A New Perspective on High-Speed Rail in the Quebec-Windsor Corridor: Addressing the Distance/Density Debate.

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1.0 Introduction

The impact of anthropogenic Greenhouse Gas (GHG) emissions on the Earth's climate is one of the most serious problems facing mankind today. As a signatory nation of the 1997 Kyoto Protocol, Canada has agreed to reduce GHG emissions by 6% over 1990 levels in the five-year period between 2008 and 2012 (UNFCCC). The transportation sector is a major contributor of GHG emissions[ii] and consumes 60% of oil extracted worldwide (OECD, 2000; OECD, 2001). If no action is taken, transport-related GHG emissions in Canada are predicted to rise to 53% above 1990 levels by 2020 (Matheson, 2000). In response to Kyoto, in 1998, the federal, provincial, and territorial governments established the Transportation Climate Change Table with a mandate to identify and analyze a range of measures to reduce GHG emissions in the transport sector. One group of measures focused on the increased use of more fuel-efficient modes such as high-speed rail (HSR), particularly for medium-distance intercity trips (defined as between 160 and 800 km; Lake et al., 1999). A 2000 Organisation for Economic Co-operation and Development (OECD) report on Environmentally Sustainable Transport also promotes the increased use of public and non-motorized forms of transport such as HSR. Currently, Canada has no HSR service, and rail, at 1.0%, represents an insignificant proportion of all intercity passenger trips (Lake et al., 1999).

In Canada, intercity transportation (trips with a one-way distance over 80 km) is dominated by private car (81 %) and air (16 %; Lake et al., 1999). Lake et al. (1999) estimates that these modes annually produce 14,760 kt and 4,212.6 kt of GHG, respectively, accounting for over 98 % of all intercity transport-related GHG emissions in Canada (see Table 1).

Table 1. Canadian Intercity Passenger Travel: GHG Emission Estimates by Mode

Mode	Pass-km (billion)	Grams per pass-km	GHG Emissions (kilotonnes)	Percent of total GHG emissions
Car (two occupants)	120	123[iii]	14,760.0	76.5
Air	23.8	177	4,212.6	21.8
Rail	1.5	118[iv]	177.0	0.9
Bus	2.4	59	141.6	0.7
Total	147.7	274.9	19,292.2	99.9

Source: Lake et al., 1999.

The reliance on airplanes and cars, in particular, has serious environmental consequences. These include a burden on the availability of natural resources, notably oil, and global and local damage to ecosystems and human health resulting from fossil fuel combustion[v] (air pollutants and GHG emissions). In addition, burgeoning road infrastructure has created unsustainable land-use patterns that adversely effect habitat, migration patterns, and ecosystem integrity. On the other hand, life-cycle assessments show that rail transport contributes less than 1% of health and environmental impacts related to such factors as air pollution, noise, accidents, and climate change (OECD, 2000).

Electrified HSR has been in operation in some OECD countries for over 40 years (e.g. Japan's Shinkansen). Since 1970, several public- and private-sector studies have investigated the feasibility of introducing a high-speed rail network in Canada, specifically in the highly urbanized corridor between Windsor, Ontario and Quebec City, Quebec. Despite favourable research findings, many detractors maintain that the population of the Quebec-Windsor Corridor (QWC) is too low, and the intercity distances too great, to support HSR. However, rising fuel prices, growing concerns about pollutant and GHG emissions, road congestion, and aging road and air transport infrastructure demand a fresh look at installing this energy-efficient and passenger-friendly transportation alternative. This study will show that, contrary to commonly held assumptions, the population densities and city-pair distances of major population centres in the QWC are sufficient to support HSR. The objective is to put this issue to rest so that attention can be focused on identifying the real obstacles to HSR transport in Canada.

The paper is presented in three parts. The first part provides a brief description of HSR in Japan, Europe and the United States. The second provides an historical overview of efforts to develop a HSR system in Canada. The final section presents findings from an analysis comparing population densities and inter-city distances in the QWC to similar European and American examples where HSR has been a success.

2.0 Existing High Speed Rail Systems

2.1 HSR and Medium-Range Intercity Transport

High-speed rail is typically defined as heavy rail public transit systems capable of traveling 200 km/h (125 mph) or faster (Vuchic & Casselo, 2002). HSR is generally considered the most environmentally sustainable option of intercity movement of people. It is the most energy diverse transport alternative, as it can use electricity generated by zero-emission hydro and nuclear power. HSR is considered most competitive with car and air between 100 and 1,000 km (Pavaux, 1991;Vuchic & Casselo, 2002). However, HSR competes primarily with airlines for the medium distance intercity passenger market. Pavaux (1991), in a study of high-speed train services in Europe, found that for journey times under three hours (a rail distance of about 750 to 800 km) intercity travel by common carrier is dominated by rail. Patterson & Perl (1999) documented the impact on other modes when the TGV was introduced into markets where door-to-door journey times are time-competitive with air. For example, between 1981, when the TGV (train à grande vitesse) was launched in France, and 1985, travel on the Paris-Lyon rail line increased 2.6 times, and air traffic dropped by 17 %. Likewise, the introduction of the Thalys high-speed train between Paris and Brussels in 1997 resulted in a jump from 24 % to 48 % in rail's share and a significant decrease in the share of road and air traffic on this route (OECD, 2001: 28). The introduction of the TGV resulted not only in a reduction in the number of flights but in aircraft size, which has positive implications for GHG emission levels, air quality, and fuel consumption (Patterson & Perl, 1999).

2.2 Overview of Successful HSR Systems

High-speed rail systems have experienced success in Japan, Europe, and, on a smaller scale, the United States. The first high-speed rail system was Japan's Shinkansen, which started operation between Tokyo and Osaka in 1964 before the Tokyo Summer Olympics. Today, Japan operates a HSR network of over 2,000 km in a country with a population of 120 million. The Shinkansen network transports 260 million passengers each year and operates 600 trains each day (OECD, 2001). Continuous technological improvements in Japanese high-speed rolling stock and infrastructure, particularly the development of more powerful motors and lighter aluminum alloy bodies, have not only increased speed and energy efficiency but have reduced noise and vibration, two negative impacts commonly associated with high-speed trains. The later Shinkansen models consume 35 % less energy than the original model while reaching higher speeds (OECD, 2001: 31).

In 1983, France introduced the first high speed trains in Europe along the 417 km route between Paris and Lyon, reducing the travel time of 4 hours for conventional rail to 2 hours (see Table 2). The TGV now runs on four lines covering 1,500 km. Germany launched the Inter

City Express (ICE) high speed network in 1991 with the construction of lines between Hanover and Würtzburg (327 km) and Mannheim and Stuttgart (100km). In 1998, the Hanover-Berlin (263 km) line was opened. An advantage of the German high-speed system is its design for use by both passenger and freight trains. It is primarily reserved for passenger traffic during the day and freight transport at night. Spain's AVE (Alta velocidad española) was first put into service in 1992 between Madrid and Seville (471 km). A second line linking Madrid and Barcelona was opened before the Barcelona Summer Olympics.

Table 2. High Speed Train Routes

Route	*Distance (km)*	*Travel Time (conventional)*	*Travel Time (high speed)*
Tokyo-Osaka	556	6:00	2:30
Madrid-Seville	471	6:00	2:14
Paris-Lyon	417	4:00	2:00
Hanover-Würtzburg	327	3:45	2:00
Berlin-Hanover	264	3:45	1:35

Source: High Speed Rail – success and challenges-, UIC, 2001.

The first high speed rail system in North America was introduced in 2000 when Amtrak opened the Acela Express service between Washington D.C., New York City and Boston, otherwise known as the Northeast Corridor (NEC).

A number of factors have contributed to the success of HSR in these markets:

- Linking large urban centers (at least 0.75 million inhabitants) (Thompson, 1994; Vickerman, 1996);
- A journey time of under three hours (distance between city pairs of under 750 km) (Pavaux, 1991; Vickerman, 1996);

- Centrally located stations which compete well with alternative modes (i.e. air) with poor access (Thompson, 1994);
- Substantial socio-economic benefits such as reduced road and airport congestion, local economic growth, and less air pollution.

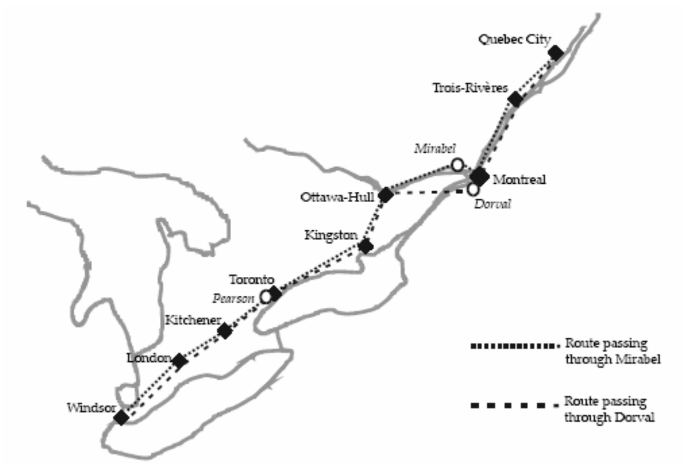
3.0 High-Speed Rail in Quebec City-Windsor Corridor

Following the introduction of successful HSR systems in Europe and Japan in the 1970s and 1980s, various private- and public-sector entities have studied the feasibility of installing a HSR network in the corridor between Quebec City, Quebec, and Windsor, Ontario, otherwise known as the Quebec City-Windsor Corridor (QWC).

3.1 Quebec City-Windsor Corridor Study Area

The study area occupies the highly urbanized corridor that runs along the United States border for about 1,100 km (see Figure 1). The proposed route stretches between Quebec City, Quebec, and Windsor, Ontario, and connects the cities of Montreal, Ottawa, Kingston, and Toronto. The QWC contains 85% of the population of Quebec and Ontario and nearly all of the major urban areas in these provinces. The population of the metropolitan areas in the corridor exceeds 12 million (2005 census) and is expected to reach about 13 million in 2016. The QWC is the busiest travel route in Canada. Intercity travelers are served by air, VIA Rail's conventional passenger trains, intercity bus lines and an extensive highway network.

Figure 1. Proposed HSR Routes for the QWC



Source: Canada, Ontario and Québec, 1995, 12.

3.2 Overview of HSR Studies

This section summarizes a review of available studies examining the provision of high-speed passenger rail services in the QWC. The review focused primarily on issues related to population density and city-pair distances (i.e. demand potential) and discusses other issues, such as projected capital and operating costs, technology, and socio-economic and environmental impacts, only as they relate to the former. Although a number of studies address the feasibility of magnetic levitation (maglev) technology, this review limits its evaluation to TGV high-speed technology.

The Canadian Transport Commission undertook the first major feasibility study of HSR in the QWC in 1970[vi]. Comparing population density in the Montreal-Ottawa-Toronto corridor with three major international corridors in the United States, Japan and England, the study concluded that prospects for HSR were “mediocre”. These negative findings could be due, in large part, to conservative population projections and to the fact that the routes chosen for comparison are not similar to the QWC. The study examined population densities in the Boston-New York-Washington, Tokyo-Nagoya-Osaka and London-Liverpool-Manchester-Leeds corridors.

Aside from attempts by VIA Rail in the 1980s to stimulate interest in implementing HSR in all or part of the QWC, very little attention was given to HSR until 1989. At that time, VIA Rail, Bombardier (Lynx train) and ABB Canada Inc. (Sprintor train) proposed plans for HSR systems, which were not built[vii]. A year later, the Canadian, Ontario and Québec governments established a joint task force to determine the potential of high-speed rail passenger services in the corridor. The task force considered two HSR technologies:

- Medium fast (200 to 250 km/h) tilt train similar to ABB’s X-2000 (Swedish HSR); and
- Very fast (300 km/h) non-tilting train similar to GEC-Alsthom TGV train.

Study results predicted that by 2005 the 200-250 km/h system would attract 10 million riders and the 300 km/h system would attract 12 million riders. The final report (Canada, Ontario and Quebec, 1995) finds that HSR, particularly the very fast TGV service, would be technically feasible but would require significant government financial support. A study undertaken on behalf of the Canadian Institute of Guided Ground Transportation had drawn a similar conclusion: although population density was “closer to the critical mass required to make HSR feasible”, government investment would be required (Hurley & Jones, 1999:4). The Transportation Table (1999) report also concludes that substantial capital investments in the rail system would be required if it is to offer a competitive alternative to air and car travel in the medium-distance market. However, in a comparative study of the QWC, and successful Japanese and German HSR corridors with similar populations and city-pair distances, Masatoshi (2001) argues that population density in the corridor is sufficient to support a financially viable service.

4.0 Comparison of Population Densities and City-Pair Distances

4.1 Methodology

The objective of this study is to test whether the population density and city-pair distances of the cities in the QWC are comparable to similar corridors where HSR has been successful. For the purposes of this study, the analysis focuses on the portion of the QWC that comprises Toronto, Ottawa, Montreal, and Quebec City. This was done for a number of reasons: many of the Canadian HSR studies argue that this segment of the corridor has the most potential, Montreal and Toronto are the most populous urban areas, and Ottawa is the national capital, and Quebec City, the provincial capital.

The methodology involved two steps. First, side-by-side comparisons were made between city pairs in the Toronto-Ottawa-Montreal-Quebec City corridor (TQC) and city pairs in existing high-speed systems with the following characteristics (see table 3 and figure 1):

- City pairs within national boundaries;
- City-pair distances similar to TQC corridor; and
- Cities of comparable population.

For the most part, population data was gathered from national statistics agencies such as Statistics Canada, for "metropolitan areas" (or a similar term), which is "a very large urban area together with adjacent urban and rural areas that have a high degree of social and economic integration with the urban core"[viii]. Secondly, cities in the TQC were evaluated according to the factors identified as important to successful HSR systems (see section 2.2).

Table 3 presents distances, trip times and populations for similar city pairs.

Table 3. City Pairs by Trip Distance, Trip Time and Population.

City Pairs	Trip Distance (km)	Trip Time	City Population
Toronto-Montreal	***629***	***2:18***	***5,304,100***[ix] ***3,635,700***
Paris-Marseilles	630	3:15	11,173,800[x] 1,516,000
Madrid-Barcelona	621	4:30	5,843,000[xi] 4,686,700
Toronto-Ottawa	***400***	***1:46***	***5,304,100*** ***1,148,800***
Paris-Lyon	417	2:00	11,174,000 1,647,700
Stockholm-Goteborg	455	2:45	1,872,900[xii] 872,200
Osaka-Nagano	450[xiii]	n/a	2,596,700[xiv] 360,700
New York-Washington	362	2:43	18,323,000[xv] 4,796,200
Madrid-Seville	471	2:30	5,843,000 1,317,098
Hanover-Nuremburg	430	2:55	1,000,200[xvi] 1,023,200
Montreal-Quebec	***272***	***1:12***	***3,635,700*** ***717,600***
Madrid-Cordova	310	1:45	3,155,400 321,100
Lyon-Marseille	254	1:40	1,647,700 1,516,100
Berlin-Hanover	264	1:34	3,396,300 1,000,200
Montreal-Ottawa	***194***	***0:51***	***1,148,800*** ***3,635,700***
Cordova-Seville	120	0:45	321,100 1,317,098
Munich-Nuremberg	159	1:45	1,902,800 1,023,200

4.2 Results

The results of this analysis demonstrate quite strongly that the TQC corridor compares favorably with HSR corridors that have experienced success. Figure 2 compares the city-pair distances and relative populations of cities in the TQC with corridors in France, Spain, Germany, Japan, United States and Sweden. The diagram clearly shows that the TQC is very similar to these corridors in terms of distance and, in fact, has a larger population base than many of the existing corridors, particularly those in Spain, Germany, and Sweden.

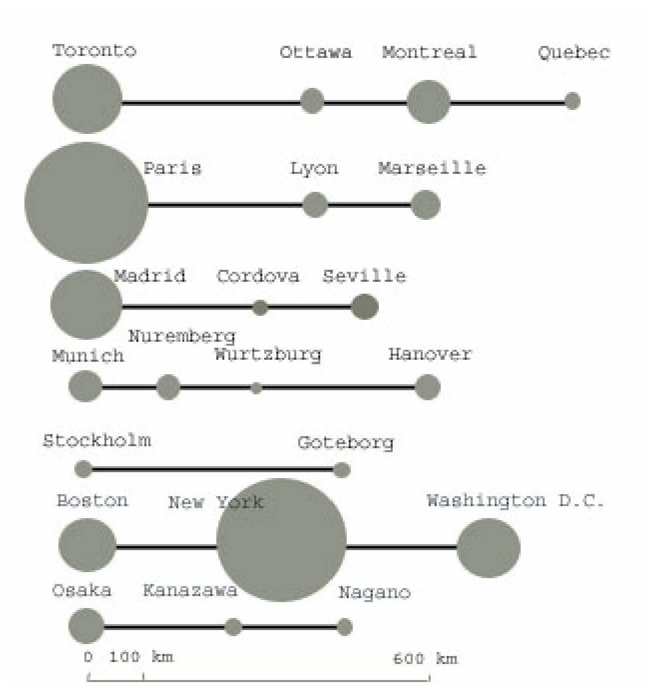


Figure 2. City-pair distance and population comparison*[xvii]*.

The TQC also possesses attributes identified above as critical to a viable HSR service. First, even the longest segment of the line (Toronto-Montreal) at 629 km is under the suggested maximum of 750 km and under three hours journey time. Second, all four cities in the corridor have populations greater than 750,000, and the Toronto and Montreal urban areas have considerably higher populations at 5,304,100 and 3,635,700, respectively. Third, Toronto, Montreal and Quebec City have centrally located train stations. Furthermore, Toronto and Montreal both have dense Central Business Districts, which more closely resemble urban patterns found in Europe than in many North American cities. This situation increases the competitiveness of HSR by reducing overall travel times and enhancing intermodal public transportation. In Montreal and Toronto, access to busy International Airports may later provide the opportunity for inter-modal complementarity. Last, the introduction of HSR in the corridor would generate many external benefits, including relieving congestion in overburdened roads and airports, improving safety and air quality, and reducing harmful transportation-generated emissions.

5.0 Conclusion

The OECD report on Environmentally Sustainable Transportation concludes that "current transport systems are not sustainable over the long term environmentally, economically or socially" and strongly suggests the need for a new policy approach (2000: 30). This study's results highlight the need to seriously evaluate the long-term environmental, economic, and social costs of ignoring HSR as a sustainable intercity transportation solution in Canada. The Transportation Table (1999) report suggests that electrified HSR between Toronto and Quebec City would result in an annual GHG reduction of ***281,000 tonnes*** in 2010 and ***423,000 tonnes*** in 2020. The study results clearly show that population density and city-pair distances in the corridor between Toronto and Quebec City are comparable to contexts where HSR has been a success, and dispels the myth that HSR would not be viable in TOMQ corridor. Future studies should address the real obstacles to HSR, such as the lack of political will and a question of who will ultimately finance a HSR system.

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Endnotes

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[i] The authors wish to thank Donny Seto and Olga Proulx for their assistance in the preparation of some of the technical aspects of the paper.

[ii] Transport contributes about 20 % of anthropogenic CO2 emissions worldwide, and close to 30% are in OECD countries (OECD, 2000).

[iii] This figure may underestimate GHG emissions for cars as it is based on an occupancy rate of two people.

[iv] The estimate for GHG emissions would be lower for an electrified HSR system because HSR is more fuel-efficient than conventional rail (maximum operating speeds of 100 km/h).

[v] In addition to GHG emissions, motor vehicles are responsible for other harmful emissions. In 1997, motor vehicles accounted for 89% of CO emissions, 52% of NO_x emissions and 44% of VOC emissions in OECD countries (OECD, 2001).

[vi] ***Intercity Passenger Transport Study*** (1970).

[vii] VIA Rail, ***Review of Passenger Rail Transportation in Canada*** (1989) The Bombardier report ***Projet d'un TGV Canadien: études de pré-faisabilité*** (1989) was unavailable to the public.

[viii] Retrieved from www.statcan.ca on March 15, 2006.

[ix] 2005 Canadian population figures are for Census Metropolitan Areas, Statistics Canada.

[x] 1999 French population data are for « aires urbaines », INSEE.

[xi] 2005 population data are for official metropolitan areas, INE (National Institute of Statistics), 2005.

[xii] 2005 Swedish population data are for Metropolitan Areas, www.citypopulation.de.

[xiii] The trip distance for Osaka-Nagano is approximate. The line is under construction and is to be completed in 2014.

[xiv] 2005 populations for Japanese cities were retrieved from www.citypopulation.de.
[xv] 2000 U.S. population data are for Metropolitan Statistical Areas, U.S. Census.
[xvi] 2003 population data are for principal agglomerations. Retrieved from www.citypopulation.de.
[xvii] Figure 1 is based on figure 8 in Masatoshi, H., ***A preliminary feasibility study about high-speed rail in Canada***, 2001,p. 7. The population circle for New York City was based on Metropolitan Division boundaries in the interest of space.