales should be regulated to ensure that its monopoly position in transportation does not subsidize its sales in the market for natural gas. The OEB's decision endorsed the Commissioner's views.

In considering prohibition against self-displacement[11] the Commissioner argued that its prohibition was the last federal regulatory barrier to a deregulated gas marketplace, and that the perpetuation of the prohibition would maintain TransCanada's pre-eminent position. Further, there was no evidence that TransCanada's contracted producers could not withstand the increased competition. The NEB, in its November 1989 Decision, lifted the prohibition on the grounds that it impeded the achievement of a market-sensitive pricing regime which contributed to restriction of competition and to higher prices for residential and commercial consumers. As a result, Ontario distributors were authorized to enter into buy/sell transactions.[12]

2. *Focus on Regulatory Changes to Increase Competition and Deregulation of Natural Gas* (14 and 6).

The Competition Bureau filed submissions on the changes to the

Ontario Energy Board Act to further deregulation. The Bureau recommended: 1) The *Act* should have a specific objective to foster competition and economic efficiency; 2) The OEB should have the authority to determine whether and on what terms gas distributors should be allowed to supply gas to consumers; 3) The Ontario natural gas legislation should require the OEB to forbear from regulation where there is effective competition, and to promote the orderly and rapid transition to unregulated markets; 4) The OEB or another body should be given the authority to order that the necessary structural changes be made to implement competition in other potentially competitive areas of the natural gas sector, such as storage and metering, where net economic benefits are likely; and 5) The OEB should have the authority to order structural separation between competitive and regulated activities. The Ontario government proposed amendments concerning natural gas in the *Energy Competition Act*.

In response, the Competition Bureau filed a submission indicating that the amendments were an important step towards more competitive and efficient markets for gas in Ontario. The submission dealt with principles for restructuring the Ontario natural gas sector, and made recommendations on the OEB objectives and on allocating the natural gas market in Ontario. Amendments were passed in the fall of 1998.

The submission to the New Brunswick Board examined Canadian competition law and policy as well as the appropriate roles and responsibilities for the Board and the Competition Bureau in the New Brunswick natural gas market. It presented competition principles that should be considered. The Board decided to: accept a proposed code of conduct for marketers; require regular reports from marketers; require the distribution company to disclose all terms and conditions of any sharing of services with an affiliate; and permit joint advertising in order to promote a level playing field.

Mergers: Over the 1986-2000 period, there were very few mergers involving natural gas pipeline transportation companies. The two most important mergers which were reported in various sources were: TCPL and ANG; and TCPL and NGTL. Since the two mergers did not raise concern enough to proceed with the matter, the examination was

terminated. Generally, the extent of competition among natural gas pipelines, if any, is extremely limited therefore the issue is that of vertical integration. Vertical mergers under the Canadian *Merger Enforcement Guidelines* 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.

Civil and Criminal Cases: Four cases (other than mergers) relating to natural gas have been reported in the Annual Reports from 1975. All these cases were with regard to propane retailing in the 1970s and early 1980s in various parts of Canada. It was alleged that propane distributors either agreed to fix prices at which retailers sold or attempted to influence upward the price at which they sold under the conspiracy or the resale price maintenance sections of the *Competition Act*. Further investigation was unable to substantiate the allegations and the matter was discontinued in all four cases. None of these cases, however, involved pipeline transportation companies.

V. The Initial Impact of Deregulation of Natural Gas on the Pipeline Industry?

To determine the initial impact of deregulation of natural gas on the natural gas pipeline industry we shall examine: structural changes and competition, expansion or new services, price of pipeline transportation services, and natural gas prices, output and exports.

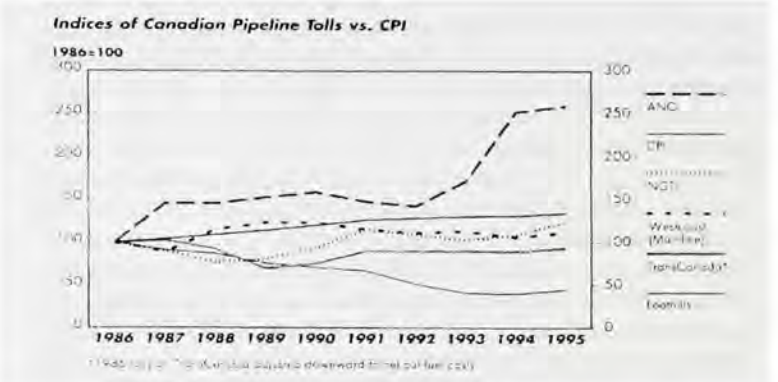
Structural Changes and Competition: Structural changes did not occur in the natural gas pipeline transportation industry immediately after deregulation was introduced. This is not surprising as there was considerable degree of excess capacity in the pipeline industry. This excess capacity, however, was soon absorbed with the increase in production and the need to accommodate the large increases in export sales. As a result, the Canadian pipeline system expanded rapidly after 1989 and new players entered the market. By 1995, the major gas transmission systems in Canada were NOVA Gas Transmission Ltd. (i.e., *NGTL*), *TCPL*, Westcoast, *ANG*/Foothills, Foothills (Saskatchewan), *TQ&M*, and *M&N*. In 1998, major changes occurred in the structure of the Canadian natural gas transmission industry.

TCPL became the owner of *NGTL* and is now the largest carrier of natural gas in North America and through its ownership in *ANG* and interest in Foothills it controls all the capacity to transport natural gas out of Alberta. Given the natural monopoly characteristics of this industry, it is not surprising that competition in this industry is extremely limited, nevertheless, some competition has emerged with the entry of Alliance Pipeline Ltd. in 1998.

Expansion of Pipeline Service or New Services: Deregulation has had a major impact on expansion of pipeline services or new services (See Table III in Section I). This expansion was made possible because of price decontrol. Formerly, users could not purchase directly from producers. With price decontrol, users entered directly into contracts with natural gas producers. This not only generated strong competition in some markets for natural gas[13] but directly impacted on the pipeline transportation industry through increased transportation contracts. As indicated by the NEB "A major part of the story of the last decade in gas transportation has been the introduction of considerable flexibility into the Canada/United States (US) network. Pipelines have responded to the needs of shippers by providing an expanded array of services, including backhaul services, delivery-point flexibility, bid-rates for carriers' services and storage and parking services. These services have greatly enhanced shippers' ability to maximize the value of their gas shipments and sales. In addition, growth in storage capacity has helped maximize the efficiency of the entire network by reducing the need for transmission facilities and by providing security of supply and enhanced delivery flexibility."[14]

Price of Pipeline Transportation Services: As far as price for 'transmission' of natural gas is concerned, between 1986-1995 "...tolls have remained relatively constant, albeit with some variations on a pipeline specific basis. This stability of tolls was achieved partly due to economies of scale and partly because the existence of under-utilized capacity in the late 1980s allowed some growth in throughput without major capital expenditures."[15] This can be seen in the chart. It is worthwhile observing that with the exception of ANG, the increase in tolls of all the other transmission companies have been lower than the

consumer price index (CPI).



Natural Gas Prices, Output and Exports: A sharp decline in 'well head prices' initially occurred. Even several years after deregulation (i.e., in 1998), the price was lower than the price in 1985. Output more than doubled from 71.1 billion cubic metres in 1984 to 160 billion cubic metres in 1998 and net domestic sales increased by 32.2 percent. The impact on exports was even more dramatic. Net exports increased from 21.4 billion cubic metres in 1984 to 88.37 billion cubic metres in 1998, a four fold increase. The benefits of deregulation have also been documented in another source.[16]

Concluding Remarks

Pipelines play an important role in the overall transportation system. This importance in transportation has somehow been overshadowed as it is usually considered a part of the resource sector.

Pipeline transportation is regulated even though the pricing of natural gas sold by producers was deregulated in 1985. This is not surprising given the natural monopoly characteristics of pipeline transportation. Transportation pipeline tolls have remained relatively unchanged over the 1986-1995 period. However, these tolls continue to attract considerable attention as the tolls can range from two to three

times the production price of natural gas. Pipeline tolls which were once determined by Cost of Service regulation are now often being determined by incentive regulation.

The typical economic analysis in pipeline applications considers the welfare changes from entry given by the total surplus. If the present value of this exceeds the capital costs and the present value of any increase in operating costs, then entry is efficient implying that the application be approved.

The Competition Bureau made several interventions in the natural gas industry. The deregulation of the natural gas industry in 1985 has had a major impact on the transportation pipeline industry. New players entered the market by 1995, and in 1998 major changes in the structure occurred with TCPL acquiring NGTL. The entry of Alliance Pipelines Ltd. into the market in 1998 has introduced some competition to TCPL and Foothills for the transportation of Canadian gas to the US midwest market. With price decontrol of natural gas, new methods of direct purchase and new transportation contracts emerged which have had a major impact on pipeline transportation.

Overall, the natural gas transportation pipeline industry benefited from deregulation of natural gas, as indicated by the growth of the industry, decline in costs and prices and increased volume of transportation due to a substantial increase in production and exports.

Bibliography

1. *Natural Gas Market Assessment 10 Years After Deregulation*, NEB, September 1996
2. Bonsor, Norman C., *Transportation Economics*, Butterworth, 1984.
3. Church, Jeffrey and Ware Roger, *Industrial Organization*, 2000.
4. See www.cepa.com/industryfacts.htm

Endnotes

1. Bonsor, Norman C., *Transportation Economics*, Butterworth, 1984, p. 129. The natural gas industry developed as a by-product of crude oil exploration and production. It was not until gas transmission lines were built that the natural gas industry received specific recognition. The natural gas industry can be divided into three component: production of natural gas, transportation of natural gas, and local distribution. The three components of this industry in Canada are not vertically integrated and ownership of the various components of this industry are generally private.

2. See "Pipeline industry faces continued growth," *PipelineNewsletter* July 2000, CEPA, p. 2.

3. In crude oil, the pipeline companies serve the following markets. 1) Transmountain Pipelines Company Ltd. serves the provinces of British Columbia and Alberta; 2) Enbridge Inc. (formerly IPL) serves the Northwest Territories, Manitoba, Saskatchewan (part), Ontario and Quebec to Montreal; 3) *Trans-Northern Pipelines Inc.*, 4) Express Pipeline Ltd. serves the province of Alberta and the State of Montana in the US; 5) *AEC Pipelines Ltd.*, 6) *Pembina Pipelines*, 7) *Cochin*, 8) Rainbow Pipe Line Co. Ltd. basically serves Northern Alberta 9) Lakehead Pipe Line Partners L.P basically serves the Great Lakes region in the US and connects with Enbridge in Manitoba and Ontario 10) *Platte Pipe Line*, 11) Rangeland Pipe Line serves the province of Alberta; and 12) *Connecting Pipeline*.

4. In natural gas: 1) *Westcoast* basically serves the Province of British Columbia. Parts of it extend into Alberta , the Yukon and NWT and it has interconnections to NGTL (i.e., NOVA Gas Transmission Limited) in Alberta and to Northwest Pipeline in the US; 2) Alliance Pipelines Ltd. transports gas to the US with connections to Westcoast, NGTL and Transgas; 3) *TransCanada* until recently was basically an interprovincial carrier which transports gas from Alberta and Saskatchewan to domestic markets in Saskatchewan, Manitoba, Ontario and Québec. It also transports gas to export markets in the US Midwest (through Great Lakes Gas Transmission) and Northwest (Iroquois Pipelines). In 1998, TransCanada acquired NGTL which basically serves the Province of Alberta with interconnections to ANG, Foothills (Saskatchewan) and TransCanada; 4) ATCO pipeline is an intraprovincial gas transporter in Alberta; 5) Alberta Natural Gas Pipeline (i.e., *ANG/Foothills*) is basically an export pipeline interconnecting NGTL to markets in Northern California, Pacific Northwest and Northwest Nevada; 6) *Foothills* (Saskatchewan) interconnects with NGTL in Alberta and Northern Border pipelines serving the US Midwest; 7) *TransGas* is basically an intraprovincial carriers of gas in the Province of Saskatchewan with interconnections to TransCanada and Foothills (Saskatchewan); 8) *TQ&M* (i.e., Trans Québec Maritimes) is basically a transporter of gas in the Province of Québec serving the markets of Montreal, Québec City and St. Lawrence River with interconnections to TransCanada; 9) Maritime & Northeast Pipeline Ltd. (i.e., *M&N*) is basically a transporter of gas in the Maritimes; and 10) Portland Pipeline is basically an export pipeline with connections to TQM and M&N. Besides these major pipelines others interconnecting and serving US markets are Northern Border Pipeline Company, Great Lakes Gas Transmission System, and Iroquois Gas Transmission System.

5. See the *Gas Resources Preservation Act of 1949* which empowered the Alberta Oil and Gas Conservation Board to determine the removal of volumes of natural gas from the province.

6. A number of factors - the excess supply of natural gas, the deterioration of the U.S. as an export market for Canadian natural gas in the early 1980's with little prospects for improvement in that decade, and the inflexibility of natural gas prices preventing Canadians from enjoying the benefits of lower gas prices - clearly indicated that the existing system of administered prices for natural gas were no longer appropriate. These developments suggested the need for regulatory reform. Further, there was no free market, both the transmission and marketing of natural gas were regulated from 'end to end'.

7. Regulations made under NEB Act are: Gas Pipelines Uniform Accounting Regulations; NEB Act Part VI (Oil and Gas) Regulations; NEB Act Cost Recovery Regulations; NEB Act Export and Import Reporting Regulations; NEB Pipeline Crossing Regulations, Part I; NEB Pipeline Crossing Regulations, Part II; NEB Rules of Practice and Procedure, 1995; Onshore Pipeline Regulations; Pipeline Arbitration Committee Procedure Rules, 1986; Pipeline Overhead Crossing Order; and Toll Information Regulations.

8. It has been pointed out that if capacity of the line is doubled average unit transportation costs will decline by approximately 30 percent.

9. See "Federated Pipe Lines Ltd. Application to Construct and Operate a Crude Oil Pipeline from Valhalla to Doe Creek," Church, Jeffrey, and Roger Ware, *Industrial Organization*, pp. 252-254.

10. *Id.* p. 254.

11. That is obtaining competing supplies of gas by the distributor that would displace gas under bundled long term contracts between the distributor and TransCanada Pipelines.

12. This provided for the re-purchase of natural gas (acquired at the free market price) at the distributors alternative end of purchases by the pipeline transporter.

13. *National Energy Board Annual Report 1988*, Minister of Supply and Services 1989, p. 42.

14. See *Natural Gas Market Assessment 10 Years After Deregulation*, National Energy Board. September 1996, p. vii.

15. *Id.*

16. *Id.*

Table VI - Advocacy Activities in Natural Gas by Year and Title

1983-4	1984-5	1986-7	1987-8	1988-9	1989-90	1996-7	1997-8	1998-9	1999-2000	TOTAL
1	1	2	2	2	2	2	1	2	1	16

1. Ontario Energy Board Hearings Concerning Ontario Industries using Natural Gas a Feedstock
2. NEB Hearings - Review of Toll Design and Methodology of Trans Canada Pipelines Limited.
3. Manitoba Public Utility Board Hearings - Cost Pass Through
4. Ontario Energy Board Hearing - Contract Carriage
5. National Energy Board - Distributor Self-displacement
6. La Régie de l'Electricité et du Gaz - Contract Carriage
7. NEB - Northridge Application for Transportation under subsection 71(2) of the NEB Act
8. Ontario Energy Board - Security of Supply.
9. NEB - Rules for Queuing for Prospective Shippers on TransCanada's Pipelines.
10. NEB - Gas Supply Information Required for Facilities Expansion Application
11. Transportation of Natural Gas Liquids - NEB.
12. Manitoba Public Utilities Board - Natural Gas Local Distribution Companies
13. Ontario Natural Gas - OEB
14. Proposed Natural Gas Regulatory Amendments in Bill 35, the Energy Competition Act
15. OEB – Proposed Licencing Scheme.
16. New Brunswick Natural Gas

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

Vers une nouvelle approche méthodologique pour analyser le phénomène de la conteneurisation des marchandises au Canada

Introduction

Le phénomène de la conteneurisation est un sujet de prédilection pour les analystes en transport. La standardisation du processus conteneurisé a permis l'externalisation et l'internationalisation des activités de production industrielle. Elle a éliminé une part de la variabilité dans la production et poussé la spécialisation à son extrême. Elle a mis en application un principe de base utilisé par l'industrie manufacturière : l'uniformisation.

Le conteneur, en standardisant l'unité de charge, a ouvert la voie vers la spécialisation et l'accélération des opérations de transbordements portuaire et terrestre. La massification des flux conteneurisés a soutenu le développement de réseaux intermodaux et la gestion des chaînes d'approvisionnements (supply chain management). Elle permet des solutions intégrées de transport aux chargeurs internationaux grâce à des services en porte-à-porte proposés par des opérateurs maritimes mondialisés (Maersk Line, Evergreen pu MSC...) et des intégrateurs logistiques planétaires (Panalpina, Kuehne & Nagel, Danzas...) via des opérateurs portuaires géants (ICTSI, Hutchinson, P&O Port Holdings, ...). Toutes ces révolutions ont été, à maintes reprises, analysées pour constituer une impressionnante littérature multidisciplinaire.

A titre d'exemple, la recherche opérationnelle identifie, par une compréhension des composantes d'un système et de leurs interactions, la solution optimale pour soutenir l'exploitation d'un terminal à conteneurs (Haezendonck, 2000) ou optimiser le déploiement des routes maritimes (Yi *et al.*,2000, Lee *et al.*, 2003). Les économistes et économétriciens analysent la demande et l'offre en relation avec les incontournables coûts d'un service donné (Cariou, 2000). C'est ainsi

Une nouvelle méthodologie pour appréhender les flux conteneurisés au Canada

Les données concernant les trafics portuaires des ports canadiens sont produites par Statistique Canada à partir des documents administratifs des douanes sur les chargements et déchargements internationaux dans les ports nationaux. Pour chaque année à partir de 1983, Statistique Canada est en mesure de produire une table pour les importations et une seconde pour les exportations [1]. Les fichiers informatisés sur le transport maritime international pour les années 1983 à 2000 ont été obtenus directement de Statistique Canada pour être intégrés dans une seule base de données relationnelle. Les informations disponibles concernent le type de marchandise, les ports d'origine et de destination de la marchandise ainsi que les tonnages conteneurisés et non conteneurisés qui ont transité entre ports.

Pour effectuer une analyse historique, plusieurs traitements ont été effectués afin d'uniformiser les données; notamment dans le cas des informations relatives au type de produit transbordé. Plusieurs classifications de produits avec différents niveaux de précision ont été utilisées par Statistique Canada entre 1983 et 2000. Par exemple, Statistique Canada utilise depuis 2000 la classification des types de biens transportés (CTBT) pour ses données sur le transport maritime. Cette classification est basée sur la classification des types de biens (CTB) qui elle, est fondée sur le système harmonisé (SH). Durant la période allant de 1983 à 2000, les données fournies par Statistique Canada utilisaient trois différentes classifications[2]. Afin d'assurer une continuité entre les années, il est nécessaire d'adopter des tables de correspondance à partir de la classification type des biens à deux

[1] Les données précédent 1983 sont entreposées sur rouleau. Bien qu'elles puissent être transférées sur des supports informatiques couramment utilisés, leur accessibilité représente des coûts prohibitifs.

[2] De 1983 à 1989, la classification des biens est basée sur la CTB à 5 chiffres. À partir de 1990 et ce jusqu'à 1999, les données fournies par Statistique Canada sont basées sur le SH à trois chiffres, ce qui réduit grandement la précision relative au type de produit. Enfin, les données concernant les trafics de 2000 sont basées sur la CTBT à cinq chiffres.

qu'ils sont en mesure de suggérer des tailles optimales pour les navires cellulaires (Cullinane *et al.* 1999) ou la productivité des équipements de transbordement (Chen, 1998). Ils peuvent aussi isoler chacun des maillons (Robinson, 1999) et suggérer des réseaux optimaux en termes de coûts (Notteboom, 2002a). De par leur maîtrise des questions mathématiques et des relations commerciales entre états, ils peuvent également établir des hypothèses sur l'évolution future de la demande en transport (Stopford, 2002). Les géographes, par leur appréhension spatiale des grands ensembles mondiaux et des réseaux de transport, s'intéressent aux distributions des flux conteneurisés (Alix, 1999, Comtois *et al*, 1997, Slack *et al*, 1996). Ces segmentations disciplinaires se trouvent la plupart du temps sublimées par des analyses croisées comme dans l'étude des structures organisationnelles issues du transport des conteneurs (Brooks, 2000, Heaver, 1995; Heaver *et al.* 2001; Notteboom, 2002b; Martin et Thomas, 2001, Slack *et al.* 2002, etc.).

Ces quelques paradigmes, sans être exhaustifs, révèlent toutefois que le conteneur est l'unité de base des analyses et très rarement fait-on appel au contenu de la boîte pour comprendre ou expliquer le phénomène de la conteneurisation des produits. Dans ce sens, notre hypothèse de travail soutient que la connaissance de la nature des produits à l'intérieur de la boîte devient de plus en plus pertinente. Cette hypothèse s'inscrit dans la perspective des économies d'envergure, de l'équilibrage des flux, de la stagnation des taux de conteneurisation des marchandises générales et d'identification de nouveaux produits ou encore dans le développement des stratégies de différentiation des services offerts par les ports.

L'objet de la présente contribution est d'analyser les flux de conteneurs par l'entremise de leur contenu dans un contexte canadien. La méthodologie et les données disponibles pour procéder à l'analyse sont proposées dans une première partie. Ensuite, quelques exemples relatifs à la connaissance du type de produit à l'intérieur du conteneur apporte de nouvelles pistes de réflexion sur l'évolution de la conteneurisation au Canada. Enfin, une dernière partie énonce les limites d'une telle approche et propose quelques futures applications dans le contexte canadien et mondial.

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chiffres. Pour faciliter la présentation et l'analyse des données, un regroupement en 17 grandes catégories de produits a été effectué :

1. Alimentaire
2. Appareils et machines
3. Céréales
4. Charbon/Coke
5. Hydrocarbures
6. Marchandises diverses
7. Minerais/Concentrés
8. Minéraux
9. Papier et pâtes
10. Produits chimiques
11. Produits forestiers
12. Produits métalliques
13. Textiles et pelleteries
14. Véhicules et pièces
15. Autres vracs secs
16. Autres vracs liquides
17. Autres (incluant résidus et déchets de toutes sortes)

Dans le cas des origines et destinations, une situation similaire se présente en ce sens que plusieurs modifications frontalières sont survenues entre 1983 et 2000. Pour les trafics précédant 1990, il est parfois impossible de retracer le véritable pays d'origine ou de destination du produit[3]. Des regroupements régionaux ont donc été effectués pour faciliter l'analyse. La composition de chacune des régions retenues dans la présente analyse correspond aux régions géographiques telles que définies par la Division statistique des Nations Unies.

Afin de valider les informations compilées dans la base de données, les trafics totaux pour chacune des années ont été comparés aux totaux diffusés par Statistique Canada dans sa publication intitulée : *Le transport maritime au Canada*. Des différences mineures ont été identifiées mais elles étaient, dans tous les cas, inférieures à 1 % du volume total de marchandises ayant transité par le port en question pour une année donnée.

Enfin, l'unité généralement utilisée pour caractériser le transport de marchandises conteneurisées est l'équivalent vingt pieds (é.v.p.). Cette mesure reflète davantage les flux des contenants que les flux du

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[3] Par exemple, un enregistrement indiquant que l'origine de 500 tonnes d'un produit est « Baltique URSS » ne permet pas d'identifier la république précise tandis qu'à partir de 1990, cette distinction est possible.

contenu. Dans la mesure où la méthodologie a pour objectif d'identifier l'évolution du taux de conteneurisation selon le produit, la proportion du tonnage conteneurisé selon le type de produit ainsi que le tonnage absolu conteneurisé est jugé plus adéquat.

Vancouver, Montréal et Halifax : trois ports au cœur du processus de conteneurisation au Canada

En premier lieu, la figure 1 présente l'évolution de la conteneurisation dans le transport maritime international par rapport au trafic total dans trois ports canadiens[4]. Halifax, Montréal et Vancouver concentraient 87 % du tonnage total conteneurisé international transitant dans les ports canadiens en 1983. Cette proportion est passée en 2000 à 96 % ce qui traduit une cartellisation de l'activité conteneurisée internationale au Canada. Dans le détail, les tonnages conteneurisés au port de Montréal ont toujours été supérieurs à ceux des autres ports canadiens jusqu'à la fin des années 1990. En fait, le port de Montréal hérite des acquis de sa précocité dans l'avènement du processus conteneurisé, entamé dès la fin des années 1960 sur le segment maritime de l'Atlantique nord. Dès les années 1990, plus d'une tonne de trafic conteneurisée sur deux passe par Montréal.

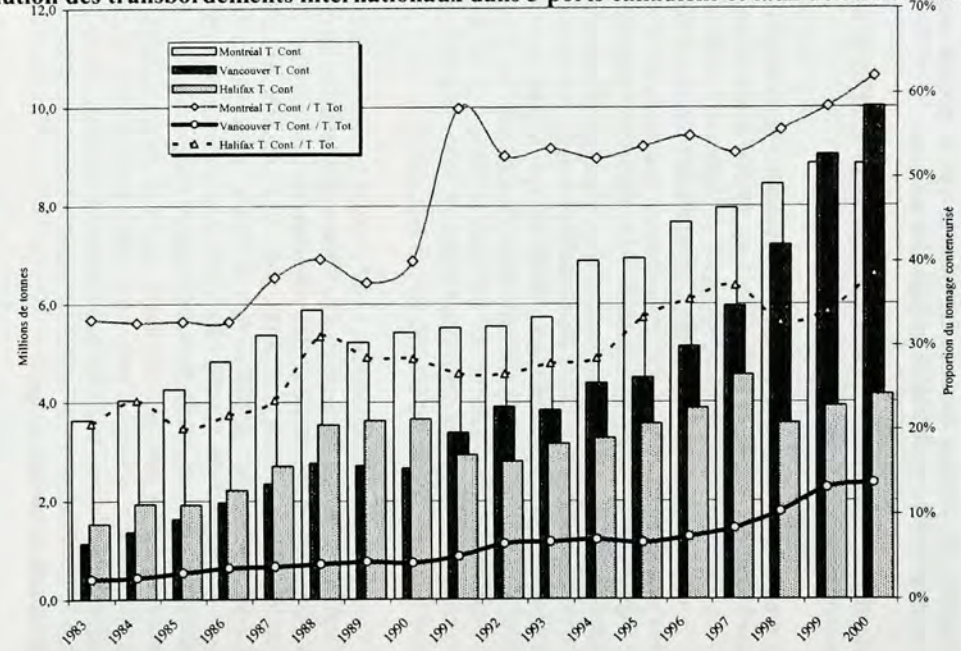
A Vancouver, le développement tardif d'installations adéquates pour le transbordement et l'entreposage du conteneur a retardé l'intégration du port dans le déploiement des capacités navales sur les circuits trans-pacifiques. L'inauguration des nouvelles capacités de *Deltaport* en 1997 a néanmoins permis au port de l'ouest de devenir le premier port à conteneurs du Canada dès 1999 avec plus de 9 millions de tonnes transbordées. Depuis, la croissance fulgurante des trafics conteneurisés au port de Vancouver continue de s'alimenter de la stimulation des échanges nord-américains avec l'Asie. Toutefois, Vancouver reste avec un faible taux de conteneurisation du trafic total dû à la persistance d'un volume prépondérant de vracs liquides et solides non conteneurisables.

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[4] Dans ce document, l'expression « conventionnel » s'utilise par opposition à l'expression « conteneurisé » et désigne les volumes de marchandises transportées en vrac ou sous forme dégroupée.

Figure 1

Évolution des transbordements internationaux dans 3 ports canadiens et taux de conteneurisation



Du côté de Halifax, la tendance générale demeure au maintien depuis la fin des années 1980. Sa forte dépendance vis-à-vis des stratégies de déploiement des compagnies de lignes régulières laisse Halifax tributaire de l'évolution des schémas de rotation. Son éloignement géographique des grandes aires de consommation de l'est nord-américain tend à s'atténuer par les efforts d'investissements du Canadien National sur les liaisons en gerbage avec Toronto, Détroit et Chicago. Halifax a vu son taux de conteneurisation des marchandises presque doubler pour frôler la barre des 40 % en 2000.

Les écarts dans la variation des taux de conteneurisation du total international des marchandises transbordées (et pas seulement des diverses) a orienté notre analyse selon la nature du produit. La présentation de quelques résultats ciblés pour Montréal et Vancouver apporte de nouvelles perspectives dans la compréhension passée et surtout future du phénomène de la conteneurisation des produits.

Échantillon de quelques résultats préliminaires

Seuls quelques extraits en rapport avec l'évolution conteneurisée des produits exportés depuis Montréal et Vancouver serviront d'exemples dans la présente contribution. En premier lieu, le tableau 1 ci-après met en perspective l'augmentation annuelle moyenne sur trois périodes quinquennales des volumes conteneurisés exportés à partir de Vancouver. La segmentation par produits illustre combien les catégories *Alimentaires, Papier et pâtes* et *Produits forestiers* ont soutenu la croissance du trafic du port de l'ouest. Cela indique combien la conteneurisation des marchandises a évolué en élargissant la gamme des produits au profit de marchandises à valeur ajoutée unitaire moindre. Les légumineuses et la viande congelée par exemple sont devenues des produits systématiquement conteneurisés au départ de Vancouver. Les produits forestiers et les pâtes et papiers continuent leur conteneurisation, mettant en place de nouvelles filières logistiques et de nouvelles pratiques d'exportation à valeur ajoutée supérieure aux modes d'exportations conventionnels.

Tableau 1
Moyennes quinquennales de croissance des exportations conteneurisées de Vancouver selon la catégorie de produit (tonnes)

Catégorie de produit	86-90	91-95	96-00
Alimentaire	17 679	49 510	112 340
Appareils et machines	2 360	6 359	13 704
Autres	-2 682	43 968	-31 087
Autres vracs liquides	-810	435	2 776
Autres vracs secs	27 472	18 150	119 295
Céréales	-15 627	8 985	-1 630
Charbon/coke	-122	33	-25
Hydrocarbures	5	44	-55
Marchandises diverses	28 358	27 498	36 420
Minerais/Concentrés	-3 723	-1 140	-1 621
Minéraux	6 401	18 721	3 829
Papier et pâtes	28 005	46 825	218 459
Produits chimiques	-1 409	7 706	13 127
Produits forestiers	-10 846	50 980	196 256
Produits métalliques	7 869	22 883	-102
Textiles et pelleteries	13 429	-340	15 331
Véhicules et pièces	2 045	5 333	-5 100
Total	**98 404**	**305 950**	**691 917**

Source : Innovation maritime, à partir de données de Statistique Canada

Pour Montréal, la limite des distributions statistiques s'avère flagrante par la part comprise dans la catégorie des *Marchandises diverses* au contenu très diversifié. Toutefois, il est pertinent de constater combien les produits alimentaires contribuent à l'augmentation des trafics conteneurisés exportés depuis Montréal. Des données plus détaillées pour la catégorie des produits alimentaires indiquent qu'environ 70 % des tonnages exportés sont constitués de légumineuses en 2000. L'analyse par produit permet de saisir l'évolution qualitative de la conteneurisation des produits. Elle peut soutenir le positionnement stratégique des ports vis-à-vis des pratiques et des besoins de nouveaux chargeurs potentiels. L'analyse sur 15 ans souligne la « mise en boîte » de produits à valeur ajoutée moindre et traditionnellement expédié dans des configurations plus conventionnelles.

Tableau 2
Moyennes quinquennales de croissance des exportations conteneurisées de Montréal selon la catégorie de produit (tonnes)

Catégoprie de produit	86-90	91-95	96-00
Alimentaire	35 748	38 541	40 036
Appareils et machines	7 287	7 876	27 675
Autres	-7 095	5 983	-1 083
Autres vracs liquides	-250	70	-483
Autres vracs secs	10 023	8 434	-19 528
Céréales	10 032	4 785	-11 724
Charbon/coke	-1 592	-28	-17
Hydrocarbures	620	-733	-43
Marchandises diverses	41 410	43 671	91 307
Minerais/Concentrés	-21 086	-1 649	861
Minéraux	11 655	-14 295	-12 961
Papier et pâtes	58 369	8 754	-10 470
Produits chimiques	15 799	15 732	-1 468
Produits forestiers	19 113	9 356	-630
Produits métalliques	32 767	11 034	-31 873
Textiles et pelleteries	13 726	-2 025	3 340
Véhicules et pièces	17 715	7 904	-9 038
Total :	**244 241**	**143 408**	**63 901**

Source : Innovation maritime, à partir de données de Statistique Canada

Plus dans le détail encore, la connaissance des matrices origines/destinations par catégories de produits permet de raffiner davantage les analyses. L'exemple des légumineuses conteneurisées en partance de Montréal est révélateur à cet égard. Le tableau 3 présente l'évolution de la part des principales régions de destination des tonnages conteneurisés exportés à partir de Montréal et le tableau 4 présente la croissance annuelle moyenne des tonnages conteneurisés exportés vers l'Europe du sud (Méditerranée). L'on constate tout d'abord que les volumes destinés en Europe de l'ouest (France, Benelux, Allemagne), bien qu'ils soient en croissance en termes absolus, ont une représentativité moindre d'année en année et ceci au profit des destinations méditerranéennes. Ensuite, les données du tableau 4 indiquent que ce sont les produits alimentaires et les marchandises diverses qui sont essentiellement responsables de la croissance des trafics vers la Méditerranée.

Tableau 3
Évolution de la part des principales régions de destination des tonnages conteneurisés exportés à partir de Montréal

Année	Europe de l'ouest	Europe du nord	Europe du sud	Autres
1983	63,4%	29,0%	2,4%	5,2%
1984	61,9%	27,8%	4,0%	6,3%
1985	65,0%	26,3%	4,0%	4,7%
1986	65,2%	21,9%	8,0%	4,9%
1987	61,5%	23,3%	8,9%	6,3%
1988	64,0%	23,2%	8,9%	3,8%
1989	63,5%	21,1%	10,7%	4,7%
1990	63,3%	20,4%	12,3%	4,1%
1991	66,4%	21,0%	9,2%	3,4%
1992	61,4%	20,9%	12,6%	5,1%
1993	57,3%	20,9%	14,3%	7,6%
1994	61,8%	18,4%	16,0%	3,9%
1995	52,7%	24,0%	18,2%	5,1%
1996	53,1%	25,7%	16,7%	4,6%
1997	52,8%	25,5%	17,2%	4,5%
1998	52,7%	26,3%	16,0%	5,0%
1999	52,5%	25,7%	16,0%	5,8%
2000	52,1%	24,1%	17,7%	6,0%

Source : Innovation maritime à partir de données de Statistique Canada

Tableau 4
Croissance annuelle moyenne des tonnages conteneurisés exportés vers l'Europe du sud (tonnes)

Catégorie de produit	86-90	91-95	96-00
Alimentaire	3 641	18 650	15 382
Marchandises diverses	6 508	7 880	16 463
Papier et pâtes	10 107	8 978	-540
Produits forestiers	8 032	7 447	-1 625
Autres	29 641	17 313	-21 762
Total :	**57 929**	**60 269**	**7 918**

Source : Innovation maritime à partir de données de Statistique Canada

Ce court exemple illustre combien la mise en place de filières internationales d'exportations de « nouveaux » produits conteneurisés sur de nouveaux marchés doit être comprise par les acteurs de la chaîne intermodale de transport. L'enjeu, tel que discuté ci-après, est bien le positionnement stratégique et anticipé sur des produits en cours de conteneurisation et, à terme, conteneurisables.

Discussion

Les quelques données présentées dans la section précédente permettent de mieux comprendre certains des facteurs sous-jacents à l'évolution de la conteneurisation au Canada. D'une part, il ressort des brefs exemples de résultats que le processus de conteneurisation des marchandises est totalement différent que l'on se trouve sur la côte ouest ou dans l'est du Canada. Cette observation est appuyée par le fait que les volumes transitant par chaque port sont constitués de produits ayant des caractéristiques et des contraintes logistiques fort différentes. Ces flux conteneurisés s'intègrent donc dans des chaînes d'approvisionnement distinctes qui n'ont en commun que la boîte. D'autre part, les exemples ont également permit de comprendre qu'une part grandissante des flux de conteneurs des ports canadiens est constituée de marchandises qui, à première vue, ne sont pas des produits traditionnellement conteneurisés.

Notteboom et Winkelmans (2001) suggèrent que l'approche d'économies d'échelle adoptée par les ports au cours des dernières années doit maintenant être bonifiée, sinon remplacée, par une approche d'économies d'envergure basée sur une plus grande flexibilité et la performance logistique de l'ensemble de la chaîne de transport. Pour y arriver, les ports doivent mieux comprendre les besoins de leurs clients pour offrir des services adéquats. Or, l'analyse des flux conteneurisés uniquement en fonction de la boîte restreint considérablement la compréhension réelle des trafics et donc des besoins de la clientèle. Sachant que chaque catégorie, si ce n'est chaque type de produit, comporte ses propres exigences et solutions logistiques, il est impératif de savoir ce qui se trouve dans le conteneur afin de pouvoir mettre en place des services adaptés.

En prenant en compte la nature du produit, son origine ou sa destination, les autorités portuaires pourraient mieux orienter leurs politiques commerciales et leurs visées marketing. Les suggestions et réflexions sur la conteneurisation des produits agro-alimentaires des Prairies s'avèrent d'ailleurs riches d'enseignement pour les trois grands ports canadiens (Prentice, 2002, LMV, 2001).

Le déséquilibre flagrant des flux de conteneurs sur de nombreuses routes maritimes cause de sérieux problèmes aux compagnies maritimes. Le cas de la route trans-pacifique est symptomatique avec des chargeurs canadiens qui profitent de ce véritable tremplin pour développer leur expertise logistique et exporter des produits forestiers et de la pâte de papier en Asie [5] (Alix et Pelletier, 2004, Prentice, 1999). Dans ce sens, des analyses sur les potentialités de conteneurisation de certains produits peuvent constituer un avantage pour les compagnies maritimes, déployant ainsi des capacités par anticipation. Cela peut s'avérer d'autant plus crucial avec les conséquences annoncées de la croissance exceptionnelle du marché chinois et des déséquilibres chroniques sous-jacents.

La connaissance croisée de la structure internationale du marché de certains produits conteneurisables et les conditions/contraintes logistiques du transport en boîte doit permettre à coup sûr une anticipation des évolutions du marché du conteneur. Elle peut soutenir le développement d'innovations technologiques et supporter le positionnement concurrentiel des chargeurs nationaux sur de nouveaux marchés internationaux.

En terminant, la méthodologie présentée ici est perçue comme étant un outil pouvant apporter des réponses cruciales aux intervenants du transport conteneurisé qui cherchent a optimiser leurs activités et a développer des nouveaux marchés et services répondant aux besoins des chargeurs. Néanmoins, cette méthodologie présente de nombreuses limites comme le manque d'uniformité historique dans la caractérisation des produits. En outre, le manque de précision dans la description des produits concourre à entretenir un flou sur les évolutions des produits conteneurisés. Toutefois, le renforcement des exigences de sûreté devrait permettre une plus grande traçabilité des produits et par conséquent soutenir la pertinence de l'approche par catégorisation de produits.

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[5] Pour le troisième trimestre 2003, il coûtait 1 995 dollars américains pour un 20 pieds en provenance de l'Asie vers la côte ouest nord-américaine contre 871 dollars américains dans le sens inverse (*Containerisation international, janvier 2004*).

Conclusion

Les quelques exemples présentés dans cette contribution ont montré combien la catégorisation par produits pouvait apporter un autre éclairage sur l'évolution du processus conteneurisé au Canada. Des logiques logistiques différentes se développent de part et d'autre du pays en corrélation avec la maturité et l'amplitude du phénomène conteneurisé. Une approche qualitative par produits permet de cerner les enjeux, les défis et les atouts d'une conteneurisation potentielle de marchandises à moindre valeur ajoutée. Cette analyse de la conteneurisation par produits transportés ouvre de nouvelles perspectives, tant pour les autorités portuaires que pour les chargeurs manufacturiers ou industriels et même les pouvoirs publics canadiens. Le ciblage des politiques tarifaires/douanières, l'ajustement des priorités d'investissements dans les infrastructures de transport ou le renforcement du positionnement sur les marchés internationaux représentent autant d'exemples de l'applicabilité de la présente démarche de recherche. La conteneurisation et le transport logistique des boîtes obéissent à des logiques organisationnelles propres qui suppléent dorénavant celles des producteurs et distributeurs de biens. C. Fiore disait déjà en 1986 que « *le transport des conteneurs s'est substitué au transport en conteneurs* ». L'apport de la présente méthode ne viendrait-elle pas changer ce paradigme?

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THE MILESTONES IN CANADIAN TRANSPORTATION -AND ITS FUTURE

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Introduction

In a recent document *StraightAhead*, the former Minister of Transport, the Honourable David M. Collenette stated "Transportation built Canada. Transportation will help to determine the future success of Canada. These may be provocative statements..." Given Canada's geography, these statements certainly have of ring of truth to them. The focus of this paper is largely on the first of the Minister's statements with a brief examination of the second statement.

Section I is largely historic in nature where we examine the major milestone in Canadian transportation between 1497- 1779, 1800-1900, 1900-1944 and 1945-2002. In Section II, we briefly examine whether transportation will help determine Canada's future success. Section III reviews the future of transportation in Canada. Finally, a few concluding remarks are offered.

I. Milestones in Canadian Transportation - The Past

Transportation played a major role in nation building in Canada. This is hardly surprising given the natural characteristics of Canada -- a vast country with its own unique geography, dominated by the Rocky Mountains in the West, the Great Lakes and the St. Lawrence Seaway in the East and the inhospitable terrain in the North. At that time, besides roads, waterways were the basic mode of moving people and goods. Canoes were used to cross the inland lakes and waterways and larger sailing vessels were used to cross the Atlantic in the 1600s.

(a) Major Milestones in Canadian Transportation 1497-1779

In 1497, John Cabot's journey across the Atlantic came to an end when his ship, the Matthew, reached 'Bona Vista' marking the discovery of Newfoundland. This discovery marked a major milestone in transportation not only as a means of reaching the New World but as a discovery of resources for England. The abundant supply of fish in the waters around Newfoundland would establish Canada as an exporting

nation.

On May 10, 1534, Jacques Cartier landed in Canada after leaving Saint Malo, France on April 20, 1534 with two ships and sixty-one men. In 1535, Cartier was the first European to sail up the St. Lawrence River hoping it was a possible route to China. He could go no further than the Lachine Rapids at Montreal Island.

In 1608, Quebec was founded by Samuel de Champlain, cartographer and explorer, marking the beginning of a new era. He explored the coastline of New England twice in search of an ideal location for a French colony, finally choosing a settlement along the St. Lawrence at present day Québec City, well suited for the fur trade. Champlain established and developed a vast trade network by forming alliances with the Montagnais Indians. He was appointed the governor of New France by Cardinal Richelieu and was given the title 'Father of New France' due to his major role in the colony's development.

By the early 1600s, explorers began to travel to Canada's interior by waterways by canoe and over land by foot or on horseback. Europeans[1] hoped to find a Northwest passage to the Orient or sought to settle in the 'Bay of the North Sea' now known as the 'Hudson Bay'. One well known mission, the 'Voyage of the Nonsuch', captained by Pierre Esprit Radisson and Sieur de Groseilliers was undertaken to establish the fur-trade. Though an earlier exploration probe was successful, it resulted in fines for trading without a licence and proposals for future missions to trade with the Cree Indians were turned down by the Government of New France. The explorers turned to King Charles II of England who viewed the mission favourably and financed the 'Voyage of the Nonsuch'. Thus in the very early days transportation by water was essential to the trade in fur, a commodity that commanded a high price in the fashion capitals of Europe.

The success of the Voyage of the Nonsuch resulted in the grant of a Royal Charter by Charles II in May 1679, to the "Company of Adventurers of England Trading into Hudson Bay", now known as the Hudson's Bay Company. With this charter, the company was also granted exclusive trading rights in the territory traversed by waterways flowing into Hudson Bay, and named the territory Rupert's Land. This

marked the beginning of the fur-trade period (1670 to 1882) and the creation of the Hudson's Bay Company, which is Canada's largest non-food retailer.

In 1680, the first efforts to open an inland navigation route were pioneered by Dollier de Casson, Superior of the Sulpician Seminary of Montreal. His efforts were met with opposition from his superiors and the apathy of local settlers. Twenty years later he succeeded in signing a contract for the construction of a canal link between Lac St. Louis and Montreal, known as the Lachine Canal today. Between the years 1779 and 1783, four small canals were built by the Royal Army Engineers on the north shore of the river to carry small vessels.[2] The canals ultimately led to the construction of the St. Lawrence Seaway 260 years later.

From the mid 1600s onward, waterways continued to be the most important form of transportation as roads were not yet extensive. Canoes were replaced with rowboats, sailboats and open boats such as the bateau and the Durham boat, and the sailing ships. The latter began to ply the Great Lakes. Vessels such as 'Outaouaise', 'Griffon', 'La Marquise de Vaudreuil', 'Ontario' 'Oswego', 'Mchegon', 'Huron', 'Onondaga' and 'Nancy' have established their special name in history by opening these waterways for transportation of both passengers and goods thereby fostering the growth of the shipbuilding industry, and enabling the development of trade between ports on the Great Lakes.

An important pre-condition for the development of overland transportation was the construction of roads. In 1734, Jean-Eustache Lanoullier de Boisclerc, the Chief Road Commissioner of New France, built the first road between Québec, Trois-Rivières and Montréal. Thereafter, connections to the U.S. were pioneered by Benjamin Franklin in 1763. This provided the impetus for the construction of a major road artery and "In 1791 the government extended this road to Kingston where there had been a post office since 1780. This extension, called the Lake Shore road followed the north shore of Lake Ontario to Ancaster where it connected with the road to Niagara ... The Niagara Post Road ran 11 miles from Chippawa to Queenston ... In 1793 construction began on Dundas Street which ran from Dundas to London and then east to Toronto."[3] The first real roadbuilder in

Upper Canada was Governor Simcoe who introduced a system of road-user charges during the first parliament of Upper Canada in 1792. The construction of roads facilitated the movement of wheeled carriages and the transportation of goods.

In 1769, James Watt in England developed the first efficient steam engine. This marked the turning point in the development of machines that used steam as a form of energy. This led not only to the development of the steam ship but also led to the invention of the steam locomotive; forms of transportation that would not only succeed in bringing the New World closer to Europe, but also in enabling more efficient trade. The use of steamships allowed the vast distances across the oceans to be crossed more quickly and the use of steam-powered locomotives enabled the settlement of the Canadian interior.

(b) Major Milestones in Canadian Transportation 1800-1900

In 1821, the first public railway to use steam locomotives and carry passengers (Stackton and Darlington Railway) began in England. In the USA the first rail line was laid in 1830. In Canada, the first steam locomotive, the *Dorchester*, a wood burner, was introduced by the Champlain and St. Lawrence Railroad. It made its historic run on July 21, 1836 from Laprairie on the St. Lawrence River to Saint-Jean on the Richelieu River, a distance of 14.5 miles. Several other railways began operations during this period including: the Montreal and Lachine Railway, the Erie and Ontario Railroad, and the Carillon and Grenville Railway. In 1851, the first *Railway Act*, was enacted which played an important role in consolidating Canada in the Confederation scheme of 1867. In 1853, Canada's first international railway, the St. Lawrence and Atlantic, was completed from the Canadian border south to Portland, Maine.

The early 1800s also witnessed the introduction of steamships in domestic waters as well as on the world's shipping lanes. The first Canadian steamship, the '*Accommodation*', built by John Molson of Molson Brewery, made its maiden voyage between Montreal and Quebec City in 1809. This was followed by the *Swiftsure* and other Molson-owned steamboats. Molson requested a monopoly on the Montreal-Quebec City route but a bill requesting the monopoly was

defeated as the Molson line was opposed by a rival, John Torrance and Company of Montreal. In 1834, the list of steamship sailings on Lake Ontario were: *Saint George*, *Adelaide*, *Peter Robinson*, *Cobourg*, *Canada*, *Constitution*, *Great Britain*, *Queenston*, *William IV*, and *Oakville*. The *'Royal William'* was the first steamboat to operate between Canada and England, setting a world record in 1833 of 25 days for the passage between Nova Scotia and England.

Two factors retarding an increase in the use of commercial vessels were the War of 1812-15, when commercial vessels were prohibited from using the Great Lakes, and the navigation acts which reserved import or export of merchandise to and from the provinces, or between the ports of Upper Canada to British ships. After the war of 1812, the Rideau Canal and three Ottawa canals connecting Ottawa to Kingston were built by Colonel By to ensure an alternative water route to the St. Lawrence which could not be cut off by the Americans. The Lachine canal was built between 1821 and 1825, to by-pass the Montreal rapids. The Welland Canal, linking Lake Erie and Lake Ontario, was originally built in 1829, then reconstructed in 1845, 1887, 1932 and a by pass was constructed in 1973. The Trent canals (linking Lake Ontario and Lake Huron from the Bay of Qunite to Georgian Bay) were constructed between 1833 and 1920.

The construction of the canals resulted in tremendous commercial advantages as suggested by the following statistics. In the year 1889, 820 steamships and 1,141 sailing vessels passed through the Welland Canal. Comparable figures for the St. Lawrence canals were 3,098 against 5,696 and for the Rideau Canal were 1,114 against 1,120. These statistics also suggest that it was not until after the late 1880s that steamships outnumbered sailing vessels.

On November 7, 1885, the first transcontinental rail line was completed at Craigellachie in the mountains of British Columbia, and on June 28, 1886 the first cross-Canada train, the *Pacific Express*, departed from Montreal for Port Moody, B.C. To celebrate this historic event, the train was greeted at every town. It arrived in Port Moody 5.5 days later on July 4, (only one minute late) and its arrival was cheered by 500 to 600 people and the Mayor of Vancouver.

In the next few years, the Canadian Pacific Railway extended this line to Vancouver which then became its western terminal. In 1876, the Intercolonial Railway linking the Maritimes to Lower Canada was completed. By 1888, prolific growth was experienced in regional rail lines and on other parts of the rail system. It is estimated that private capital equivalent to $15billion today was invested in railway companies by 1900. By the early 1900s, three transcontinental lines had been built though there was insufficient traffic to even fully utilize one. This led to massive railroad bankruptcies and loan defaults which forced the Government to intervene and led to consolidation and the formation of the Canadian National Railways in 1919.

(c) Major Milestones in Canadian Transportation 1900-1944

The early part of the 1900s witnessed the development of the Canadian automobile industry. Serious operations began in 1904 when Gordon McGregor established the Ford Motor Company of Canada in Walkersville, Ontario. Before World War I, automobiles were made by a few, small, new firms and former carriage makers. The Fossmobile, the London Six, the Redpath, the Russell and the Everitt were automobiles made in Canada. In 1913 the MacGregory Company was producing more cars than any other factory in the British Empire. By the mid-1920s, the Brooks Automobile Company produced the last distinctively Canadian automobile. Thus by the end of the war, smaller companies had been acquired by larger ones. Ford took over the MacGregor Company and General Motors took over McLaughlin of Oshawa. The increase in demand made it one of Canada's growth industries which, in conjunction with related industries would make it the largest industry in the next few years.

In 1910, Montreal's public transit system received recognition for its fare of 5-cent per ride. The transit company had its origins in three companies: the Montreal City Passenger Railway (1861) later called Montreal Street Railway (1886), Montreal Island Beltline Railway (1893) later called Montreal Terminal Railway (1899) and Suburban Tramway & Power (1904) later called Public Service Corporation (1910). In 1901, Montreal Street Railway bought Montreal Park & Island Railway (1894), and by 1910, this company had 140 miles of

railway carrying 144m passengers compared to the 2m passengers it carried in 1868. In 1911, all three companies were merged to form the Montreal Tramways Company.

In the 1920s, the use of the automobile increased in popularity and affordability, accompanied by a shift away from steam powered automobiles. While 275,000 automobiles were registered in 1918, the number increased by seven hundred percent, to 1.9 m., by 1929. In terms of manufacturing, the total number of passenger automobiles increased from 69,801 in 1918 to 188,721 in 1929 and the number of commercial auto vehicles for military use and buses increased from 7, 319 to 50, 293 for the same years. This represented increases of 170% and 587% and stimulated the growth and development of better roads.

In the late 1930s, Canada's first national airline, Trans-Canada Airlines (i.e., TA) was formed as a result of an agreement between the federal government and the Canadian National Railways. This agreement led to the enactment of the *Trans Canada Airlines Act* in 1937, which provided for the creation and the preservation of a virtual monopoly for TA in transcontinental, domestic, and international areas of operation. Government airmail contracts were awarded only to TA. In 1941, Canada's second national airline, United Air Services Ltd. (re-named Canadian Pacific Air Lines a year later) was created by Canadian Pacific Railways through an amalgamation of eleven aircraft operations. This new form of transport would revolutionize international travel.

The early 1940s witnessed the emergence of the pipeline transportation industry in crude oil. The first three major crude oil pipelines were the Interprovincial Pipe Line, the Transmountain Pipeline and the Montreal-Portland. Transportation of natural gas began a decade later with the construction of the Trans-Canada Pipeline, the Westcoast Transmission Line, and the Alberta Gas Trunk Line. By 1999, its freight operating revenue exceeded any of the other transportation modes.

(d) Major Milestones in Canadian Transportation 1945-2002

After the mid 20th century, the airplane captured the imagination of the country. In the 1950s, new airports with modern air navigation

and air traffic control systems were developed. While most airport construction had occurred before and during the WW II, the task of extending runways and improving airport facilities for passengers was a post war phenomena. One source noted "...a massive program of air terminal construction was begun in the mid-1950s, with buildings being erected at Gander, Montreal, Toronto, Winnipeg, Edmonton, Halifax, and Ottawa. These were all large buildings of the latest design, incorporating features from the leading airports in the world."[4] In addition, during the 1950s, three systems of early warning radar (Pine Tree, Mid-Canada and DEW Line) were built across Canada. This not only accommodated growing passenger traffic, larger aircraft, increased aircraft movement but also post war defence needs.

The 1950s witnessed the origin of the rail intermodal system (trailer on flat car i.e, TOFC and container on flat car i.e., COFC) in Canada. Intermodal traffic grew dramatically from 2.2m. metric tonnes in 1970 to 21.9m. metric tonnes in 2000. The early growth in TOFC was overshadowed by the growth in COFC. Between 1970-2000, COFC increased 5,371 percent from 369, 429 to 20.2m and TOFC declined by 10 percent from 1.9m to 1.7m.

On March 30, 1954, Canada's first subway system in Toronto was opened between Union Station and Eglinton Station. The Toronto Transit Commission has a long history which dates back to 1861 when the Toronto Street Railway Company obtained a franchise to operate public transportation. In 1892, the TTC operated the first electric street car in Toronto (which was retired a century later in 1993). The subway's significance to travel in Toronto has been tremendous as seen by the fact that between 1954-2002, the subway was extended fourteen times and customer trips peaked at 463m in 1988.

On June 26, 1959, the Great Lakes/St. Lawrence Seaway System was officially opened by Her Majesty Queen Elizabeth II, Prince Phillip, President Dwight D. Eisenhower of the United States and Prime Minister John Diefenbaker of Canada. The Seaway project was undertaken by Canada and the United States, at a cost of one billion dollars, to satisfy the increasing demand for electricity and to enable increased trade. Dams on the Seaway generated more than 2.2m

horsepower in electrical capacity and the Seaway established a better shipping route from Montreal to ports on the Great Lakes. The significance of the Seaway can be seen in the fact that traffic has grown from 30m tonnes in 1960 to 41.7m tonnes to 2001 having reached a peak in 1974 of 74m. In terms of revenue, tolls account for $73.4m, it also generates $2b in personal income and 40,000 jobs.

In 1960, the Trans-Canada Highway was completed, one of Canada's outstanding engineering feats, providing high-standard highway conditions through some of the most difficult road building terrain in the world. Before 1960, a modern highway linking the provinces of Canada did not exist. As a result, in December 1948, the first Federal-Provincial Conference on the Trans-Canada Highway was held which resulted in the passage of the *Trans Canada Highway Act*. The Highway not only enabled the free flow of traffic but also resulted in the building of many additional feeder highways which have contributed to the economic growth of the nation.

On October 14, 1966, Montreal's Metro, with 26 stations, on three lines was inaugurated. Discussion of opening a metro in Montreal date back to 1910, but it was only in 1960 that plans were formalized. Construction began on May 23, 1962 and the cost of the three lines was $213.7m. In 1966, Montreal became the 8 th City in North America and the 26th in the world to have an underground transportation system. The construction of the metro helped to ease congestion that had affected the city for some time.

In 1969, the first liner container services began by Dart Container Line and Manchester Liners from Montreal to Europe. In the next two years, new container terminals or berths were established in Canada. Container traffic twenty foot units (TEUs) increased from less than 100,000 in 1970 to more than 1.2m. in 2000. Today, though container shipping accounts for only 6% of total cargo shipped, its value is more than 25% of all cargo shipped (as more valuable commodities are shipped by container).

On October 29, 1978, the first passenger trains operated by VIA Rail Canada began their journey across this country. VIA's trains have been operating from the Atlantic to the Pacific, from the Great

Lakes to Hudson Bay. VIA links more than 450 communities over 14,000 km. of track. In 2002, VIA carried more than 4 million passengers.

The 1980s saw a rapid increase in the courier services business from $0.7m in 1980 to $4.9m in 2000. Canada's largest courier service, Purolator Courier Ltd. can be traced to December 1960. In the late 1990s, Purolator was purchased by Canada Post Corporation making it the largest domestic courier. This type of purchase is being emulated by other governments and today the larger courier companies in the world are evolving to integrated logistics companies which provide total solutions or supply chain solutions.

In 1997, the Confederation Bridge was opened, linking Borden-Carleton, Prince Edward Island and Cape Jourimain, New Brunswick. The bridge spans 12.9km and is the longest bridge over ice covered waters in the world. The Bridge is privately maintained, managed and operated by Strait Crossing Ltd and its subsidiary. The Bridge is expected to have a significant impact on the economy of the two provinces by enabling easier movement of passengers and transportation of goods.

On October 26, 1999, the restructuring of the airline industry to protect the public interest by Transport Minister, David M. Collenette began. And on December 21, 1999, the Transport Minister announced that the Government of Canada was prepared to approve the Air Canada offer to acquire Canadian Airlines based on the secured commitments from Air Canada. The restructuring was necessitated as three earlier attempts by Canadian Airlines to restructure ended in failure resulting in quarterly losses of several million dollar and its demise.

By the end of 2000, the impact of new technology on transportation was clearly visible. Information and Communications Technology (through electronic data interchange affected the flow of goods, inventory storage, border crossing, and vehicle and cargo identification; and through the Internet enabled transactions electronically from the office) provided shippers with more choices and created demand for new services; revolutionized the transmission

of goods through logistics; and enabled better location, identification, assessment and control of vehicles on the road, rail, water and air through Intelligent Transportation Systems. There were also significant new technologies in each transportation mode: in road - B-train, and axle development; in rail - diesel engines, double stack trains, high speed passenger trains and subways, and intermodal technologies; in water - containerization, mega-sized ships, and gantry cranes; and in air - various types and sizes of jet aircraft. This was dovetailed with major changes in infrastructure such as network of highways, airports, ports, and railway.

In conclusion, a review of the past provides ample testimony that transportation played a vital role in building Canada.

II. Will Transportation Help Determine the Future Success of Canada?

To examine this issue a few of the factors that closely link transportation and the Canadian economy will be reviewed.

(a) Employment, Output and Economic Growth

Transportation is a major contributor to employment, output and economic growth. Transportation has been responsible for employing 850,000 people on a full time basis which represents 7% of total full time employment in Canada in 2000. For the same year, transportation industries accounted for 4.1% of the gross domestic product which in absolute terms was $32, 114 million. This statistic takes on far greater significance when considered as expenditures on transportation by households, businesses and governments as it accounts for 16% of the gross domestic product. The annual growth rate of the transportation sector for the decade is 6.1% compared to 3.3% for the rest of the economy.

(b) Regional and Urban Development

Transportation plays an important role in the provincial economies. In 2000, the provincial GDP accounted for by transportation, ranged from a low of 3.4% in Saskatchewan to a high of 5.7% in Manitoba or New Brunswick or in absolute terms from a low of $102.9 million in PEI to a high of $14,704.7 million in Ontario. Transportation is

not only essential to intra-provincial trade but also to inter-provincial trade. In 1999, intra-provincial trade accounted for 87% of total domestic trade in goods and services ($1,459 billion) compared to 13% of inter-provincial trade. This importance led to the inclusion of regional and urban development as part of national transportation policy in the *National Transportation Act* now the *Canada Transportation Act*.[5]

(c) Development of Exports

Transportation has not only enabled Canada to become a major exporting nation but has also played a key role in the development of resource-based industries. In 2000, exports of goods were $412.9 billion (excluding services of $66 billion) of which 87% was to the U.S. Exports of bulk commodities (such as chemicals, grain, forest products, coal, ores and metals, fertilizer, etc.) from locations far from urban concentrations would be unimaginable without an integrated system of transportation. Exports play a vital role in the prosperity and growth of Canada as it accounts for a very significant portion of gross domestic product.

This brief review suggests that transportation will help determine the future success of Canada, though there is hardly any doubt that it will also depend on several other factors.

III. Transportation - The Future

The future of Transportation in Canada will likely be linked to the following factors.[6]

(a) New Technologies

The future of transportation, like in many other industries, is connected to the development of new transport technologies, and the adoption of Information Communications Technology to transport.

1. *Development of new technologies*:

New technologies affecting transport can be classified into: Technologies related to a specific mode and technologies related to infrastructure. The most significant marine developments are: containerization; mega-sized carrier; multimodal transportation and gantry cranes. In the rail mode, the most significant technological

developments were: diesel engines; double stack trains; and technology to facilitate intermodal traffic - Road Railer and Iron Highway. In the air mode, the most significant technological developments were: the jet engines and planes of various sizes. In the highway mode, the most significant technological developments were: 'B' train; axle development; and sleeping cabin in trucks.

Regarding technologies related to infrastructure, there has been significant investment to build new container terminals, to dredge the Port of Montreal for larger ships, to complete tunnel clearances, to purchase railway lines in the US, to build airports and modern navigation systems, and to construct highways.

2. *Adoption of Information Communications Technology*(ICT):
a. Electronic data interchange is being used to enhance efficiency by expediting smooth passage of goods through indication of arrival and departure of shipments; lowering the need for larger inventories and storage capacity for them; facilitating border crossing through electronic release of invoices between importers or brokers and custom officials; and enabling vehicle and cargo identification and tracking.
b. The Internet enables shippers and transportation providers to do business directly and almost instantaneously. Systems to indicate the precise nature of their shipments and schedule requirements, cost estimates and ability to bring about considerable economies.
c. Logistics systems are increasingly using high-tech equipment like bar code scanners and computer logging and tracking systems. In addition, third party logistics providers are being increasingly considered as they enable reductions in cost.
d. Intelligent transportation systems brings together the user, the vehicle and the infrastructure in a single communications system that operates in four performance areas: location, identification, assessment and control through automated vehicle location, route guidance, automatic vehicle identification, etc. Examples of such technologies are use of bar codes, transponders, global positioning, and spread spectrum technology.

(b) Increasing Competitiveness in a Global Economy

The focus of Canada's transportation industry is becoming

increasingly global. Industry players are larger, a growing share of their revenues are earned abroad, they define themselves as global or North American players, and they are merging or forming alliances with foreign carriers. These trends in globalization are expected to continue. To survive in this global economy, an efficient transportation system is needed to ensure that Canadian firms can compete effectively in a more integrated North American market and a global market. "Competition is a means to ensure existing competitors and new entrants innovate, take risks, and provide new services ... resulting in cost reductions, efficiency gains and service improvements."[7]

Canada has undertaken a number of initiatives aimed at increasing competition, such as deregulation, reduction of subsidies, and signing liberal international agreements. Adjustments in marketplace framework are still possible and opportunities continue to exist,[8] such as seeking greater compatibility and harmonization with the US and internationally, gradually liberalizing Canada's air bilateral regime, contributing to international shipping policy, and monitoring the impact of international agreements.

(c) Expansion in Trade and Infrastructure Development

World trade fuelled by the FTA, FTAA, NAFTA, the WTO, and the Bogor Declaration of 1994 (i.e., free trade within APEC for developed countries by 2010 and free trade with all developed countries by 2020) will continue to place increased need for development of transportation infrastructure. Transport Canada states "High quality transportation infrastructure is key to our competitiveness, attracting foreign investments, respecting the environment and quality of life. Unprecedented demand placed on key corridors and international gateways, ... require attention to sustain our economic growth and quality of life."[9] A partial attempt to achieve this was a radical shift in the management of the transportation infrastructure from the government to the private sector in the 1990s. New commercial enterprises were established to take over operations and control costs of NAV Canada, airports in the National Airport System, and Canada Port Authorities.

The government is also committed to maintaining a climate conducive to investment in infrastructure and has identified three areas of focus: continuation of commercialization and divestiture of government-owned transportation infrastructure with some fine tuning of the governing entities; strategic investments in support of competitiveness, sustainable growth and well-integrated transportation will be made in partnership with other sectors; and reasonable access by remote communities to the national transportation system.

(d) A Liberalization in Transportation Agreements

A liberalization of transportation has been ongoing for some time but received the most attention with the 1995 Canada-United States Open Skies Agreement in air transportation and the Brock-Gotlieb understanding and NAFTA as it relates to trucking. There is no disagreement about the benefits of the 1995 air agreement with the United States for all stakeholders[10] or the benefits of the agreements with regard to trucking. There will therefore be continued pressure on the government to continue to negotiate similar agreements with more trading partners, to liberalize foreign ownership rules, and possibly to permit the creation of a Canada-only foreign owned air carrier. This pressure will also apply to other transportation sub-sectors that have similar restrictions. Further, the existing different regimes for these sub-sectors makes such a policy less tenable. In the long-run, different regimes will becoming increasingly difficult to maintain and justify when other industries in our economy are not afforded similar protection and are subject to open and unfettered competition.

(e) Growing Sustainable Transportation Concerns

Sustainable[11] transportation considerations have been growing in importance and will continue to grow given ever increasing internal and external trade. Sustainable transportation requires ensuring that environmental impacts are considered along with economic and social considerations in transportation decision making. These impacts include air and water pollution, greenhouse gas emissions and the use of land and other natural resources which produce harmful effects.

The government has taken a number of initiatives in this regard. The best example is the *Action Plan 2000 on Climate Change*. Others

are listed in Transport Canada's Sustainable Development Strategy,[12] but further work needs to be done in this area. Accordingly, the vision in *StraightAhead* proposes a further commitment to environmental responsibility. Some of the more important actions this report has proposed for the future are: including environmental concerns as part of the national transportation policy in the *Canada Transportation Act*; promoting vehicles and fuels that produce fewer emissions; promoting increased use of alternative modes of transportation for passenger travel and more efficient transportation of goods; launching a national environmentally sustainable awareness campaign; and collaborating with other bodies to determine full cost of transportation, including environmental costs, so that they may be better reflected in prices.

IV. Concluding Remarks

In sum, the milestones in transportation provide evidence for the Minister of Transport's statement that 'transportation built Canada'. They indicate the vital role transportation plays in the Canadian economy. There is little doubt that transportation has been a major factor in building and unifying Canada since Confederation. Its importance was specifically recognized by statute when the national transportation policy was made an objective in the *National Transportation Act of 1967*.

The future of transportation in Canada will be linked to a few important factors. The most important of these will be technological developments. The Government has already recognized this and has established mechanisms to develop and commercialize innovative technologies.[13] Other important areas of government involvement are through increasing research and development, supporting university research, ITS and Innovation in business practice. The former Transport Minister in his document, *Straight Ahead,* has made eight proposals in this regard. Transport Canada will work or will promote: an increase in transportation related R&D with the transportation and non-transportation sectors; an increase R&D in transportation related issues with the private sector and universities; the possibility of establishing a visiting chair program at Transport Canada; the

development of an ITS R&D Plan with its partners; the support of ITS technologies; the development of a technology road map for logistics with the Industry Canada-led initiative; the adoption of e-commerce technology; and the promotion of Government On-Line initiative.[14] The former Minister has also provided funding for such projects.

The historical record in transportation may suggest that technological changes proceeded smoothly over time. This is far from true. At times, there has been considerable resistance to change as often vested interests did not favour revolutionary ideas. It is therefore not surprising that new ideas and new methods often called for new men and new institutions. "It was not the stage coach owners who built the railroads, nor the owners of fleets of clippers who developed the steamer ... Nor did the railroad magnates promote the automobile. ... the automobile magnates did not become airplane pioneers."[15] The slowness in adopting changes and innovation has also been pointed of the first class mail monopoly in Canada.[16] It draws attention to the dangers of monopoly in rapidly dynamic economies.[17]

It is considerations like this that have lead to a recently proposed amendment to the merger provisions of the *Competition Act* which will prevent the use of the efficiency limitation in situations that will result in a monopoly. The rationality behind this amendment is not surprising given the past and the rapidly changing technological world in which we live. In the words of a US Court, "Possession of unchallenged economic power deadens initiative, discourages thrift and depresses energy; immunity from competition is a narcotic, and rivalry a stimulant to industrial progress; the spur of constant stress is necessary to counteract an inevitable disposition of let wellalone."[18] This sums up in a sentence the philosophy embodying anti-trust legislation on this issue.

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12. Mcgrath, T. M. *History of Canadian Airports*, Lugus Publications, Toronto, Ontario 1992, p. 51.
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* ***The views expressed are those of the authors and not those of the Competition Bureau or Industry Canada.***

Endnotes

1. Henry Hudson (1610), Button (1612), Munk (1619), Foxes and James (1631)), Ren Robert Cavalier, Sieur de la Salle (1666), Henry Kelsey (first explorer of the Prairies 1690), etc.

2. See the *Montreal/Lake Ontario Section of the Seaway*, www.seaway.ca

3. Adie, Douglas, *The Mail Monopoly: Analysing Canadian Postal Service*, 1990, p. 33.

4. Mcgrath, T. M., *History of Canadian Airports*, Lugus Publications, Toronto, Ont. 1992, p. 51.

5. Section 3(d) now 5(d) states "transportation is recognized as a key to regional economic development and that commercial viability of transportation links is balanced with regional economic development objectives so that the potential economic strengths of each region may be realized." The NTARC in 1993 recommended that this section be deleted as an element of transportation policy but it was not. The use of transportation policy as a tool for regional development was questioned as more effective tools were available.

6. Transport Canada lists six priorities for the future: maintain and enhance the safety regime; foster competitiveness in a global economy; support infrastructure development; advance sustainable transportation; facilitate transition to the knowledge-based economy; and complete the divestiture programs. See *Looking to the New Millennium*, Transport Canada, TP 13605, p. 12.

7. *Straight Ahead*, A Vision for Transportation in Canada, Transport Canada, 2003, p. 19.

8. *Id.* p. 23. Also see *Looking to the New Millennium*, Transport Canada, TP 13605, pp. 18-19.

9. See *Looking to the New Millennium*, p. 21.

10. *Straight Ahead*, p. 30.

11. Development that meets the needs of the present without compromising the ability of future generations to meet their own need

12. See *Sustainable Development Strategy* for 1997 and 2000 and *Sustainable Transportation: The Canadian Context*, Monograph No. 15, Transport Canada, Ottawa, Canada 2001, p. 14.

13. These include: Canadian Foundation for Innovation, Technology Partnerships, Industrial Research Assistance Program, Sustainable Development Technology, Program for Energy Research and Development, Climate Change Action Fund, Canadian Transportation Fuel Cell Alliance, and Green Municipal Investment Fund. Straight Ahead, A Vision for Transportation in Canada, Transport Canada, 2003.

14. See *Straight Ahead*, pp. 78-80.

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16. "An examination of postal history gives little or no support to those who would try to preserve the present government monopoly over first class mail. Private delivery systems adapted more quickly to changing market conditions and innovated first and most successfully." Adie K. Douglas, *The Mail Monopoly*, The Fraser Institute, 1990, p. 14.

17. ...the waste of monopoly would lie, not in depriving the community of what it now has or what it might have in the immediate future, but of what it might have in the longer future. *Id.* p. 214.

18. *U.S. v. Aluminum Co. of America*, 1948, Fed. 2d., 416 (1945). The US DOJ Merger Guidelines recognizing this stated " Efficiencies almost never justify a merger to monopoly or near monopoly."

Forecasting Freight Transport Demand in Alberta Using Dirty Data and Flawed Models[1]

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Abstract

Transportation industry practitioners, shippers, and government planners and policy analysts often find it useful to have a broad picture of the future demand for transportation. This paper shows how such a picture could be painted using publicly available data resources and standard econometric tools. Perhaps more importantly, the paper also demonstrates the fragility of the estimates and the large errors that should be attached to the forecasts. In particular, we provide the details of the specification, estimation, and validation of the econometric models used to forecast freight transport demand in Alberta for the modes of air, rail, and road. We estimate the elasticity of freight transportation demand by mode. These estimated elasticities are then applied to time-series forecasts of Alberta GDP to obtain a consistent estimate of future transport demand associated with forecasted growth in the provincial economy. The forecasts are discussed with reference to their fragility and their substantive implications.

1 Introduction

Transportation is atypical in many economic aspects, most particularly in the derived nature of its demand which complicates the traditional forecasting process. In this paper we

[1] We would like to thank Peter Wallis for his support

demonstrate a straightforward approach to forecasting freight transport demand using publicly available data. Many practitioners and policy makers strive to provide those "magic numbers" which they can use to enhance their decision making and provide much needed justification or support. Planning for new infrastructure, altering key policies and ensuring that transportation is as efficient as possible are all contingent on reasonable estimates of future economic activity. The primary goals of this paper are to outline an empirical approach and to demonstrate the challenges of providing reliable estimates of future transportation activity.

Key to our approach in this paper is to acknowledge at the outset that the data are "dirty" and that the statistical models used to estimate parameters and make forecasts are probably wrong; another way of stating this is that we are being honest with the reader in the same way that we would be honest with ourselves.[2] We proceed by first building a forecasting model of economic activity in Alberta. We then relate economic activity to transport demand by mode. Finally, these inputs are combined to provide a consistent forecast of transport demand.

2. Forecasting Economic Activity

Forecasts of Alberta economic activity are generated from autoregressive integrated moving average (ARIMA) models. ARIMA models are generalizations of simple autoregressive models that employ three distinct elements: an autoregressive term, corresponding to the lagged residuals in the forecasting equation; the order of integration, with each integration order corresponding to differencing the forecasted series; and the moving average term, which improves the forecast by using lagged values of the forecast error. The ARIMA modeling strategy, pioneered by Box and Jenkins (1976), provides a parsimonious representation of the data generating process that is particularly suited to forecasting applications.

2.1 Specification

[2] As one of our famous econometrics teachers one admonished regarding econometric model building, "It is okay to fool somebody else, just don't fool yourself."

The elements of the ARIMA model are determined by examination of the correlations and the partial correlations of the series to be forecasted. The series forecasted in this paper are modeled using an ARIMA(1,1,1) model, which corresponds to[3] $(1 - L)y = \mu$ where $\mu_t = \rho\mu_{t-1} + \varepsilon_t + \theta\varepsilon_{t-1}$. This parsimonious specification was found to accommodate the statistical properties of the data.

2.2 Diagnostics

After estimating the model on the sample of data, we computed a dynamic forecast over the final five-year interval for which data were available: 1997–2001. The forecast evaluations provide a metric for quantifying the accuracy of the forecasting model. Several metrics of forecast accuracy were investigated for each series, including root mean squared error, mean absolute error, mean absolute percentage error, and Theil's inequality coefficient. Perhaps the most intuitive of these is the mean absolute percentage error; simply the average forecast error in percentage terms, treating overestimates and underestimates equally.

2.3 Data Description and Transformation

The data on real Alberta GDP by industry sector were obtained directly from the tables of real GDP produced and published by the government. Abbreviated variables names have been used in the statistical analysis; the mapping between the abbreviations and the official industry sector names is given in Table 1. The forecasting model requires that the data be stationary. Each price series was tested for the presence of a unit root using the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979; Dickey and Fuller, 1981)[4]. In this statistical test, the following regression equation is estimated for each price series:

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[3] See Box and Jenkins (1976), Harvey (1981), or any other good time series book for notational conventions.

[4] There are many alternative statistical tests to test the null hypothesis of nonstationarity. These other tests, such as the KPSS test (Kwiatowski et al., 1992), the Phillips-Perron test (Phillips and Perron, 1988), yield the same substantive results.

$$\Delta y_t = \beta_0 + \beta_1 y_{t-1} + \sum_{i=1}^{L} \beta_i \Delta y_{t-i} \quad (1)$$

For the ADF test to be valid, it is a necessary condition that the residuals from equation (1) not be serially correlated. The maximum lag length was set at eight (Δy_{t-8}) terms in each testing equation and the final lag term was determined according to the Schwarz information criterion (Schwarz, 1978). This selection of the lag length will contain the appropriate number of lagged terms as long as the initial lag length is long enough. The alternative strategy of beginning with a parsimonious model and adding lags until there is no presence of serial correlation is biased towards not rejecting the null hypothesis of a unit root (Enders, 1995, ch. 4).

Table 1 Acronyms for Alberta Industry Sectors

Acronym	Complete Name of Industry Sector
ACCOMM	Accommodation & Food Service
ADMINWASTE	Admin. Support, Waste Management & Remediation
ARTS	Arts, Entertainment & Recreation
CONST	Construction
CROPANIMAL	Crop & Animal Production
EDUC	Educational Services
FIRE	Finance, Insurance, Real Estate, Renting & Leasing
FISHING	Fishing, Hunting & Trapping
FORESTRY	Forestry & Logging
HEALTH	Health Care & Social Assistance
INFOCULT	Information & Cultural Industries
MANU	Manufacturing
MINING	Mining, Oil & Gas
OTHSERV	Other Services
PROFSERV	Professional, Scientific & Technical Services
PUBADMIN	Public Administration
RETAIL	Retail Trade
TRANSPW	Transportation & Warehousing
UTILITIES	Utilities
WHOLESALE	Wholesale Trade

Standard practice in time series autoregressive modeling is to first transform the data to obtain stationarity and then to model the transformed series (Box and Jenkins, 1970; Harvey, 1981). The first difference operator was applied to the output series and the transformed series were tested for nonstationarity using the augmented Dickey-Fuller test. The Ljung-Box (Ljung and Box, 1978) test for serial correlation indicated that the residuals

from each testing equation were white noise. Each of the transformed data series was found to be stationary, and so the analysis proceeds with the series in first-differenced form

2.4 Estimation: Forecasts and their Standard Errors

To develop a suitable forecasting model, we used the available data excluding the most recent five years. We then identified the best forecasting model for the estimation sample and evaluated a out-of-sample forecast using the most recent five years of data. Of particular interest is the mean absolute percentage error, showing the average error of the forecast in the unitless dimension of percentage. Also the bias, variance, and covariance show the sources of error in the forecast. The mean absolute percentage errors of the developed models were less than 10% for most industry sectors. However certain sectors had quite large errors in the developed models, including construction, fishing, and professional services. The forecasting model fit particularly well in the manufacturing, mining, and wholesale sectors, each with a mean absolute percentage error of less than 3%.

Table 2: Forecasts for Alberta Industry Sectors

	Year				
Sector	2005	2006	2007	2008	2009
ACCOMMF	3657.831	3770.131	3881.984	3993.902	4106.333
ADMINWASTEF	2945.544	3212.038	3508.400	3828.840	4180.397
ARTSF	1042.972	1085.561	1130.169	1176.744	1225.299
CONSTF	10626.63	11106.26	11608.70	12133.57	12682.24
CROPANIMALF	3663.378	3807.245	3955.370	4108.867	4268.211
EDUCF	4550.689	4625.831	4702.215	4779.859	4858.786
FIREF	20483.03	20903.63	21347.24	21812.28	22297.49
FISHINGF	1.806043	1.732669	1.659268	1.587314	1.517563
FORESTRYF	369.2624	380.1363	391.5907	403.5073	415.8391
HEALTHF	5115.081	5206.997	5301.680	5399.102	5499.241
INFOCULTF	5876.610	6290.183	6732.802	7206.576	7713.687
MANUF	14587.08	15384.85	16226.14	17113.45	18049.28
MININGF	22601.14	23068.65	23547.71	24037.62	24538.13
OTHSERVF	3000.285	3101.948	3206.056	3312.759	3422.204
PROFSERVF	5403.123	5470.620	5546.573	5627.618	5711.990
PUBADMINF	5101.074	5190.881	5266.274	5352.184	5430.420
RETAILF	5761.788	5898.651	6048.749	6209.737	6380.023
TRANSPWF	7023.015	7172.886	7323.617	7475.176	7627.512
UTILITIESF	3487.328	3640.006	3799.366	3965.702	4139.320
WHOLESALEF	6801.524	6972.578	7143.641	7314.705	7485.769

Table 2 shows the point forecast for each component of Alberta GDP for the 2004–2010 horizon using the developed models.[5] Table 3 shows the estimated standard error of forecast for each component of Alberta GDP for the 2004–2010 horizons.

Table 3: Standard Errors of Forecasts for Alberta Industry Sectors

Sector	2005	2006	2007	2008	2009
ACCOMMS	395.6228	481.1281	567.6592	655.2116	743.7838
ADMINWASTES	891.0032	1087.684	1304.925	1539.895	1799.502
ARTSS	69.73141	84.07000	98.22001	112.3831	126.7145
CONSTS	2884.751	3405.888	3927.213	4455.463	4996.717
CROPANIMALS	410.4218	427.7189	445.4723	463.8830	483.0281
EDUCS	228.6439	263.8284	296.6964	328.0271	358.3025
FIRES	1723.017	1844.642	1945.847	2034.164	2114.261
FISHINGS	0.460378	0.444264	0.426508	0.408507	0.390821
FORESTRYS	58.01369	63.56501	69.08633	74.66620	80.34927
HEALTHS	361.7011	450.6284	543.0248	638.6101	737.1400
INFOCULTS	869.8559	1051.784	1241.665	1442.432	1656.437
MANUS	1866.760	2185.314	2512.395	2851.967	3207.016
MININGS	1746.468	1785.455	1823.672	1862.217	1901.410
OTHSERVS	200.1579	220.6767	238.9237	255.6142	271.2239
PROFSERVS	583.9911	596.1740	607.5469	618.7563	630.0184
PUBADMINS	214.4201	238.5710	263.0264	283.6797	304.0941
RETAILS	449.0390	473.2498	494.6659	514.8359	534.5586
TRANSPWS	361.2455	548.4463	792.3172	1082.375	1413.601
UTILITIESS	382.5945	437.1433	492.5826	549.4312	608.0869
WHOLESALES	459.5084	504.3684	545.5491	583.8319	619.7544

3 Modeling Transport Demand in Relation to Economic Activity

For each transportation mode our goal is to provide a forecast of future demand in response to future economic growth in the Alberta economy. Through a simple log-linear regression

[5] At the time the statistical analysis was conducted, the most current complete year of Alberta GDP data was 2001. Because 2002 and 2003 data may be released shortly after this paper is published, and because they are years of extreme events, we have chosen to begin our forecast in 2005. The final year of the forecast period is 2009; forecasting farther than this into the future is imprudent because the forecasting model loses precision rapidly as the forecast horizon increases.

model we estimate the elasticity of transportation demand with respect to industry output. The estimated elasticities will be used in conjunction with the sectoral forecasts of economic growth detailed in the previous section to obtain an estimate of future transportation demand.

The elasticities of transport demand with respect to economic output are obtained directly by estimating equations of the form

$$\log(\text{transportation output}) = \alpha + \beta \log(\text{sector output}) + \mu \quad (2)$$

where μ is a stochastic disturbance with zero mean and finite variance. The regression parameter β is precisely the elasticity of transportation output with respect to sector output. We estimate this equation for various metrics of transportation output *(e.g.* tons, ton-km) and various sectors *(e.g.* manufacturing, agriculture and animal production, mining, forestry, wholesale).

In addition to performing least-squares estimation on equation (2), we also estimated the elasticities using statistical methods that account for various undesirable properties in the data. First, we account for measurement error that may be present in the regressors in the elasticity equations. We can explicitly account for the imprecision of the regressor variables in estimating the various transportation output elasticities in a way that accounts for measurement error by estimating an errors-in-variables model. In the context of our model, measurement error would lead to an underestimate of the elasticities and also lead to erroneous statistical inferences (Chow, 1983, pp. 14–15). Thus, it is important to perform a sensitivity analysis to quantify how the empirical results are affected by various assumptions about the precision of the regressor variables. The precision is quantified as 1-(noise variance/signal variance); we report the elasticity estimates and their standard errors for the under the assumption that the precision of the regressors is 0.75.[6]

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[6] The errors-in-variables regressions were estimated in Stata 7 for linux. For details of the estimation method and formulae see Stata (2001, volume 1, pp. 432-436).

To control for the influence of outlying observations, we also estimated the elasticities using least absolute deviation regression. In this regression model, also called a median regression, the median of the dependent variable is modeled instead of the mean, so this estimator is robust to extreme outliers (see Judge et al., 1985, ch. 20). The estimates are presented below by transportation mode and the metric of transportation output.

3.1 Trucking

The elasticity of trucking demand with respect to industry output was estimated separately for shipments originating in Calgary and Edmonton. The estimation was performed separately for trucking output defined in units of tons and tonkilometers using data obtained from the Statistics Canada publication *Trucking in Canada*. To make our results easily replicable, we display the data in Table 4. Only the results using ton-miles are reported in this paper.

Table 4: Trucking Data by City of Origin

	Calgary		Edmonton	
Year	tons	ton-km	Tons	ton-km
1995	4557	2770889	7340	3812619
1996	4690	3015146	8635	4373743
1997	4569	2822357	8345	4211560
1998	4934	3032733	7912	4030159
1999	6756	4167701	8085	3917413
2000	6249	4255814	10168	5518298
2001	5691	3564363	9532	4705237

Source: Statistics Canada, *Trucking in Canada*, various issues.

In Tables 5 and 6, variation in elasticities by economic sector is evident, as is variation by estimation approach within sectors. The estimates for the errors-in-variables approach are typically the largest of the three approaches. For some sectors, the large standard errors relative to the estimates indicates a lack of significance. In part, the issues associated with the aggregated nature of the data on which these estimates are based come to the fore.

Table 5: Elasticity Estimates for Calgary-Origin Trucking Ton-Kilometers

	Method of Estimation		
GDP	least-	errors-in-variables	quantile regression
cropanimal	2.802	3.737	3.075
	(1.177)	(1.238)	(2.198)
Forestry	0.907	1.209	1.123
	(0.261)	(0.155)	(0.563)
Manu	1.121	1.495	0.834
	(0.549)	(0.623)	(0.815)
Mining	1.727	2.302	3.790
	(3.722)	(4.928)	(8.651)
wholesale	0.731	0.974	0.496
	(0.334)	(0.368)	(0.464)

Note: Estimated standard errors are in parentheses.

Table 6: Elasticity Estimates for Edmonton-Origin Trucking Ton-Kilometers

	Method of Estimation		
GDP Sector	least-squares	errors-in-variables	quantile regression
cropanimal	0.129	0.173	-0.571
	(1.218)	(1.622)	(2.235)
Forestry	0.410	0.547	0.274
	(0.289)	(0.357)	(0.599)
Manu	0.710	0.947	0.697
	(0.421)	(0.505)	(0.655)
Mining	4.627	6.169	3.459
	(1.727)	(1.662)	(3.347)
wholesale	0.464	0.619	0.414
	(0.258)	(0.305)	(0.391)

Note: Estimated standard errors are in parentheses.

Despite the error issues associated with the source data, the estimates in Tables 5 and 6 do reflect the economic character of the two cities involved. Wholesale is fairly similar between the

two but on the whole, Calgary's sectors appear to be more reliant on trucking, or at least, demand for trucking output increases more substantially with changes in output.

3.2 Rail

The elasticity of railway demand with respect to industry output was estimated separately in terms of tons and ton-kilometers using data obtained from the Statistics Canada publication *Rail in Canada;* the railway data are available on request from the authors. The railway output measures are for all of Canada. This has no impact on the estimated elasticity in the log-linear regression model up to a proportional transformation of the transportation output variable.

Table 7: Elasticity Estimates for Rail Ton-Kilometers

	Method of Estimation		
GDP Sector	least-squares	errors-in-variables$_f$	quantile regression
Cropanimal	0.408	0.430	0.393
	(0.042)	(0.039)	(0.042)
Forestry	0.497	0.523	0.503
	(0.048)	(0.045)	(0.076)
Manu	0.338	0.356	0.349
	(0.018)	(0.011)	(0.019)
mining	0.727	0.766	0.713
	(0.071)	(0.067)	(0.078)
wholesale	0.322	0.339	0.326
	(0.017)	(0.011)	(0.023)

Notes: Estimated standard errors are in parentheses.

The results in Table 7 are intuitive in that the sectors traditional demanding rail services, forestry, mining, and agriculture also exhibit the largest elasticities.

3.3 Air

The elasticity of air demand with respect to industry output was estimated for tonnage at the Calgary and Edmonton international airports using data obtained from the Statistics Canada publication *Canadian Civil Aviation*. The aviation data are reproduced in Table 8. Because air traffic is only reported in units of tons, we have restricted our elasticity estimation to the

manufacturing sector.

Table 8: Aviation Tonnage Data by Airport

year	Calgary	Edmonton
1995	43970	12572.4
1996	53556.5	13156.2
1997	73831.4	16543.3
1998	61708.8	18727.8
1999	59964.5	15538
2000	54002.1	9379.3

Note: Reported in units of tons $\times 10^3$.

Table 9: Elasticity Estimates for Manufacturing Air Tonnage

	Method of Estimation		
Airport	least-squares	errors-in-variables	Quantile regression
Calgary	1.069	1.425	1.519
	(0.605)	(0.695)	(1.179)
Edmonton	0.056	0.074	0.900
	(1.141)	(1.521)	(2.028)

Note: Estimated standard errors are in parentheses.

Of particular note in the air elasticity estimates is the difference in size and significance between the two cities with Calgary exhibiting a more responsive air cargo market for the manufacturing sector. Again, this may reflect the economic character of Calgary which has a vibrant and growing high-tech manufacturing sector.

4 Forecasts of Future Transport Demand

Forecasts of future traffic demand growth are obtained by applying the mode and-sector-specific estimated elasticity against the percentage increase in each industry sector as calculated from the industry sector forecasts shown in Table 2. This provides the percentage increase in traffic relative to the base year 2000; forecasts in physical units of output are the product of the percentage growth and the base year magnitude in physical units.

Tables 10 and 11 show the future percentage increases in trucking originations at Calgary and Edmonton, respectively, for the forestry,

manufacturing, and wholesale sectors. The agricultural and mining sectors have been omitted, since it is obvious that the near-zero forecast in growth for these sectors translates into near-zero growth in transportation demand.

Table 10: Trucking Demand Growth in Calgary by Industry Sector

	Industry Sector		
Year	Forestry	manu	wholesale
2005	8.929	25.044	11.064
2006	11.607	31.774	12.952
2007	4.427	38.870	14.839
2008	17.362	46.355	16.727
2009	20.398	54.249	18.615

Entries indicate point forecast of percentage growth in Edmonton originating trucking tonnage by industry sector relative to traffic in year 2000.

Table 11: Trucking Demand Growth in Edmonton by Industry Sector

	Industry Sector		
Year	Forestry	manu	wholesale
2005	4.464	8.167	8.471
2006	5.803	10.616	9.916
2007	7.213	13.196	11.361
2008	8.681	15.880	12.807
2009	10.199	18.657	14.252

Given the previous results related to forecasts and elasticities of demand, the high percentage increases in trucking activity associated with manufacturing in both cities is expected. Calgary's anticipated growth in high-tech manufacturing, a sector linked to road and air freight, is also evident.

Table 12 shows the estimated growth in rail tonnage for each industry sector. The growth is not at the same level associated with trucking which is reflective of rails role in these sectors. What is difficult to reflect in these numbers is the role of intermodalism and how it is captured in the output statistics utilized.

Table 12: Rail Demand Growth in Alberta by Industry Sector

	Industry Sector		
year	Forestry	manu	wholesale
2005	2.504	3.322	2.074
2006	3.255	4.214	2.428
2007	4.046	5.156	2.782
2008	4.869	6.149	3.136
2009	5.721	7.196	3.490

Entries indicate point forecast of percentage growth in total Alberta rail tonnage by industry sector relative to traffic in year 2000

Table 13 shows the estimated growth in total airfreight tonnage at the Calgary and Edmonton international airports. The stark difference between the two centres is perhaps indicative of the growth of air cargo services in Calgary. This does not suggest that air cargo is not important, for example, to manufacturing in Edmonton. It is possible that some air cargo traffic may be leaking out of Edmonton on truck to eventual air shipment out of Calgary.

Table 13: Aviation Demand Growth at Calgary and Edmonton Airports

	Airport	
year	Calgary	Edmonton
2005	27.344	1.533
2006	34.692	1.945
2007	42.440	2.379
2008	50.612	2.838
2009	59.231	3.321

5 Conclusion

The results in this paper suggest that using readily available public data and standard econometric approaches, it is possible to generate forecasted activity levels for various modes into the near future. It is further possible, for example, to translate the provided percentage increases in tonnage output to 2009 into truckload or railcar units. In this regard, the estimates provide an

aggregate view of future demand and can be of value to planners in business and government by providing a generalized perspective on the future. Planners in Calgary, for example, may be able to utilize this information in regional transportation models employed for future scenario exploration.

However, in particular the output elasticities are based on aggregate sector level data with its own "warts" and issues of temporal consistency. Sectors like trucking are characterized by hetereogenity and aggregate tonnage numbers, even for the city as a spatial unit , are not the best indicator. Further, modern supply chains use a variety of modes and the ability of sector-specific surveys to capture this reality is doubtful. The earlier adage on modeling being an exercise of caution and only as reliable as the data on which it is based applies in this context. The call for more effort and attention to be directed toward properly measuring and accounting for transportation activity is made here as well.

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Edmonton Commercial Movements Study

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INTRODUCTION

The Edmonton Region is a major origin and destination for the movement of goods and services. Economic activity in the Region involves the shipment of various categories of goods and services from where these goods and services are produced to where they are consumed. The ability of the transportation system to permit the safe and cost-effective handling of these movements helps determine the economic health of the Region, and also impacts the quality of life for the citizens of the Region.

The need for a more complete understanding of commodity movements and related logistics issues in the Greater Edmonton Region was identified as a key component in the Greater Edmonton Competitiveness Strategy sponsored by Economic Development Edmonton. Surveys of the nature of goods and services movements were implemented by a joint team from the City of Edmonton and Alberta Transportation in 2001 and 2002, as follows:

- **The Edmonton Region Commodity Flow Study** designed to survey business establishments, to obtain descriptions of the basic patterns of goods and services flows throughout the Edmonton Region and the corresponding nature of the person and vehicle movements generated by business establishments in the shipment of goods and services from location of production to location of consumption.
- **The Edmonton Region External Truck / Commodity Survey** designed to study the movement of commercial goods by trucks in and out of the Edmonton Region.

SURVEY APPROACH

Past experience has shown it is very difficult to conduct a systematic study of goods and services movements in urban areas. This is partly because previous efforts have focused on movements by the trucking (transport and handling) industry, which is fragmented into a large number of heterogeneous, privately-owned businesses making numerous and complex movements.

A novel survey approach was designed for the work reported here in order to avoid some of these issues, seeking to (a) concentrate on the activities of all business establishments; (b) pursue a large survey sample; and (c) minimize survey burden for respondents. Features of the design included:

- covering all establishments involved in the shipment of both goods and services, including transportation depots;
- seeking information on individual shipments of goods and services on one weekday, rather than for a longer period;

- covering only the outbound component of movements generated by a given establishment – except for transportation depots, where both the inbound and the outbound components are covered in order to obtain further relevant information for this particular category;
- designing a special survey approach for establishments with large numbers of small shipments (such as postal services, couriers, newspaper delivery, refuse collection services). These establishments allocate fleets of vehicles to routes in order to carry these many small shipments. The approach with these 'fleet allocator' establishments was to observe just the vehicle movements;
- offering significant direct assistance, including face-to-face contacts, training, and staff for data collection;
- including the External Truck / Commodity Survey to intercept trucks entering and leaving the Region, to ensure complete coverage of the movements of interest; and
- obtaining the active support of organizations involved in goods and services movements in the Edmonton Region, including Economic Development Edmonton, the Alberta Motor Transport Association, and the Alberta Capital Region Alliance.

The spatial components of the various types of goods and services vehicle movements occurring in urban areas, and captured by the survey approach, are summarized in Figure 1.

SURVEY IMPLEMENTATION

Edmonton Region Commodity Flow Study

Between October 2001 and August 2002, 27,478 business establishments were contacted in the Edmonton Region to determine their eligibility to participate in the Commodity Flow Survey. This represented almost all the businesses known to exist in the Region. At the same time, information was also collected to establish the

number of employees, location and industry category of the establishment. Of these business establishments, 13,792 were eligible to participate in the survey in that these establishments produced either a product or service that required transportation. Of these eligible establishments, 4,324 agreed to participate in the survey.

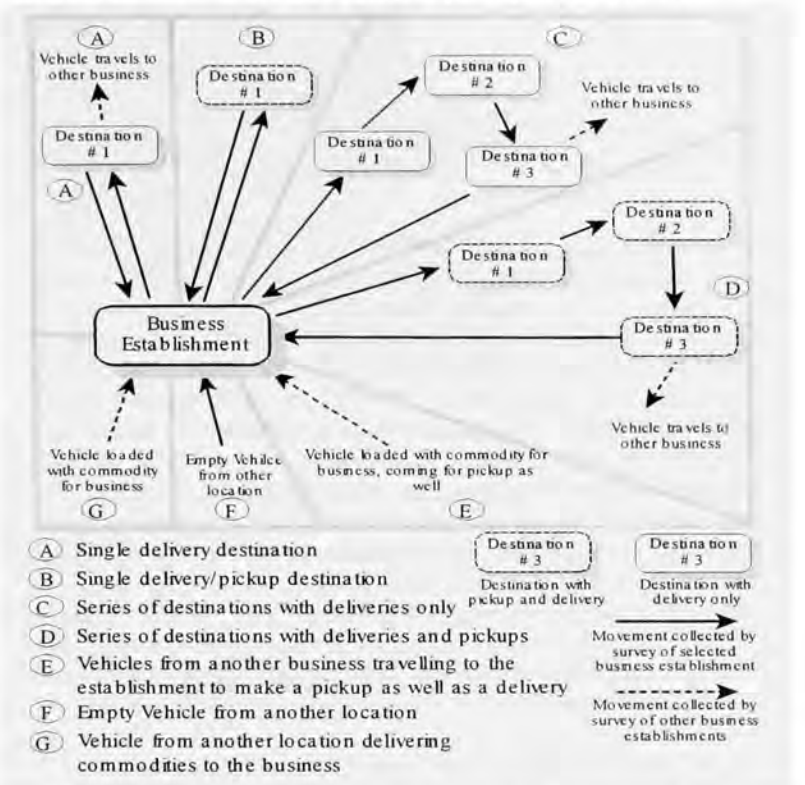


Figure 1: Range of goods and services vehicle movements in urban areas

Establishments provided data on their shipments of goods and services, and associated vehicle movements on the survey day.

The CFS study area was based on the Edmonton Census Metropolitan Area (CMA), as shown in Figure 2.



Figure 2: Commodity Flow Study Area

The expansion of the survey data – to establish a representation of the population of commercial movements in the Edmonton Region – involved scaling each establishment across three independent variables; establishment size in terms of the number of employees, industry category, and geographic location, using the total number of employees within each variable to determine the individual establishment expansion factors. The average expansion factor for all establishments was 2.36.

Edmonton Region External Truck / Commodity Survey

In the fall of 2001, Alberta Transportation and the City of Edmonton conducted roadside interviews at 24 sites on provincial highways entering the CMA study area between 8:00AM and 4:00PM. Over 6,500 truckers transporting commodities into and out of the Edmonton Region were interviewed, almost a 100% sample of all

trucks travelling at that time. The resulting data were scaled up to represent daily truck and commodity movement into and out of the study area.

SURVEY RESULTS

Edmonton Region Commodity Flow Study

The expanded results of the Commodity Flow Survey for the entire Edmonton Region are presented below in terms of various dimensions and distributions.

Vehicle Characteristics: The vehicles used to deliver goods and services fall into three general categories; passenger vehicles (cars, pickup trucks), single-unit trucks and multi-unit trucks. On a typical weekday, about 23,400 vehicles are used to deliver goods and services throughout the Edmonton Region. These include about 13,500 passenger vehicles, 4,900 single-unit trucks and 5,100 multi-unit trucks. Establishments in the industrial and transportation handling industries use nearly 80% of all multi-unit trucks. Wholesale and industrial establishments use more than 55% of all single-unit trucks whereas private services and industrial establishments use about 60% of the passenger vehicles.

The majority of the nearly 10,000 single unit and multi-unit trucks that are used to deliver goods and services on a typical weekday have a gross-vehicular weight (GVW) of between 12,000 kg and 60,000 kg. Figure 3 shows the distribution of GVWs for these vehicles.

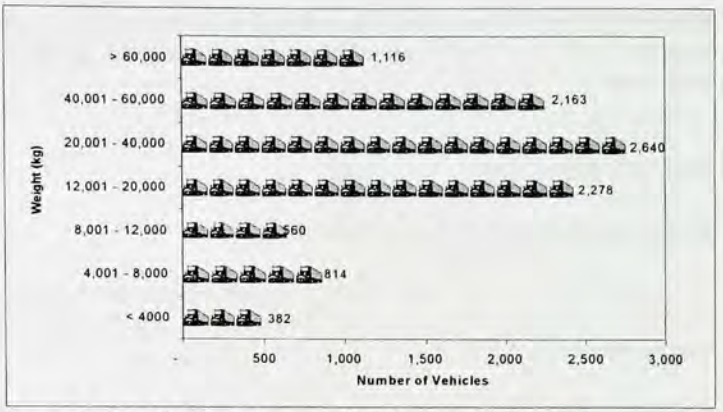


Figure 3: Distribution of gross vehicular weights (in kgs)

Fuel Type: The distribution of fuel type used by vehicles is shown in Figure 4. Nearly 90% of all passenger vehicles use gas, whereas 98% of the multi-unit trucks use diesel. Less than 2% of all passenger vehicles and single-unit trucks used propane.

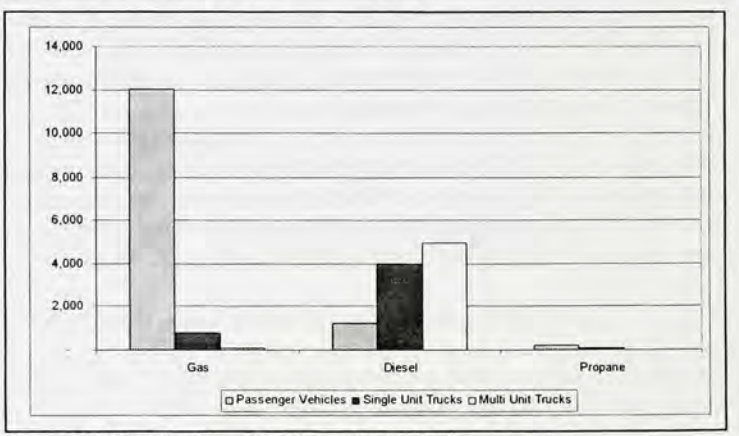


Figure 4: Distribution of fuel used by vehicle type

Vehicle Ownership: The distribution of vehicle ownership is shown in Figure 5. Companies own the majority of vehicles. Over 40% of all trucks are 'for-hire' whereas only 16% of passenger vehicles are 'for-hire'. The driver is the owner for about one in five passenger vehicles and about 2% of all trucks.

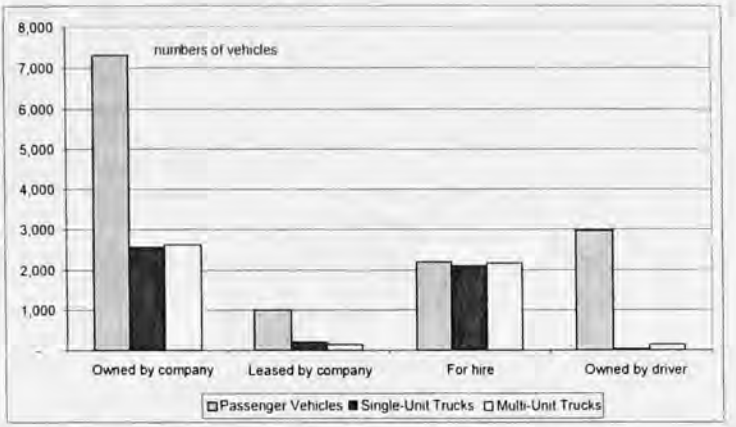


Figure 5: Distribution of vehicle ownership by vehicle type

Trip Generation by Vehicle Type: Approximately 165,000 commercial vehicle trips are generated in a typical day, with about 128,000 originating within the City of Edmonton, 17,000 within Sherwood Park and St. Albert and 19,000 in the remainder of the Region. It is notable that not all of the surveyed establishments were engaged in shipping goods or services on their assigned survey day, even though they did 'normally' ship goods/services: Only about 75% of the establishments that ship goods or services did so on their survey day. Passenger vehicles are the predominant vehicle type, accounting for nearly 60% of all vehicle trips. Single-unit trucks are used for approximately 30% of all trips, with multi-unit trucks accounting for the remaining 10%.

Trips by Goods Category: Figure 6 shows the distribution of goods trips by category of goods carried. Printed matter, fabricated metal,

and food or kindred were the three most common commodities carried in terms of trips made.

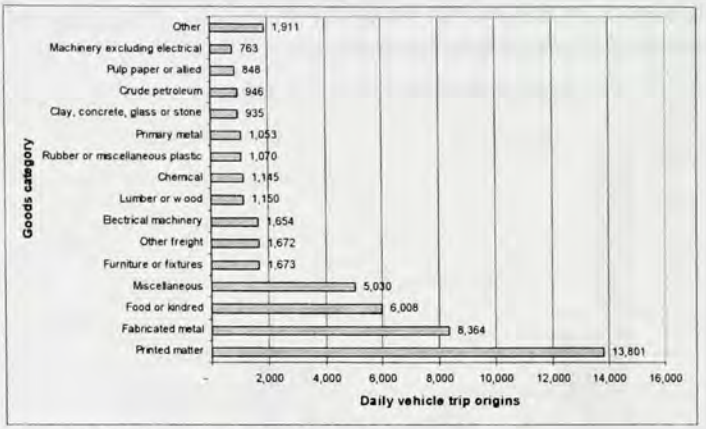


Figure 6: Daily vehicle trips by goods category

Trips by Service Category: Figure 7 shows the distribution of service trips by category of service provided.

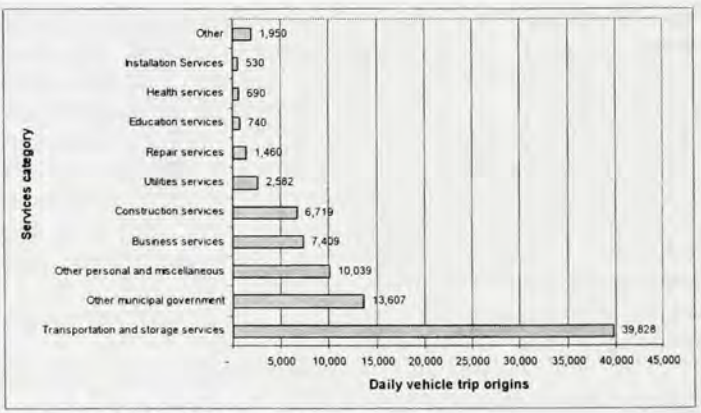


Figure 7: Daily vehicle trips by service category

Transportation services, municipal government and personal / miscellaneous services were the three most common service categories in terms of trips made. Transportation service trips are predominantly made by courier companies.

Spatial Pattern of Origins and Destinations: Just over 93% of commercial movements in the Edmonton Region both start and end within the Region, and only 2% are external to external. Figure 8 shows the pattern of vehicle movements between origins and destinations for trips within the Edmonton Region. Figure 9 shows the same pattern for trips within the urban built-up area, including Edmonton, St. Albert and Sherwood Park.

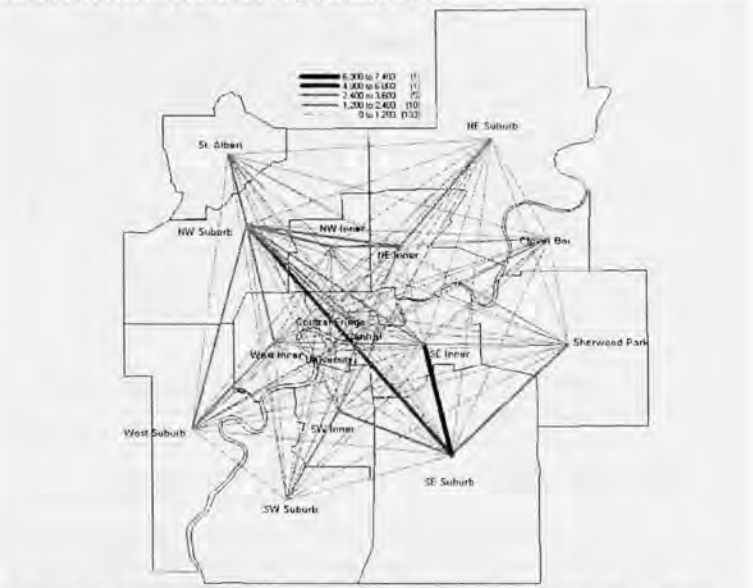


Figure 8: Pattern of commercial vehicle trips in Edmonton Region

Trips by Time of Day: The time of day of a trip is the mid-point of the trip start and end times. Figure 10 shows the time of day distribution for trips by different vehicle types. The distribution is

much the same for all vehicle types. The quantity of trips rises quickly to a peak between 07:00AM and 10:00AM and then tapers off during the rest of the day. The peak hour for all commodity movement vehicle trips is 9:00AM to 10:00AM, when 12% of the daily total occurs. During the AM Peak Period (7:00AM to 9:00AM) 15% of daily total occurs.

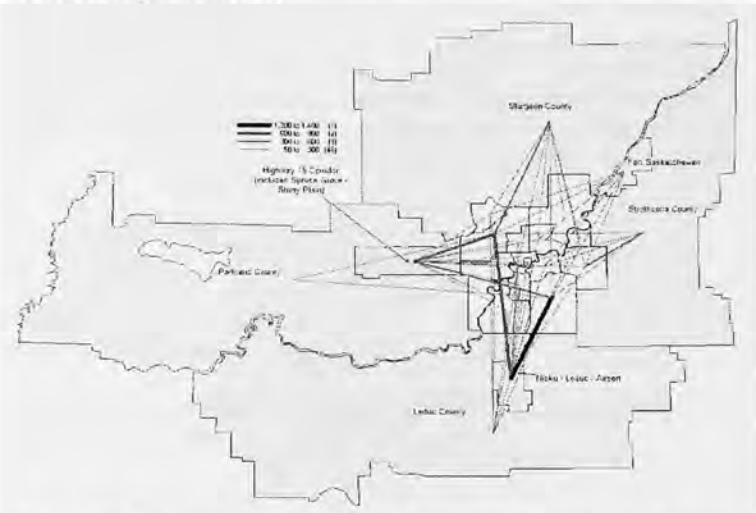


Figure 9: Pattern of commercial vehicle trips within urban built-up area of Edmonton Region

Edmonton Region External Truck / Commodity Survey

The Edmonton Region External Truck / Commodity Survey found that approximately 16,000 trucks enter or exit the Edmonton Region over the 24 hours of a typical weekday, carrying approximately 660,000 metric tones. Further findings regarding this volume of trucks include:

- 40% cross between 8:00AM and 4:00PM, with the peak half-hour volume occurring between 5:30PM and 6:00PM;

- 72% are owned by the company producing the goods being shipped;
- 77% are multi-unit and the remaining 23% are single-unit;
- 36% are empty and 19% are carrying manufactured goods, machinery, or equipment;
- 62% are carrying a single commodity and only 2% are carrying more than one commodity; and
- 42% have one trip end (either origin or destination) in the City of Edmonton, 37% have one trip end in the Edmonton Region and 21% are making external to external trips.

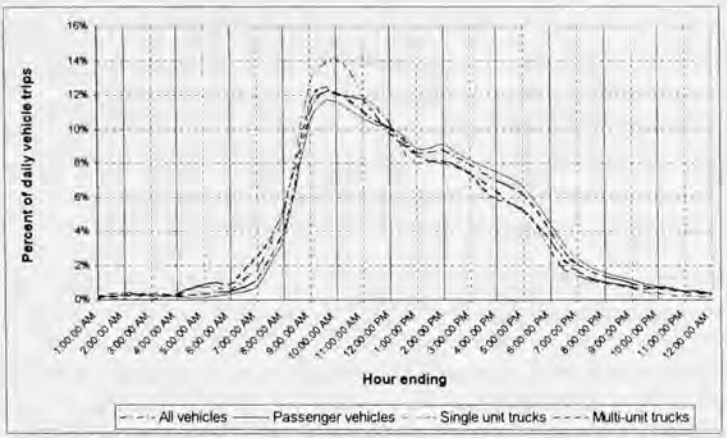


Figure 10: Time of day distribution for commercial vehicle trips

Truck Volumes on Roadways

The expanded pattern of truck movements from the two surveys was loaded to the node-and-link representation of the roadway network of the Edmonton Region in the Edmonton Transportation Analysis (ETA) transportation computer model. This loading respected the current truck route restrictions on the network, particularly in the City of Edmonton, where trucks greater than 8 tonnes have to use designated truck routes.

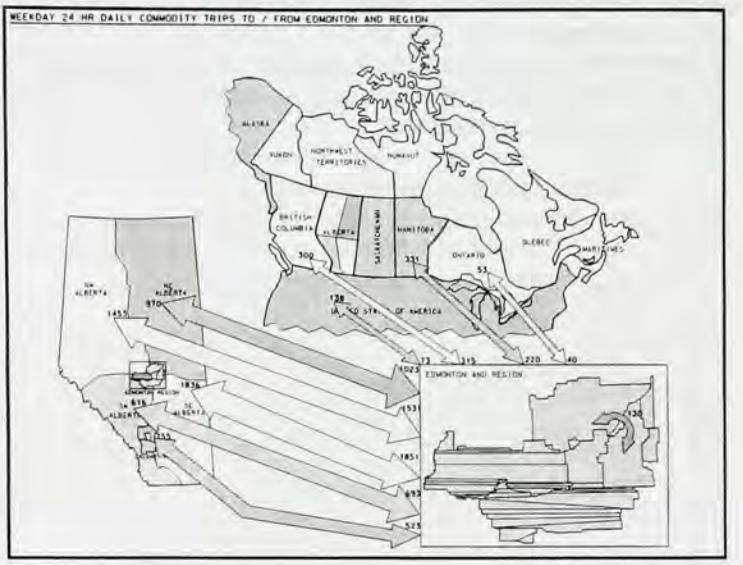


Figure 11: Origins and destinations of trucks crossing external cordon on a typical weekday

The resulting truck flows on the model network are shown in Figure 12. The width of the 'bar' on each roadway is proportional to the volume of trucks using the roadway over 24 hours.

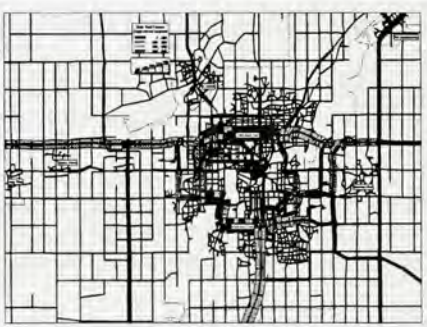


Figure 12: Truck flows on roadways when the survey-derived pattern of trips is assigned to the Edmonton Regional Model network

These assigned truck flows were found to match very closely the corresponding observed values obtained from vehicle classification counts. For both the single-unit and multi-unit truck categories the overall match between survey and corresponding observed values was within 5%, with individual directional values ranging from -25% to +25%. Because these vehicle classification counts are obtained independent of the surveys, this close match is a strong indication of the validity of the surveys.

CONCLUSIONS

This paper has described the design and implementation of a new approach to obtaining data on goods and services movements in urban areas, and has presented the results. The approach has been demonstrated to be very successful, providing high-quality data. A considerable amount of high quality data was obtained. Overall survey truck volumes corresponded very well with observed values, confirming the validity of the process.

The work that has been done has provided the City of Edmonton and the Province of Alberta with significant additional information on truck movements, well beyond that available from simple count information. This information data will help inform transportation planners, transportation service providers, the general public and politicians, and lead to better planning of transportation systems to accommodate these demands. It has already been used to help estimate the potential truck usage of the proposed Anthony Henday Drive strategic ring road around Edmonton. In addition, the observations of specific choices made in the movements of goods and services included in the data are being used to upgrade the Edmonton Regional Transportation model with an explicit truck trip forecasting component. This will facilitate the estimation of the mobility benefits accruing to goods and services movements from proposed transportation system improvements.

A number of important lessons were 'driven home' during the design and execution of the surveys described here, as follows:

- It is vital that the local business community and trucking associations 'buy-in' to the study. These groups are the best promoters of such projects, acting as ambassadors to the individual, private businesses that are asked to contribute by allowing their behaviours to be observed.
- It is essential that the study is designed to minimize the survey burden for respondents and with the confidentiality of the participants taken into consideration.
- It is also very important that the respondents can see how their participation will result in improved planning, leading to improvements in their situations.
- Sufficient resources have to be available to complete the data collection appropriately and responsibly. The approach used involves a significant amount of face-to-face contact with individual business establishments, with active support in data collection provided where required. High-quality survey personnel are needed in order to perform these interactions with a clear understanding the underlying survey needs. The availability of such personnel is key to obtaining survey participation and maintaining survey quality. Unfortunately, it is also expensive.

Review of Urban Commodity Movement Demand Modelling Approaches

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INTRODUCTION

It has long been recognized that commercial movements – including flows of trucks delivering goods and services, business travel by people and the use of cars and other 'light duty' vehicles for business purposes – are important components of travel demand. But the comparative homogeneity of household-based travel and household units generally together with the larger contribution to total travel made by private individuals has led to an emphasis on the representation of household-based travel in transport demand models, particularly in the urban context. The modelling of commercial movements at the urban level has received much less attention, even

in comparison to interurban and longer distance commercial movements (Regan and Garrido, 2002).

This paper presents a brief review of the approaches and techniques that have been used in attempts to represent commercial movements as part of larger models of transport demand at the urban scale, covering the current state-of-the-art in practice. It has drawn on several other such reviews considering various aspects of the modelling of commercial vehicle movements, including MEP (2002), Regan and Garrido (2002), and Fischer (2004). The taxonomy of techniques considered in this paper includes: basic observed-matrix expansion processes, variants on the transportation planning (4-step) method, the Quick Response Freight Manual method, spatially-disaggregated input-output techniques, supply chain representations, and forms of microsimulation. This consideration includes an evaluation of strengths and weaknesses in each case and outlines the potential for specific future directions. As such, it forms a basis for a broader discussion of the representation and evaluation of urban commercial movements generally.

OVERVIEW OF URBAN COMMERCIAL MOVEMENT

Commercial vehicle movement is very different from personal movement in many respects. Urban commercial movement is also different from commercial movement over larger areas, such as states, provinces, nations and even international areas.

Rail, ship, barge, aircraft and pipeline transport are inefficient over the smaller scale of urban areas, hence urban commercial movement is almost exclusively road-based (Ogden, 1992). There are instances of other modes – walking, cycling, barge, rail and even of specialized aircraft – in the movement of goods and services within urban regions, but these are unusual and very small relative to the total.

Additionally, a large component of commercial movements within urban areas is made with light commercial vehicles (LCVs), including four-tire, two-axle vehicles such as pick-up trucks and vans

and even passenger cars. Interurban transport makes load consolidation more economic, and the larger volumes of goods moving between larger areas (Harris and Liu, 1998) also increases the importance of heavy commercial vehicles such as tractor-trailer combinations over longer distances. Further, the service sector constitutes a large proportion of the urban economy, in large part serving the population in the urban area where it is located. It is clear that a complete consideration of urban commercial movement requires consideration beyond just freight movements, expanding to include service deliveries with the urban area.

MATRIX EXPANSION TECHNIQUES

One commonly used approach to urban commercial vehicle modelling is the development of an OD matrix of such movements that is consistent in some way with a 'seed' matrix along with other information obtained from origin-destination surveys and/or roadside counts. This includes Fratar/Furness expansion techniques and entropy maximization mathematical programming processes (Ortúzar and Willumsen, 1994). These are comparatively straightforward treatments, and thus are easy to perform and can be relatively inexpensive. They do not attempt to include any explicit representation of the behavioural mechanisms involved, and they do not adjust output values in response to policy inputs. Still, in many cases they provide enough detail for the intended analysis, especially if commercial vehicle movements and the benefits of policy options for commercial activity are not the primary focus of the model.

The sources of information – origin-destination surveys and roadside counts – each have their advantages and disadvantages, which transfer to the related matrix expansion techniques. With an origin-destination survey, commercial operators are asked to provide information on their vehicle movements. This may be done in interviews at the roadside with drivers or at commercial establishments. In general, surveying all such firms is prohibitively expensive, so a sample is collected and the results expanded to represent the population. This is difficult for two reasons: (a) good

'population' targets are difficult to determine for firms, in part because firms (business establishments, companies and corporations) can exist in many databases without any employees and where other scales of activity are not readily available and (b) firms are highly heterogeneous, much moreso than households, which results in much greater sampling errors.

Different challenges arise when synthesising an OD matrix from observed roadside counts. The most obvious one is the challenge of determining which vehicles are commercial vehicles. Heavy goods vehicles can safely be assumed to be operating for commercial purposes, but light vehicles are often identical to personal vehicles; indeed, many light commercial vehicles are also used for personal trips, so the determining the purpose associated with a given light vehicle passing by requires some form of interview. Additionally, the synthesis of an OD matrix from roadside counts can be fairly inaccurate, although it becomes more accurate with a strategic placement of count locations and in areas dominated by freeways and expressways rather than a more grid-like pattern of arterial roadways.

MODIFIED FOUR-STEP MODELS / QUICK RESPONSE FREIGHT MANUAL

The standard four-step model is one of the most common modelling techniques used for personal travel, and the extension of this approach to urban commercial vehicle movement modelling is an obvious one. Examples include work reported by Hutchinson (1974) and List and Turnquist (1994). Perhaps the most familiar modified four-step model for freight is the one detailed in the Quick Response Freight Manual (QRFM) (Cambridge Systematics et al, 1996).

The appeal of four-step modelling is obvious; it provides a familiar framework and an easy analogue between personal and commercial models. Additionally, the QRFM provides a detailed set of coefficients and values useful in developing a local model with low data requirements. In some applications it provides a model that is suitable to the task, using comparatively little easy to obtain data.

The QRFM is in essence a three-step rather than a four-step model because mode choice is subsumed within the trip generation portion of the model and not considered explicitly. Vehicles are generated within three vehicle classifications ('light', 'single-unit' and 'combination') based upon zonal attributes such as population and employment within broad SIC categories. Trip distribution is accomplished primarily with a gravity model, and assignment is done as additional vehicle-miles added to the personal model. Factors can be used to provide for time-of-day characteristics.

As its name suggests, the QRFM provides a quick (or rapidly established) method for estimating commercial vehicle flows. But many tradeoffs are made. By using predetermined factors based primarily on studies of goods movements in a few urban areas in the US, data collection requirements are reduced, but the question of local applicability is raised. Vehicle mode choice is not sensitive to policy changes, although commercial vehicle mode choice is less sensitive than personal mode choice, mitigating this problem. Time of day is similarly not policy sensitive in this modelling approach. Again, as its name suggests, the QRFM concentrates on freight vehicle movements, rather than all commercial vehicle movements.

An additional concern, more generally applicable to the family of four-step models, is the emphasis on trips as opposed to tours. In a larger model area, such as a provincial or regional model, the majority of vehicles may make a small number of long journeys, which can be approximated reasonably by a trip model. However, in urban areas many goods tend to be distributed in series of shorter trips made in tours (City of Edmonton, 2003).

SPATIALLY DISAGGREGATE INPUT – OUTPUT TECHNIQUES

By disaggregating a standard economic input/output table to reflect the spatial distribution of production and consumption in an economy, a spatially disaggregated input – output (SDIO) model can

be created to model the transportation system and the local land use, as well as the interaction through time of development of these elements. The emphasis on input-output leads to the development of commodity flows between zones. SDIO models include the MEPLAN (Hunt and Echenique, 1993), TRANUS (de la Barra, 1998) and PECAS (Hunt and Abraham, 2001) frameworks.

These synthetic commodity flows include flows of goods and services (commodity categories) between businesses, and as such, commercial vehicle movements can be developed from these flows. Vehicle-type split models can also be incorporated. An example is the Oregon Generation 1 Statewide TRANUS model (ODoT, 2003). However, a number of difficulties arise in the practical simulation of commercial vehicle movements from these data. Trip chaining and other logistic-related results such as less than load and empty vehicle movements must be related to the simulated zone-to-zone commodity flow information, which is tenuous and typically done using multipliers based on average rates. Such approaches are perhaps better suited to interurban and longer distance commodity movements, not urban commercial movements.

SDIO models provide an excellent format for simulating zone-to-zone commodity flow data, but their emphasis is also on land use modelling and land use / transport interaction, not just on commercial vehicle movements specifically. Many of the important elements of commercial movements in urban areas, including tours and less-than-load, must be added, which is generally done using very simple factoring if at all.

URBAN TRUCK TRIP ANALYZER

The Urban Truck Trip Analyzer (UTTA) is a modelling system developed by Jack Faucett Associates (JFA, 2004) specifically for urban freight movements. It is, in many ways, a hybrid of the four-step approach and the commodity movement component of the SDIO systems described above. The UTTA has a modular design, with

destination choice, mode choice and route choice considered in separate modules.

The destination choice module is the most unique feature of the UTTA. The model begins by considering two types of trips; goods movement and non-goods movement trips.

Goods movement vehicle trips are based on observed commodity flows, in this case based on observed data (typically derived from the Commodity Flow Survey (BTS, 1997)), rather than synthesized as with SDIO models. Individual zone-to-zone flows for different commodities are converted to goods vehicle flows using average rates. Trip-chaining (forming tours) is indicated to be a significant factor in the documentation (JFA, 1999b), especially for warehouse to retail flows, and is represented using an average conversion rate for trips-per-tour – the same as the typical approach with SDIO models – for just warehouse to retail flows.

Non-goods vehicle trips are determined using a vehicle-based model very similar to the QRFM described above; vehicle trip ends are generated for each zone as a function of land use and then distributed using gravity models. The resulting OD matrices are then split by time-of-day, if required, using fixed factors.

Mode split (or allocation of vehicle trips to vehicle types) is very simple: goods trips are made with heavy commercial vehicles, and non-goods trips are made with light commercial vehicles.

A comparatively wide range of considerations are included in the discussion and descriptions of the UTTA (JFA 2004, 1999a, 1999b) and the treatment of trip distribution includes representation of a lot of influences at a fairly disaggregate level. But the implementation includes many simplifications. The treatment of mode split is extremely limited. Tours are discussed, but only warehouse-to-retail movements are considered to form tours, with only a simple factoring of the trips used in any case. Another assumption used in practice is to neglect distance in the distribution process – which is argued to be

reasonable in an urban context. In addition, the UTTA has many of the strengths and weaknesses of a four-step model; it is more advanced in a number of areas specifically related to commercial movements, but many of these advances are small steps, with significant simplifications.

SUPPLY CHAIN MODELS

A model with explicit representation of the components of the supply chains for the major industries in an urban area would have a high degree of fidelity. For example, the model would represent the movement of foods from growers to processors, from processors to distributor warehouses, and from distributor warehouses to supermarkets, representing the vehicles in each case, tracing each of the various types of goods supermarkets require, (refrigerated goods, shelf goods, and so on). Some elements of this sort of modelling of the supply chains have been done for specific industries. The Dutch GoodTrip model is an example (Boerkamps et al, 2000).

In the GoodTrip model, the demand for goods is developed first, with the corresponding demand for the transport of these goods following. This means that the model works backwards up the supply chain from consumers to producers, determining the goods flows. A mode choice is made for the overall aggregate goods flows, then the flows are disaggregated into vehicle loads and routes. The model includes explicit representation of the consideration of logistics and the supply chain in the choices made, rather than of the spatial relationships considered in the techniques described above.

Because a supply chain model can consider logistics by industry, it can provide valuable insight on the distribution of specific categories of goods from production through wholesale to retail. It would produce different vehicle flows from a book warehouse as compared to a food warehouse, for instance. While this is valuable for analysing an industry, a model of the full range of commercial movements for an entire urban area would require such specific information for the supply chains for all of the industries present. In a situation where

only one or two industries are of concern or where they dominate, this type of model may be worth the additional data requirements. However, supply chain models would be difficult to scale up to cover the diverse nature of most larger-size urban areas.

Additionally, supply chain models emphasise goods flows, neglecting transport associated with service vehicles. Finally, changes in logistics and business practise would need to be predicted into the future for a supply chain model. This is a concern with all commercial vehicle movement models, but is vastly heightened with supply chain modelling techniques.

MICROSIMULATION

Microsimulation approaches use Monte Carlo techniques to select the attributes of individual goods and services vehicle movements, or even individual goods shipments and service deliveries, summing the results to obtain aggregate quantities of goods and services vehicle flows. The sampling distributions that assign the selection probabilities to the attributes can be either (a) observed frequency distributions, making the resulting microsimulation 'stochastic' or (b) assigned probabilities from choice behaviour models, such as logit models, making the resulting microsimulation 'behavioural'.

If changes in policy-related inputs to the model do not result in changes in the sampling distributions used by the Monte Carlo processes – which can be the case with a stochastic microsimulation that does not adjust the observed frequency distributions being used – then the model is unable to provide indications of the results of policy actions. A behavioural microsimulation would avoid such lack of policy responsiveness provided it has choice behaviour models that include representation of the impacts of policy actions on choices.

One immediate challenge with a microsimulation model is the increased computational demand that arises; directly simulating hundreds of thousands of trips is a processor-intensive task. The continuing advance of computer technology has made this approach

more feasible. A second major challenge with microsimulation is obtaining the required data. Given the high degree of heterogeneity, detailed activity data is required for a large sample.

Additionally, there are operational difficulties that arise with a model that may not produce invariant outputs – where the random element in the Monte Carlo process results in a random element in the output values – even given the same inputs.

One benefit of microsimulation is flexibility. The model is constrained primarily by data limitations, computing power and development time. Flexible time of day treatments, tour-based analysis, service movements, vehicle type choice, commodity flow, fleet and supply chain operation and other complexities can be added.

An example of a model using the stochastic microsimulation approach is the CT component of the Oregon 2nd Generation TLUMIP model (Hunt, 2001). It selects the attributes of individual shipments of goods from observed frequency distributions available in data collected in surveys of commodity movements in the United States, stopping when the selected total values of shipments for categories of commodities are consistent with commodity flow values determined in another component of the Oregon TLUMIP model.

Behavioural microsimulation has the potential to provide an inclusive and robust model, although at a high cost in development and data. The only working behavioural microsimulation we are aware of is the one just recently developed for the City of Calgary (Hunt and Stefan, 2003) – but we continue to search the literature.

The Calgary model employs a tour-based approach using an on-going incremental stop selection process, not the 'rubber-banding' process typically used with person tour-based models (Jonnalagadda et al, 2001). It assigns vehicle type (from 'light', 'medium' and 'heavy'), stop purpose (from 'goods' service', 'other' and 'return to establishment'), and stop location (by model zone) and includes service and goods movement vehicles.

COMMERCIAL VEHICLE NETWORK ASSIGNMENT

The descriptions above cover the processes used to establish OD matrices or individual trip lists for commercial vehicles. This leaves the processes used for assigning commercial vehicles to networks.

The range of processes for assignment of commercial vehicles is much the same as it is for private vehicles. In most instances, some form of aggregate, equilibrium process is used for commercial vehicles, in some way jointly with the private vehicle assignment. At the more sophisticated end of these processes is multi-class assignment with generalized costs for link traversal that include both time and money cost components, with the money cost determined as a function of the link distance added to any toll that is present. A few models have used micro-assignment with trucks and other commercial vehicles included in the lists of assigned vehicles together with private cars (Hunt, 2001). Of course, current traffic micro-assignment programs generally include proportions of medium and heavy vehicles (presumably making commercial trips) along with buses in their simulated traffic, with the potential for different driving behaviour and vehicle characteristics included. But it appears that in the development of such micro-assignment models the treatment of these medium and heavy vehicle proportions – including the determination of the numbers of such vehicles and their OD patterns and resulting routings – does not receive as much attention as the (admittedly far larger) private vehicle component. This suggests that there is lots of potential for further development and use of micro-assignment approaches in the assignment of commercial vehicles, and for the use of the various modelling techniques considered above in the determination of the OD tables of such vehicle movements to go into these micro-assignment models.

The relative weightings of the time and cost components for the commercial vehicle categories being loaded onto networks often imply higher values of time that those used for the private vehicles. This is based on the idea that the drivers are working and thus should

value their time at their wage rates, which are generally higher than the values of drive time for people not working. One interesting development related to this problem is the Copenhagen Harbour Tunnel Study, which uses stated preference study data to produce a normally distributed value of time (MEP, 2002).

Additional complexities arise in the assignment of commercial vehicles because of the truck restrictions policies and designated truck routes that are typically present in the urban context. Only certain links may be available to different categories of trucks. In addition, trucks of certain types may be required to minimize the distances they travel on certain categories of roads. The route choice algorithms used in truck assignment modelling need to respect such restrictions in order to ensure at least a reasonable degree of policy responsiveness. The literature on urban truck and commercial movement modelling is generally fairly silent about any such complexities within the route choice algorithms in particular. But the Oregon 1st Generation TLUMIP model (ODoT, 2003) was modified to include explicit representation of responses, including route choice responses, to a range of truck weight restrictions on bridges – where certain bridges could only be used by trucks below specific weights – as part of a testing of alternative strategies for bridge repair. The model developed for the City of Calgary (Hunt and Stefan, 2003) ensures that 'heavy trucks' minimize the distance travelled on non-truck-route roadways by including a large additional penalty per unit distance for the non-truck-route components of alternative routes in the path building component of the assignment process.

SUMMARY

A number of different approaches have been used in the modelling of urban commercial vehicle movements. In this range there is generally a trade-off between the data and analysis requirements and the robustness and policy sensitivity of the model. An important consideration in the selection of a technique is the policy context for the modelling and the determination if the commercial movement component of the modelling system needs to respond: a model using

matrix expansion techniques may be all that is required to add background commercial traffic to a larger set of models designed to analyse the AM peak period.

The identification and representation of the use of light vehicles and passenger cars for commercial purposes is a problem that arises with many model development and related data collection projects. The delivery of services is often neglected. Trip chaining and other logistics-related impacts such as less than load and deadheading are also often not considered in practical urban-level modelling work. It would appear that advances could arise with efforts in urban commercial movement modelling directed at the design and development of behavioural microsimulation techniques that include representation of relevant logistics considerations and that are more inclusive of the full range of commercial movements being made.

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