Transport
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Ontario

Québec - Ontario High Speed Rail Project

Final Report

August 1995

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Appendix C contains a list of other government contributors to the HSR study, beyond the study team. These individuals have provided input and comments to the various component studies. The Steering Committee also wishes to express its appreciation for the effort made by these specialists.

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Executive Summary

This report presents the results of the Québec/Windsor High Speed Rail feasibility study, which was funded equally by the governments of Canada, Québec and Ontario. The study, which began in 1992, involved a number of firms specialized in transportation issues and a federal-provincial team who investigated the prospects and implications of introducing a High Speed Rail (HSR) passenger transportation system in the Québec-Windsor Corridor. This study is a continuation of the work performed by the Ontario/Québec Rapid Train Task Force (O/Q RTTF).

The study was headed by a Steering Committee composed of the Deputy Ministers from the three ministries of transportation.

Objective and Scope

The objective of the study was to recommend whether or not the Governments of Canada, Québec and Ontario should decide to initiate and/or support the development of high speed passenger rail services in the Québec-Windsor Corridor.

This study included a detailed assessment of potential representative routings for HSR service from Québec City to Windsor, associated construction costs, detailed traffic forecasts and consumer surplus estimates, a thorough review of representative technologies, their operational characteristics and resulting operating costs, an evaluation of socioeconomic, industrial, economic, urban and environmental impacts, and impacts on other modes. It also included a potential industrial strategy, a detailed financial analysis, an evaluation of financing possibilities and a cost-benefit analysis.

The routings and technologies considered in the study are representative. They are not necessarily final choices for application in Canada. In fact, a range of technologies was examined as well as a number of different routing options. Different segments were also studied, including the full Québec-Windsor Corridor and shorter segments such as Montréal-Toronto and Québec-Toronto.

Two broad speed/technology alternatives were analyzed, the medium fast (200 to 250 km/h) technologies incorporating body tilting represented by the ABB X-2000 train, and the very fast (300 km/h and over) technologies without body tilting, typified by the GEC-Alsthom TGV-Atlantique train.

New Features

Although a continuation of the O/Q RTTF, this study incorporates new features not previously found in any other Canadian HSR study:

- Much more extensive surveys of current travel characteristics, conducted in three waves, with three times as many completed questionnaires as ever before on the various modes. Stated preference surveys asked passengers questions about tradeoffs between modal attributes such as travel time, fares and frequencies;
- Use of three demand forecasting consultants with three different forecasting approaches, but with the same input assumptions, and a reconciliation of these forecasts into one forecast;
- Extensive consultation with an Advisory Group composed of the major stakeholders, namely the existing bus operators, airlines and train operators in the Corridor and major manufacturers of rolling stock;
- More detailed analysis of economic impacts taking into account how such a project could be financed without increasing the public debt, thereby assuming that governmental financial support would be funded by correspondingly reduced capital expenditures in other areas of government investment by the federal government and the governments of Québec and Ontario;
- Consultations and technical visits to operators in Sweden and France as well as with

ABB and Bombardier in Canada to gather detailed information and to review data and assumptions;

- Development of a detailed financing plan, in collaboration with the Banque Nationale de Paris, a major bank involved in large infrastructure project financing;

- A cost-benefit study, that is, an economic analysis of the project from the point of view of Canadian society as a whole, and the development of provincial cost-benefit models that consider the project from the point of view of the provincial governments.

Key Findings

The present study did not define final routes for HSR but only "representative" routes, in order to obtain more detailed cost estimates, trip times and revenues projections. Two representative route alignments were developed, one for each family of technology. Although both routes extend from Québec City to Windsor, they follow somewhat different alignments.

Table 1 presents main characteristics as well as the major cost and revenue findings.

Total system costs between Québec and Windsor (some 1200 km), are estimated at $9.5 billion for the 200 km/h system and at $10.5 billion for the 300 km/h system. Costs for the Toronto-Montréal segment (over 600 km) are estimated at $5.4 billion and $6.1 billion respectively for the 200 km/h and 300 km/h systems. The Québec-Toronto 300 km/h scenario would cost $8 billion. System costs exclude inflation and financing costs; total financing requirements including inflation and financing costs are presented in Table 2 and discussed in the section on financial analysis.

In order to provide year-round high speed operation, existing tracks and roadbed need complete reconstruction.

There are no significant differences in costs between using existing rail lines and new greenfield routes, nor are there any significant differences in costs between the 200 and the 300 km/h routes.

Existing HSR systems are adaptable to Canadian conditions but would require some modifications. Suppliers and operators would therefore need to invest in some research and development since existing high speed rail R&D programs do not address some specific needs of a Canadian HSR.

Table 1 - HSR Characteristics

	200 km/h System	*300 km/h System*
Length (km)		
Québec-Windsor	1228	1234
Montréal-Toronto	610	629
Express Travel Times (H:MIN)		
Québec-Montréal	1:34	1:12
Montréal-Toronto	3:05	2:18
Toronto-Windsor	1:56	1:24
Ridership in 2005 (thousands)		
Québec-Windsor	10065	11867
Montréal-Toronto	5619	6646
Revenues in 2005 (1993$ millions)(1)		
Québec-Windsor	694	887
Montréal-Toronto	428	550
Total System Costs (1993$ billions)(1)		
Québec-Windsor	9450	10481
Montréal-Toronto	5402	6079
Operating Costs in 2005 (1993$ millions)		
Québec-Windsor	259	303
Montréal-Toronto	158	186

(1) Excludes GST and PST

HSR operation could improve travel times significantly over existing Via Rail services. For example, a trip time of 1 hour and 12 minutes could be achieved between Montréal and Québec and a trip time of 2 hours and 18 minutes would be feasible between Montréal and Toronto with a 300 km/h technology. A variety of multiple stops and express trains would be offered.

The improved travel times would be accompanied by significantly increased frequencies, which would compare with those of air carriers, on all cities to be served by HSR within the Corridor.

Ridership and Revenues

The total intercity passengers in the Corridor in 1992 correspond to some 109 million person-trips. Automobiles account for 99 million trips, air accounts for 4.1 million, followed by rail with 2.9 million and bus with 2.6 million.

HSR could attract more than 10 million riders per year in 2005 on a 200 km/h system and nearly 12 million for a 300 km/h system in the Québec/Windsor corridor. In 2025, the respective numbers of passengers would be 15 and 19 million. The Montréal-Ottawa-Toronto segment accounts for nearly 56% of total corridor ridership, and Québec-Toronto, approximately 75%.

Approximately 80% of future HSR travellers could be diverted from other modes in the corridor. Those being diverted from automobile would account for 40% of HSR ridership, 18% from air (local and connecting flights), 15% from VIA Rail and 8% from buses. Induced traffic (trips that would not have been made without HSR) generated by this new service could represent approximately 23% of the ridership for the 300 km/h system, compared with 18% for the 200 km/h system.

Approximately 60% of the patronage is forecast to be non-business and 40%, business. Business ridership, however, generates approximately 50% of revenues.

In 2005, first-year revenues in constant 1993$ for the 300 km/h system (for the entire corridor) would be $900 million and $700 million for the 200 km/h system. In 2025, revenues would be $1.5 billion (1993$) and $1.2 billion respectively. With operating costs in the range of 40% of operating revenues, excluding taxes and commissions, HSR would generate a substantial operating surplus, which would improve over time.

Other potential net revenues on the order of $50 million per year could be generated from the operation of light freight and small parcel trains and from station concessions.

Impacts

The levels of diversion of travellers from their current modes to HSR would not reduce the requirements for additional road or airport infrastructure investment.

Air carriers could lose 44% of their projected corridor ridership in 2005. The reduction in contributions to overhead and profit, when taking into account avoided investments, would be approximately $99 million per year. In the short term, the competitive response of the airline industry may be very aggressive. However, this may not be sustainable in the long run.

There are no major legislative barriers to the implementation of HSR, and, on the labour front, constraints are expected to be eliminated through changes in collective agreements which will permit cost-effective operations.

HSR will reinforce the Québec-Windsor corridor as Canada's primary urban area and will tend to reinforce the general trends towards larger metropolitan areas.

Analysis of the industrial impacts show that Canada has a strong, fully integrated, internationally competitive rail supply industry that could supply 85% of manufactured components of an HSR system, regardless of the technology.

There is little export opportunity regardless of technology. Export potential to the US will depend on HSR projects in that country. Most new HSR projects in the US are expected to be built in an incremental approach with tilt technology on existing tracks. A Canadian HSR tilt technology project could potentially generate exports of components and services of up to $860 million over 20 years. A non-tilt technology could generate exports of $500 million over the same period. Without such projects, Canadian exports are estimated at $260 million.

If government funding was financed through reallocation of capital expenditures of the federal government and the governments of Québec and Ontario:

- HSR would have modest impacts on total output, employment and real income. Over 25 years, for the full 300 km/h corridor scenario, 43,700 person-years of employment, or an average of 1,750 jobs per year, would have been created and government debt would be reduced by $6.5 billion (nominal);
- there would be mixed impacts on employment and output. For example, employment would increase by approximately 10,500 jobs per year over the construction period. Approximately 3,400 jobs per year would be lost over the operating period from 2004 to 2020;
- economic impacts would be concentrated in Québec and Ontario, where most of the activity would take place;
- negligible impacts on the tourism industry.

If government funding was financed through expansion of its debt, real output would be increased over the course of the operating phase, but at the expense of a cumulative increase of $8.3 billion (nominal) in government debt and increased borrowing from foreign sources. Over 25 years, 193,000 person-years of employment, or an average of 7,720 jobs per year, would be created if the full corridor was built.

Positive environmental impacts would be a reduction of the anticipated increase in intercity transportation energy consumption in the corridor, leading to a reduction of atmospheric emissions. Public safety in intercity transportation would also be improved due to reduced car travelling and the elimination of at-grade road crossings.

On the negative side, a new HSR corridor would create a new barrier, particularly in inhabited areas. There would be negative impacts related to increased noise and to crop losses on high quality land. This impact, as well as noise impacts, could be reduced through proper planning and mitigation measures.

Financial Analysis

Total system cost for the 300 km/h technology between Québec City and Windsor is $10.5 billion (1993$). A yearly inflation rate of 3% would add $3.4 billion for a total cost of $13.9 billion. Financing costs during the construction period add a further $4.4 billion, for a total cost of $18.3 billion spent up to 2005.

Total system cost for the 200 km/h technology between Québec City and Windsor is $9.5 billion (1993$). A yearly inflation rate of 3% may add $3.0 billion for a total cost of $12.5 billion. Financing costs during the construction periods add a further $4.0 billion for a total cost of $16.5 billion spent up to 2005. Table 2 presents the total financing requirements for a number of scenarios.

The project, taken as a whole, represents a high financing risk for each party involved.

A wholly-owned private sector option is neither viable nor financeable, as the private sector's cost of funds would significantly exceed the HSR project's financial returns, regardless of the considered scenario.

Public sector risk and financial support would be minimized if construction, operating and financing risks were to be shared with the private sector.

Table 3 presents the financial results of selected scenarios. For the best scenario, Montréal-Toronto with a 300 km/h technology, the private sector could support up to a maximum of 28.6% of the capital costs of HSR while achieving an internal rate of return (IRR) of 12.3% after taxes. Within such a partnership, the project could generate an internal rate of return (IRR) of up to 7.1% for the public sector's investment, including tax revenues, or 3.6% excluding tax revenues.

Table 2 -Financing requirements up to 2005 ($ million)

	System costs 1993$	*Inflation Costs 3%*	*Capitalized interests during construction*	*Total spent up to 2005*
200 km/h				
Québec-Windsor (via Dorval)	9,450	3,134	3,860	16,444
Montréal-Toronto (via Dorval)	5,402	1,773	2,229	9,404
300 km/h				
Québec-Windsor (via Mirabel)	10,481	3,446	4,414	18,341
Montréal-Toronto (via Dorval)	6,079	1,969	2,653	10,701
Québec-Toronto (via Mirabel)	7,996	2,619	3,403	14,018

By modifying the distribution of cash flows (as between the public and the private sector), it is possible to adjust the projected rate of return to 12% for the private sector for any of the scenarios considered. This would potentially enable each scenario to be both viable and financeable from the private sector's perspective, although at the expense of the public sector, while still maintaining a public-private partnership structure. However, such a skewing of cash distributions would weaken the relationship between risk and reward.

With the private sector IRR fixed at 12%, the public sector IRR would decline, except for the best scenarios, i.e., the MOT-D-300 scenario. The public sector IRR would be less than 3.5% including tax revenue and negative excluding tax revenue for all other scenarios. For the MOT-D-300NA scenario, the public sector IRR would increase from 7.13% to 8.27%, while the private sector IRR would decline from 12.34% to 12%.

The financial analysis concluded that governments would more than fully recoup their investment (on an undiscounted basis) within the first 30 years of operations. On a discounted basis, at 9%, which is the assumed government's long-term borrowing rate for the purpose of this study, and considering the conservative estimate of the residual value, the governments end up paying a net contribution to the project. Should HSR proceed, it is likely that the interest rates at which a project is financed will differ from those used in the analysis. It must however be remembered that the real rate of interest is high from an historical perspective while inflation is relatively low.

The Québec-Toronto 300 km/h via Mirabel scenario yields returns to both the private and the public sector which are similar to the MOT-M-300 km/h scenario. It is quite possible that a 300 kph Québec City-Toronto (via Dorval) option would also be viable and financeable from the private sector's viewpoint.

Table 3 - Financial Results

	Base Scenarios Québec-Windsor		*Québec-Toronto (via Mirabel)*	*Best Scenario Montréal-Toronto (via Dorval - No airport connection)*
	200 km/h (via Dorval)	*300 km/h (via Mirabel)*	*300 km/h*	*300 km/h*
Public-Private Partnership				
Public Sector IRR[1]	2.57%	4.56%	5.49%	7.13%
Private Sector IRR	9.38%	10.79%	11.04%	12.34%
Project Financing				
Maximum % of Private Sector Risk and Financing	22.7%	25.3%	26.0%	28.6%
Public-Private Partnership (private sector fixed rate)				
Public Sector IRR	-7.5%	1.65%	2.52%	8.27%
Private Sector IRR	12%	12%	12%	12%
Wholly-Public Financing				
IRR Including Taxes	4.83%	6.58%	6.80%	8.18%

(1) IRR - Internal Rate of Return

Table 4 - Cost-Benefit Analyses Results

	Base Scenarios Québec-Windsor		*Québec-Toronto (via Mirabel)*	*Best Scenario Montréal-Toronto (via Dorval)*
	200 km/h (via Dorval)	*300 km/h (via Mirabel)*	*300 km/h*	*MOT-D-300*
Cost-Benefit Analysis				
Net Present Value (1993$ million)	-320	684	763	1,285

Cost-Benefit Analysis

Table 4 presents the results of the cost-benefit analysis expressed in net present value for an 8% discount rate.

The discount rate is a very important factor in the cost-benefit analysis. The federal government uses a 10% discount rate in all their analyses. A 7% discount rate was suggested by the consultants in charge of the benefit-cost analysis as it approximates the real rate of interest on borrowed funds in the financial analysis. Also, this rate is used by Hydro-Québec in evaluating large hydroelectricity projects. The three governments agreed on a discount rate of 8% to be used as the base case for the purposes of this study.

With a discount rate of 8% all scenarios are economically viable except for the 200 km/h full corridor scenario. At a 10% discount rate, only the Montréal-Toronto 300 km/h scenario through Dorval would be viable. At a 7% discount rate, all scenarios would be viable.

Consumer surplus, which is an economic benefit, was estimated at some $21 per passenger, for a total of $250 million for the Montréal-Toronto through Dorval scenario.

The cost-benefit analysis concurs with the financial analysis in concluding that routing through Dorval is always superior to routing through Mirabel. The same is true with respect to technology. Both studies conclude that the 300 km/h technology yields results that are superior to the 200 km/h technology.

Risks, Assumptions and Sensitivities

Any megaproject the size of the Québec-Windsor HSR project, whether for the entire corridor or for the Montréal-Toronto segment, entails a number of risks and uncertainties. In this case, the lack of experience with HSR in North America and particularly in Canadian climatic conditions creates uncertainty in the ridership and revenues, in the construction and maintenance of such a high quality roadbed and in operations in our winter conditions. Several studies focused on these specific issues, which were known at the outset of the study to evaluate the feasibility and risks, provide appropriate contingencies or evaluate the sensitivity of the results to various parameters.

All efforts have been made to provide an objective evaluation rather than a promoter's perspective. In addition to the consultants who undertook the studies, the three governments have thoroughly reviewed the methodologies, input assumptions and results. The major railways, suppliers and operators were consulted, particularly on the issues of construction and operating costs. The overall demand forecasting strategy, with the use of three forecasting firms and the largest corridor database ever assembled, was designed to produce reliable forecasts.

A study of this nature can progress and be completed only if a great number of assumptions are made. Many are related to the reaction of existing travellers to HSR and the price they are willing to pay. Others are related to a number of issues which influence capital, operating or financial costs of the project. Finally, other assumptions are related to the impacts and help decision-makers evaluate the merits of the project. A number of sensitivity analyses have been completed to test the robustness of the results of most of the component studies and thus to evaluate the risks and uncertainties of the project.

The financial returns are most sensitive to variations in construction costs, the duration of the construction period, project revenues and to the terminal value of the project, with real interest rates potentially a major factor. Should HSR proceed, it is highly likely that the interest rates at which the project is financed will differ from those used in the financial analysis. At present, the real interest rate is high from an historic perspective, and inflation is relatively low.

The cost-benefit results are most sensitive to changes in the discount rate, consumer surplus estimates, initial capital costs and revenues.

Conclusion

The Steering Committee has a high degree of confidence in the results of the studies. It believes that the overall results provide a sufficient degree of precision to make the following conclusions and recommendations:

- HSR is technically feasible;
- HSR would provide a useful addition to transportation infrastructure but would require significant resources;
- An HSR system at 300 km/h is superior to a 200 km/h system in all respects;
- An HSR system would not reduce needed government investments in infrastructure in other modes;
- HSR could not proceed without significant government financial resources;
- There is little export opportunity regardless of technology;
- The Montréal-Ottawa-Toronto segment represents the best scenario. Québec-Toronto is next best, but was not analyzed to the same level of detail;
- Some scenarios could be economically and financially viable, depending on accuracy of projections with respect to construction cost, ridership and revenues, interest rates, discount rate and actual inflation;
- From an environmental point of view, HSR would improve public safety and decrease air pollution, but would have a negative impact on land use;
- The study did not assume a long term aggressive response from airlines; more work would be needed on this aspect.

Recommendation

Based on these conclusions, the Steering Committee recommends that any future work should only consider very fast technologies.

The following conditions must be satisfied before any further work is undertaken:

- The initiative for the next stage lies with the private sector, who should underwrite at least 50% of the next phase of the project;
- The private sector must agree to take on all project risks (construction risks and management of a high speed rail operation) if the project goes ahead to implementation;
- In view of the fiscal situation of governments and because, according to the study, 70% to 75% of the cost would have to be paid by the public sector, governments should indicate whether or not they are prepared to proceed with the next phase, considering the demand for other transportation and infrastructure investments;
- The governments should also take into account the rate of return of the project.

If all of these conditions are met, the next phase would include the following elements:

- System design optimization;
- Environmental assessment and approval;
- Preliminary engineering;
- Ridership and revenue forecast;
- Necessary regulatory approvals such as safety, etc.

Even if the above conditions cannot be met, the Steering Committee suggests that the governments revisit the project in three to five years.

1

Introduction

High Speed Rail Feasibility Study

The Québec-Windsor Corridor extends some 1,200 kilometres from Québec City to Windsor. The major urban centres in the Corridor include Québec City, Trois-Rivières, Drummondville, Montréal, Ottawa-Hull, Kingston, Toronto, Kitchener-Waterloo, Hamilton, London and Windsor. This area includes 92 percent of the total population of Québec and Ontario, and 56 percent of the population of Canada. Figure 1.1 shows the existing and projected population of the urban centres in the Corridor.

The potential for a high speed rail (HSR) system carrying passengers between cities within the Corridor has been the subject of a number of previous studies. Prior to the present study, the Ontario/Québec Rapid Train Task Force (O/QRTTF) Report, supported by the Ontario and Québec governments and released in May of 1991, was the most comprehensive work on the subject. The Task Force concluded that it was not possible, from the information available at the end of the Task Force's studies, to make a final decision and recommended further assessments, with the participation of the Federal Government.

Therefore, on behalf of their respective governments, the Ministers of Transport Canada, the Ministry of Transportation of Ontario and the Ministère des Transports du Québec agreed to establish a federal-provincial team to investigate in detail the prospects and implications of introducing a high speed passenger rail service in the Corridor. This study is a continuation of the work performed by the Ontario/ Québec Rapid Train Task Force. The present HSR Feasibility Study is headed by a Steering Committee composed of the Deputy Ministers from the three ministries of transportation. The Study, which began in early 1992, is supported by and actively involves the three governments as equal partners.

Objective of the Study

On the basis of the O/QRTTF conclusions, the Steering Committee agreed that the objective of the present study would be:

> ***To recommend whether or not the Governments of Canada, Ontario and Québec should decide to initiate and/or support the development of high speed passenger rail services in the Québec-Windsor Corridor.***

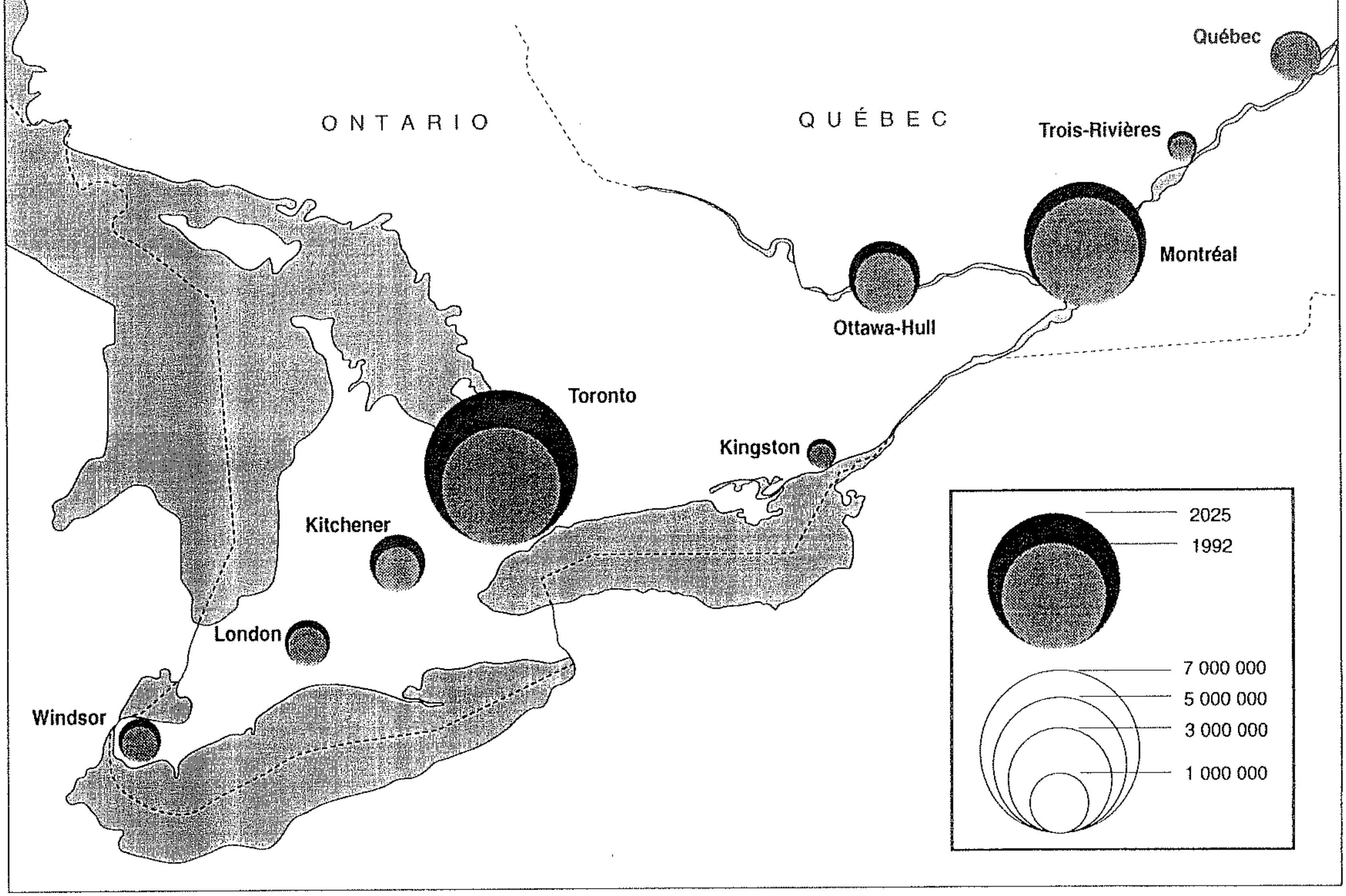
In order to achieve this objective, the study was to:

- determine the market feasibility of such a service using quantitative means;
- identify a specific technology that would satisfy performance, industrial benefit and financial criteria;
- identify corridors, stops and interconnections with other transportation services;
- identify the maximum extent of the service and the means by which it can be offered by the private sector and outline eventual government involvement in the implementation of the service.

The focus of the study was on high speed rail technologies already in commercial service, which provide a clear competitive advantage over other modes available and that have the potential for development of future generations of rail technology using the same infrastructure.

This led to the study of medium fast HSR technologies running at or over 200 km/h and very fast technologies running at 300 km/h and more.

Figure 1.1 - Existing and projected population of the urban centers in the Québec-Windsor Corridor



Scope of the Study

This study on HSR follows previous research undertaken by Via Rail in the 1980's, suppliers of equipment, and by the Ontario/Québec Rapid Train Task Force. It is differentiated by its use of a new, very large, custom designed database which focuses on current travel patterns followed by an intensive effort to develop robust passenger forecasts. There has also been a thorough detailed review of the capital and operating costs of HSR. The level of effort in these areas is substantially greater than in any other previous study. This new information has led to the development of a financial analysis, a review of socioeconomic impacts and to the undertaking of an original cost-benefit analysis for the overall Canadian economy.

Recognizing the variety of subject areas to be dealt with and the number of disciplines involved in a feasibility study as broad as this, the Steering Committee decided to commission a number of component studies. The general work plan, which presents the component studies and their interrelationship, is shown in Figure 1.2.

Consultants and experts commissioned by the Steering Committee after public calls for proposals have undertaken all these component studies except the development of the socioeconomic scenarios. Appendix A provides references for all the reports produced. Individual reports were prepared for each component study. This volume does not include all the results of the component studies; further details are given in the individual component studies reports.

As can be seen from the list of the component studies, this study was intended to be very broad ranging and to examine all facets of the requirements for high speed rail and its likely impacts and implications. It was not intended to produce a final design for an HSR system for the Québec-Windsor Corridor. Rather, representative technologies were chosen and routings were designed to develop realistic costs. These were representative in the sense that they reflected the best practice available, but were not the final choice for application to the Canadian Corridor. In fact, a range of technologies was examined, as were several routing options. Different route segments were also considered, including the full Québec-Windsor Corridor and shorter sections such as Montréal-Ottawa-Toronto and Québec-Toronto.

In other countries, passenger rail systems using steel wheel and steel rail technology operate at commercial speeds up to 300 km/h and at much higher speeds in test operations. In Canada, passenger rail services operate at top speeds up to 160 km/h. Both Via Rail and the O/QRTTF concluded that, to provide major improvements over existing services, an HSR system would have to reach top speeds of 300 km/h or more. Magnetic-levitation (maglev) systems were not considered as no such system is in commercial service in the world today, moreover, maglev systems have no particular advantage in the topography of the Québec-Windsor Corridor.

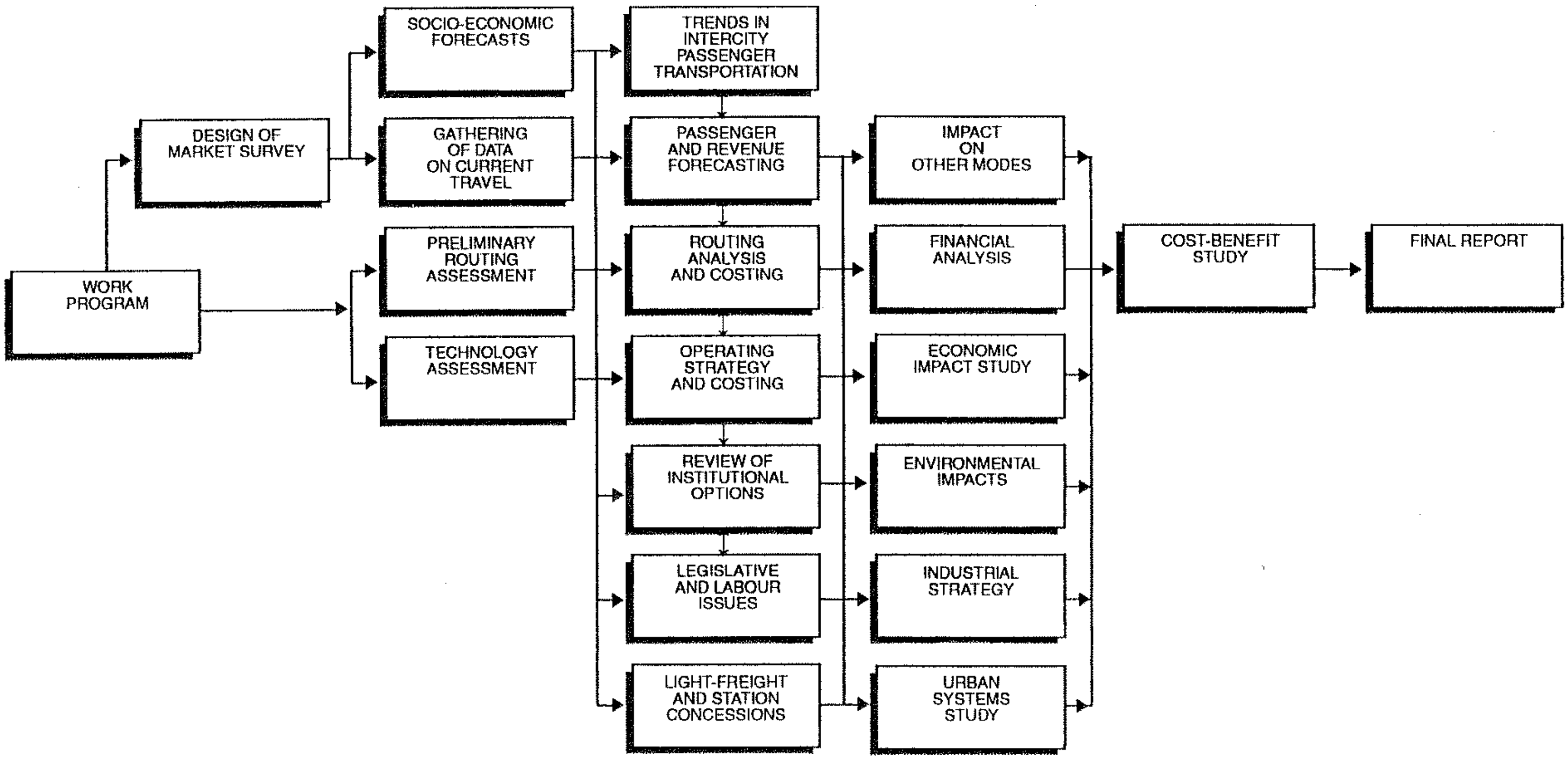
It was recognized that an HSR system would take a considerable amount of time to implement; therefore, the earliest date a system could be expected to be in operation would be around 2005. To examine the full implications of HSR, a horizon of 30 years, from 1995 to 2025, was used in most of the component studies. This was extended to 40 years in the financial analysis.

This report summarizes the results of the analyses and the conclusions reached by the Steering Committee regarding the feasibility of HSR service in the Québec-Windsor Corridor.

Advisory Group

At the outset of this project, the Steering Committee identified and met the major stakeholders, namely, the existing bus operators, Voyageur Colonial, Orléans Express and airlines operating in the Corridor, Air Canada and Canadian Airlines, railway companies, CN Rail, CP Rail, VIA Rail, as well as major manufacturers of rolling stock, ABB and Bombardier. All agreed to collaborate in order to ensure the best quality of results. The collaboration of the operators was particularly useful in undertaking the passenger surveys on the various existing modes.

Figure 1.2 - Québec-Ontario HRS project general work plan



The railways were part of the review process to define representative routes. Via Rail made available all previous studies and working documents. Its contribution in the process of the review of capital and operating costs was significant.

French National Railways (SNCF) through its consulting subsidiary Soferail, and Swedish National Railway Company (SJ) through its consulting firm Swederail, were consulted on the operating practices and costs. Most stakeholders were consulted by the consultants responsible for various component studies.

As reports were nearing completion, the stakeholders were also asked to review results and provide comments.

Previous Studies

As mentioned, there have been many studies of the potential application of high speed rail to the Québec-Windsor Corridor. It was the Committee's intention to build on the results of these earlier studies, particularly those concerning the Ontario/Québec Corridor, rather than to start over. These include:

- *Inter-city Passenger Transport Study*, Canadian Transport Commission, September 1970;
- *Alternatives to Air: A Feasibility Concept for the Toronto-Ottawa-Montréal Corridor*, Canadian Institute of Guided Ground Transport on behalf of the Transportation Development Centre of Transport Canada, July 1980;
- *High Speed Passenger Rail in Canada*, VIA Rail Canada, April 1984;
- *Review of Passenger Rail Transportation in Canada*, VIA Rail Canada, July 1989;
- *Pre-feasibility Study of a High Speed Rail Service in the Québec-Montréal-Ottawa / Hull-Toronto Corridor*, Bombardier, August 1989;
- *Sprintor, Pre-feasibility Study, Windsor-Québec Rail Corridor*, ABB Canada Inc., May 1990;
- *Ontario/Québec Rapid Train Task Force*, Ontario and Québec Governments, May 1991.

During the course of the project, Air Canada and CP Rail completed a joint study on HSR ridership and revenues. The results were made available to the Steering Committee.

The main source of information, particularly for the routing study, came from the Via Rail 1989 Review. The O/QRTTF was particularly useful in defining the areas of interest of the current study. These previous studies were generally less exhaustive and were based on information already available from other studies.

2

High Speed Rail Technologies

HSR was developed in countries such as France, Germany, Japan and Sweden to improve travel times, increase the capacity of existing rail links and preserve the competitiveness of rail.

Interest in the application of high speed rail to the Québec-Windsor Corridor has been stimulated by improvements in rail technology and their application in other countries. Although passenger railways have been in operation for more than a century and a half and have been incrementally improved, the modern high speed rail age can be said to date from 1964, with the opening of the New Tokaido line between Tokyo and Osaka in Japan. This was an entirely new railway line, built to a different gauge than the rest of the Japanese National Railways, dedicated to passenger transportation only. The high design standards used in the construction of this line permitted maximum speeds of 220 km/h over most of the route and the sophisticated signalling system permitted very frequent service, with trains scheduled as closely as five minutes apart. The original 515-kilometre line has been extended by another 550 kilometres and two new high speed rail lines have been constructed in Japan. Maximum speeds have been increased to 275 km/h as the technology evolved.

Subsequently, new high speed rail lines have been constructed in four European countries, most often as a link within a larger network of conventional rail.

• FRANCE. Three new HSR lines have been constructed. The Paris-Lyon 425-kilometre line started its operation in 1981. Trainsets run at their design speeds of 270 km/h on dedicated tracks between Paris and Lyon and then continue on to the southeast regions of France and Switzerland, on conventional tracks at 220 km/h.

Subsequently, the TGV-Atlantique and TGV-Nord were designed and operate at speeds of 300 km/h. Accesses to major cities use conventional tracks as they are already electrified, grade-separated and equipped with proper signalling systems.

• GERMANY. German Railways have developed a program of upgrading strategic routes and building new, high standard links in the network. Contrary to the practice in Japan and France, however, these new and upgraded lines are used by both passenger and freight trains. In 1992 a new generation of rolling stock was developed to operate at 250 km/h on the high speed lines.

• ITALY. Italy has entered the high speed era by constructing a new 260-kilometre line operating at 250 km/h between Rome and Florence. This line was built in sections and completed in 1988. It is intended that the HSR network be extended considerably beyond the original line.

• SPAIN. Although the Talgo tilt-train technology has been implemented gradually over the years, in 1993 a new high speed line was constructed between Madrid and Seville. As in the case of Japan, the new line was built to standard track gauge and is therefore separate from the remainder of the Spanish rail network, which uses a different gauge. The main service is provided by trainsets patterned after the French TGV system. In addition, however, the Spanish have adopted a type of train that can pass from the new standard gauge line to the remainder of the system. The new line is used by passenger trains only.

In other countries, incremental improvements to existing lines have been implemented to increase speed. In Great Britain, intercity trains travel at 225 km/h and in Sweden, the X-2000 runs at 200 km/h.

In Sweden, Italy and Spain, passenger trains have been designed with car bodies that tilt outwards as they go around curves. The purpose of the tilting mechanism is to compensate for the centrifugal force which causes discomfort to passengers when passing through tight turns at high speed. A tilting train can therefore negotiate a curve at a higher speed than a conventional train while maintaining passenger comfort. The purpose of this innovation is to permit higher speeds on existing lines that are already electrified. A similar system of tilting trains was developed in Canada in the 1970's in the form of the LRC trainsets.

In Sweden, improvements to the 456-kilometre main line between Stockholm and Göteborg were implemented as a complete system that included:

- tilting trains;
- some improvements to the infrastructure, particularly at-grade road/rail crossings;
- improvements to signal and other control systems.

The combination of these measures resulted in a new high speed system, with top speeds in the order of 200 km/h. The line continues to be used by conventional trains and by freight traffic.

In the United States, the Northeast Corridor between New York and Washington has been upgraded so that most of the line presently allows speeds of up to 200 km/h. Plans call for 240 km/h operation in the near future.

HSR projects are in the planning or design stages in other countries such as Russia, Korea and Taiwan.

All of the above systems, except for the Canadian LRC, are electrified, that is, electricity is supplied directly to trains from overhead wires.

Representative Technologies

Although it was not the Committee's intention to select a specific technology, the necessity of referring to specific technologies in order to determine capital and operating costs and other potential impacts became apparent. Based on the results of the O/QRTTF, two types of high speed rail technologies were examined for potential application in the Québec-Windsor Corridor:

- medium fast (200-250 km/h) technologies incorporating tilt-body features, as developed in Sweden and Italy. Tilting mechanisms allow trains to go faster around curves without sacrificing passenger comfort; and
- very fast (300+ km/h) technologies without tilting capability, similar to HSR systems of Japan, France, Germany, Spain and Italy. These technologies operate on dedicated tracks with a geometry that enables the trains to maintain their cruising speeds.

To be considered as a candidate representative technology, an HSR technology had to meet the following qualifications:

- the technology must be currently in commercial service;
- it must be capable of providing intercity trip times that represent a clear competitive advantage over other transportation modes serving the Québec-Windsor Corridor; and
- it must have the potential for development of future generations of equipment operating on the same infrastructure.

300+ km/h Non-Tilting Technologies

Three technologies within this family meet the basic requirements:

- the GEC-Alsthom TGV (Train à Grande Vitesse), manufactured by GEC-Alsthom and operated by French National Railways. Several varieties of equipment are operated. The TGV-Atlantique model was retained as typical of the French technology. The TGV is the only system in revenue service that currently operates at 300 km/h. The TGV-A also has the longest operating history of the three, having entered service in September 1989;
- the InterCity Express or ICE, operated by German Railways and built by a Siemens-led consortium. The ICE entered fleet service with German Federal Railroad in June 1991. The ICE fleet is limited to 250 km/h due to track geometry and environment constraints;

• the Shinkansen Series 300, designed and operated by the Central Japan Railway Company. The Shinkansen Series 300 EMU equipment entered commercial service with JR Central in mid-1992, and thus has only a short service history. The Series 300 equipment is restricted to 270 km/h in service due to the alignment geometry of the JR Tokaido line on which it operates. At the time of the review, only a few Series 300 trainsets were in service, although the fleet size grows as deliveries continue.

Due to its highest commercial speeds, long operating history and data availability, the GEC-Alsthom TGV was selected as the representative technology for the 300 km/h family.

200-250 km/h Tilt-Body Technologies

Two technologies within this family meet the basic requirements:

• the ETR-450, designed and built by Fiat and operated by Italian State Railways; and

• the X-2000, designed and built by ABB and operated by Swedish State Railways.

The ETR-450 has a longer operating history, having entered revenue service in early 1988. Italian State Railways (FS) now has 15 nine-car ETR-450 trainsets in service. The ETR-450 operates at a maximum speed of 250 km/h. The X-2000 entered service with Swedish State Railways in September 1990, and operations have been expanding as deliveries continue and the fleet grows in size. The Swedish X-2000 operates at a maximum speed of 200 km/h. An unmodified production trainset has been tested at 250 km/h on high-speed track of German Federal Railways, while a slightly-modified trainset leased to Amtrak for demonstration purposes reached 248 km/h during tests on the North-East Corridor between New York and Washington.

In terms of operating history, the ETR-450, in service since 1988, would seem to be a good candidate to be the representative technology for this family. However, this technology has been upgraded and changed considerably, including changes in major subsystems. The X-2000, on the other hand, is unlikely to undergo major alterations over the period of interest to the Project. It was considered that, because of this stability, the X-2000 would be a better representative technology for the requirements of this project.

Technology Assessment

As the chosen technologies were already operating successfully in other countries, a detailed technical evaluation of these technologies was not performed.

The technology assessment focused on the following issues:

- safety and conformity with Canadian standards;
- potential problems related to HSR operation in Canadian climatic conditions;
- R&D status;
- specific requirements for a Canadian project;
- design standards (discussed in the routing chapter); and
- potential environmental impacts related to each technology (discussed in the environmental chapter).

Technical visits to operators in Sweden, Italy and France by the consultant responsible for this study permitted the gathering of a great deal of information on all aspects of the systems and their operations. Discussions were held with ABB and Bombardier (the North American licensee of the TGV technology) to review data and assumptions. Discussions were also held with Transport Canada and the Federal Railway Administration, which regulates railway safety in the US.

Safety and Conformity with Existing Standards

One of the major difficulties experienced by the manufacturers and potential North American operators is the fact that HSR trainsets, though very safe, do not meet some North American standards. Most notable is the requirement for longitudinal strength of locomotives and cars commonly called "buff load". The European or ULC standard sets this load at 400,000 lbs, compared with 800,000 lbs for the United States and Canada. This has a major bearing in the structural design of the trainsets.

HSR trainsets must, at some point, particularly in urban areas, share tracks or right-of-way with conventional rail. Because of this situation, there must be some commonality in the standards. After discussion with the manufacturers, Transport Canada and the Federal Railway Administration of the United States federal government, the following conclusions were reached:

- FEASIBILITY OF ADAPTATION TO NORTH AMERICAN VEHICLE STANDARDS. The builders of the rolling stock for the two representative systems, ABB and Bombardier, committed themselves to meeting those standards. This would require changes in the TGV power car and the X-2000 power car, coach and driving trailer. Such adaptations appear feasible.

- FEASIBILITY OF MODIFYING OTHER EXISTING REGULATIONS. The prospects for compliance appear encouraging in the Canadian context, where Transport Canada's Safety Group has been emphasizing performance-based standards and pragmatic resolution of safety issues rather than specifying detailed standards and practices.

- AT-GRADE CROSSING REQUIREMENTS. On the new high speed lines built in Japan and Europe, there are no at-grade road-rail crossings. In Sweden, the X-2000 does operate at speeds up to 200 km/h on existing lines with grade crossings. As explained later in this report, it was decided that all new lines would need to be completely grade separated from crossing traffic. For operation on existing lines, some grade crossings may be permitted, but with track speed limits of 200 km/h or less and with increased levels of crossing protection.

- NON-REGULATORY RULES AND PRACTICES. At issue are differences in operating rules and practices between Canadian and foreign HSR operators. The review encompassed train crewing, maintenance practices and general skills requirements. The main conclusion was that, while there remain significant differences in operating philosophies, VIA Rail has been taking measures that have narrowed the gap between Canadian and offshore productivity and that there should not be insurmountable problems in operating HSR services in Canada.

Adaptability to Canadian Climatic Conditions

Canadian climatic conditions will affect infrastructure design and construction, as well as achievable system performance. Principal issues include the effects of ice and snowfall on the limits of safe operation and on the behaviour of tracks, vehicles and electric overhead, signalling and control systems.

No HSR system has been designed or currently operates at speeds of over 200 km/h in climatic conditions comparable to those in Canada. Such conditions include freeze - thaw cycles, extremely low temperatures (-50°C) wide temperature variations either daily or seasonally, freezing rain, wet snow, large accumulation of snow or ice, and others. These conditions may affect not only the operations and speeds but also the infrastructure design.

In France, there is practically no tolerance for vertical movement of the HSR tracks. This is significantly different from Canadian rail or road conditions.

The major challenge remains in the design and construction of stable track structures under the demanding freeze-thaw and geotechnical conditions found in the Québec-Windsor Corridor. A comprehensive design review for Corridor climatic conditions should be integral to the development of an HSR system in Canada.

Research and Development Status

A review of current research and development related to the representative technologies was undertaken to identify activities that have the potential to reduce capital costs and to improve cost effectiveness and efficiency in the Canadian context. The findings of this review are relatively optimistic with respect to the representative technologies themselves, but less so with respect to the infrastructure. There is a rather broad range of corridor-specific, regulatory and institutional issues that will have to be resolved before any of the candidates' technologies can be deployed and operated in the Québec-Ontario Corridor. Accordingly, it is clear that there is important R&D work that could contribute to the successful transfer of these technologies. The areas where R&D appears necessary are:

- subgrade and track structure stability;
- adhesion management (wheel/rail);
- cost efficiency;
- improvement in design of grade-separation structures;
- optimization of catenary and pantograph designs for Canadian conditions;
- investigation of active pantograph control strategies and techniques;
- impacts during construction, common to any major linear facility project; and
- impacts during operation, such as noise and vibration, electromagnetic fields and increased traffic noise and congestion in the vicinity of stations and terminals.

Most active R&D initiatives affecting HSR in general and the two representative technologies in particular do not target areas of particular relevance to Canada. The current initiatives in France focus almost entirely on adding capacity and increasing performance, which may well improve the financial returns for additions to the existing network by providing better-positioned transportation products, but generally do not address these issues. In Sweden, there is quite a broad range of R&D projects that have either been recently completed or are ongoing.

Specific Issues

- PERSONS WITH SPECIAL NEEDS. Canadian policy states that all modes of transportation should be accessible to all travellers including seniors, persons with disabilities, strollers, etc. The representative technologies as implemented in Europe do not meet all these objectives. HSR services in the Québec-Windsor Corridor would be fully accessible. High-level platforms would be used at stations and terminals to eliminate any need for wheelchair lifts.

- FEASIBILITY FOR LIGHT FREIGHT. The movement of light freight on HSR lines and/or on HSR trains, as done in the U.S., France and Germany, appears to offer potential for revenue enhancement with little marginal cost to HSR operations. Such services are offered in separate cars of passenger trains or in dedicated trains.

- COMPATIBILITY OF INFRASTRUCTURE WITH FUTURE GENERATIONS OF TECHNOLOGY. HSR technology is not static. Improvements are continuously being made. Each of the candidate technologies and the characteristics used in the study was examined to ensure that the infrastructure standards would be compatible with future generations of equipment. It was found that basic physical compatibility is not an issue; however, the ability to fully exploit performance improvements will be. For example, the "representative" alignment for the 200-250 km/h family has been laid out for 250 km/h curves. The next generation of X-2000 rolling stock will be developed for 250 km/h, and further developments are possible. Similarly, the 300 km/h design speed of the current version of the TGV does not represent the ultimate speed limit. In fact, the next generation of TGV is designed to operate at commercial speeds of 350 km/h. Germany's ICE is designed to operate at 280 km/h. The design of any HSR system should not preclude future upgrading.

- HSR RELIABILITY. The representative technologies exhibit a very high level of operational reliability, backed up by systematic preventive maintenance that is intensive by North American standards. As a first-order indicator of system reliability, 97% of TGVs operating on dedicated tracks in France arrive on time, as do more than 95% of the X-2000s.

Conclusion

Two types of high speed technologies were selected for further analysis for potential application in the Corridor, a medium fast (200-250 km/h) technology incorporating tilt-body features and a very fast (300-350 km/h) technology without tilting capability.

3

Routing and Infrastructure

Scope and Results

None of the studies previously conducted has been conclusive as to the most appropriate routing. Estimates have been questioned and none has really addressed the constraints and difficulties of building and maintaining HSR tracks in the Canadian environment.

The objective of this study was to examine alignment options and station locations in order to identify those routings that offer high commercial speeds, lower capital costs and better market penetration while taking maximum advantage of the attributes of the technologies. **Representative routes** were developed to provide the basis for analysis of capital and operating costs, operating characteristics and other impacts of HSR systems in the Corridor. The intent was also to compare the costs of using existing right-of-way versus new corridors.

A representative route for these corridors is a route or alignment selected because it incorporates physical design attributes consistent with the technical criteria and represents a potentially cost-effective, environmentally acceptable solution.

A two-phased approach including a multi-criteria comparative evaluation led to the selection of three types of routes on which more detailed analysis was completed for the purpose of cost estimation:

- corridors making maximum use of existing railway trackage or right-of-way for the 200 km/h scenario;
- corridors making maximum use of existing railway trackage or right-of-way (ROW) for the 300 km/h scenario; and
- corridors made up largely of completely new right-of-way outside major urban centres for the 300 km/h scenario (green field scenario).

The findings of a comparative analysis of the three types of routes led to the development of two composite representative routes made up of a combination of optimized segments. Significant capital cost savings where achieved by accepting design speed reductions in a few locations where they did not significantly increase travel time.

Figure 3.1 presents the routes for both technologies. Table 3.1 describes these routes.

The 1,228 km route for the 200 km/h technology is composed of 32% or 400 km of new ROW and the balance of existing rail ROW. It was assumed that 450 km (37%) of ROW could be shared and that 378 km (31%) of ROW would be acquired specifically for HSR use.

The 300 km/h route has 1,235 km of trackage. The station-to-station distances add up to 1,251 km because 16 km of line between Laval and Montréal are included in both the Québec/Montréal and the Ottawa/Montréal sections. The new trackage is estimated at 650 km (52%) and 317 km of existing ROW would need to be acquired. The remaining 288 km (23%) of ROW would be shared.

The following presents a brief description of the routes and the differences between the 200 km/h and 300 km/h scenarios.

Windsor-Toronto

From Windsor the existing CP Rail routing is used on the assumption that the CP Rail freight can be consolidated on other rail lines in the area. In London, the 300 km/h routing uses a new suburban routing around the city with a suburban stop. The 200 km/h line includes a routing through the city on existing right-of-way with a station in the vicinity of the former CP station.

Figure 3.1 - Québec - Ontario HSR representative routes

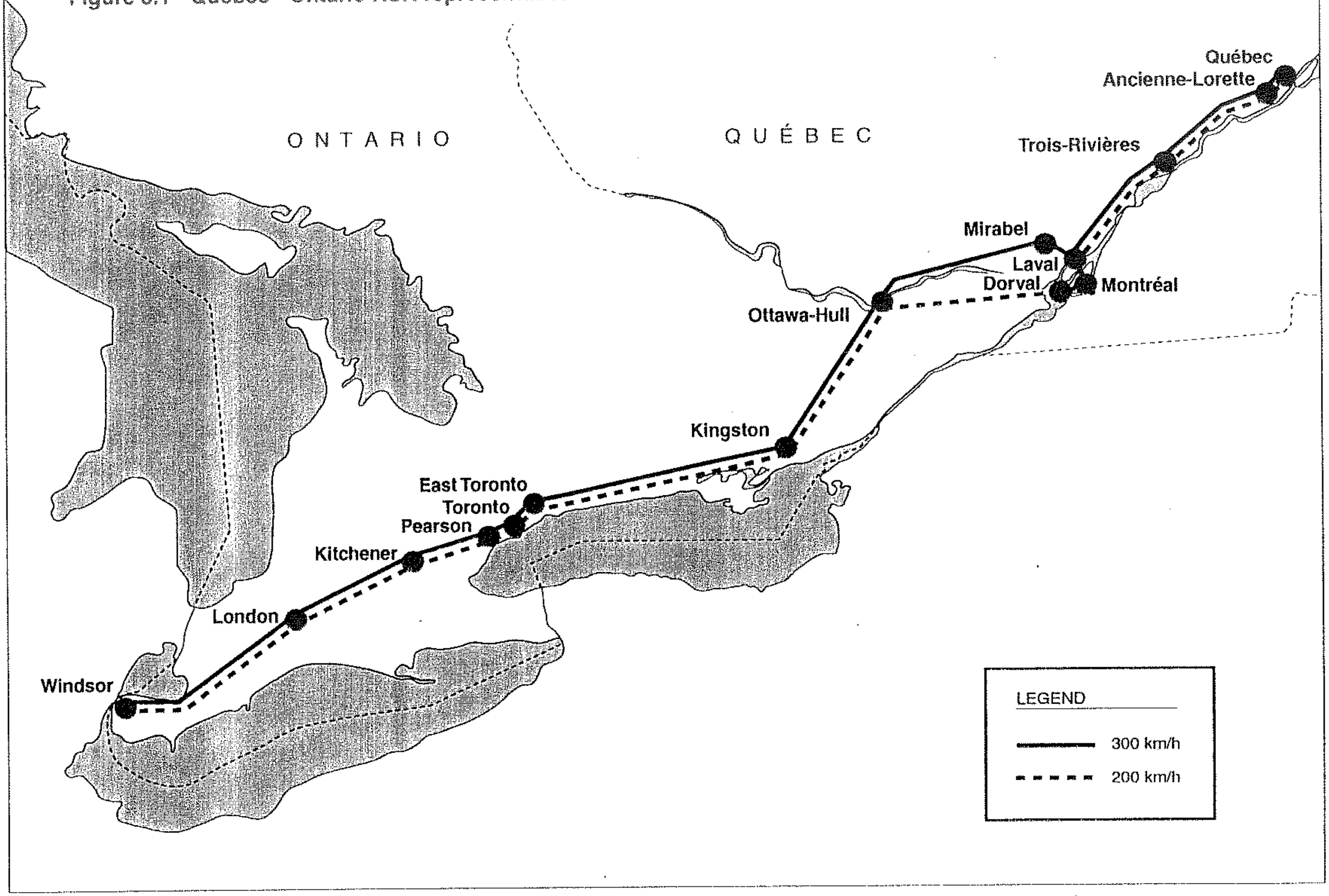


Table 3.1 - The base case routes

Route Section	200 km/h Route		300 km/h Route	
	Length (km)	*Description*	*Length (km)*	*Description*
Windsor - London	184	Existing rail route	193	Existing rail route
London - Toronto	185	New route	181	New route
Toronto - Kingston	257	Toronto-Napanee: existing Napanee-Kingston: new	259	Toronto-Cobourg: existing Cobourg-Kingston: new
Kingston - Ottawa	152	New route	152	New route
Ottawa - Montréal	177	Existing right of way to Rigaud. Existing rail route to Montréal	194	Existing rail routes with new section through Mirabel
Montréal - Québec	273	Existing rail route	272	Existing rail route
Total - Station-to-Station	*1,228*		*1,251**	
Total - Trackage	*1,228*		*1,235*	

* 16 km of line between Laval and Montréal are included in both Ottawa-Montréal and Montréal-Québec sections.

Toronto-London

Between London and Toronto, both routes follow a new alignment that passes between Kitchener and Cambridge. This new routing continues to the proximity of Pearson Airport. From this point an existing CN alignment is followed to Toronto Union Station.

On this section, the candidate routes included a line via Dundas (passing close to Hamilton) and lines that passed through the Grand River towns area (Kitchener/ Waterloo, Cambridge and Guelph). Ridership analyses indicated that ridership potential is slightly higher for the latter routing. It is anticipated that Hamilton will be connected to Toronto by a frequent rail service operated by GO Transit so that passengers can quickly connect to HSR services. In addition, the routing via the Grand River towns would pass near L.B. Pearson International Airport at Toronto, offering the possibility of a considerable number of passengers connecting between HSR and air services (connect-air). Accordingly, it was decided that the routes for both representative technologies would use the more northerly corridor to reach Kitchener.

Montréal-Toronto

Based on the results of the Ontario-Québec Rapid Train Task Force and other studies, a single spine routing with trains between Montréal and Toronto passing through Ottawa was adopted. This avoids the duplication of infrastructure associated with the present VIA route structure where separate Montréal-Ottawa-Toronto and Montréal-Toronto routes are operated. However, it does add approximately 40 km to the Montréal-Toronto routing, but with top speeds of 200 km/h to 350 km/h, this would only add between 15 and 7 minutes to the through journey compared with a more direct routing.

Toronto-Kingston

Out of Toronto both alignments follow the existing CN right-of-way. For the 300 km/h technology, the routing leaves the CN line near Cobourg and follows a new alignment to the north of Highway 401. The 200 km/h follows the existing CN right-of-way approximately up to Napanee. This routing then follows the 300 km/h route on a new alignment.

Kingston-Ottawa

A new alignment is used by the routes for both technologies up to Smiths Falls. From Smiths Falls to Ottawa, the existing CN right-of-way is followed to Ottawa.

Ottawa-Montréal

Between Ottawa and Montréal, the two alignments are completely separate. The base 300 km/h routing follows the north shore (of the Ottawa River) and travels via Mirabel airport and Laval to Montréal (using the existing Mount Royal Tunnel). The 200 km/h routing follows the M and O subdivision (owned by VIA), on the south shore of the Ottawa River and an existing rail corridor on Montréal Island next to Dorval Airport, ending at Central Station. In addition, a 300 km/h technology scenario was analyzed on the 200 km/h south shore routing between Montréal and Ottawa to find its cost and ridership implications. Other routes are possible and have not been fully examined due to the scope of this study. For example a route serving Mirabel and then crossing to Ontario further is possible and was studied in the initial phases of the routing study. Further work would be necessary, particularly in this request, to make a final choice.

Québec-Montréal

Between Québec and Montréal, the route on the north shore of the St-Lawrence was preferred due to the availability of the existing CP Trois-Rivières subdivision, the larger market at Trois-Rivières, no crossings of the St-Lawrence River and potentially lesser environmental impacts. Both routes use the CN Mount Royal Tunnel and a new connection to the CP line through Laval and then follow the CP line along the north shore (of the St. Lawrence River) to Québec. There are minor differences between the two routes in the extent of improvement to the routes in the Trois-Rivières area.

Stations

Potential station locations were defined in order to estimate travel times and for use in the estimation of ridership and revenue. The criteria used were as follows:

- the need to provide access to HSR services in areas with potential to generate significant revenues for HSR services;
- a desire to provide stations in urban areas with convenient inter-modal connections to the road system and to local urban transit systems; and,
- the need to limit the number of stations in order to improve end-to-end travel times.

Since, in all cases, existing railway routes were used to enter the major cities, the trains would not be travelling at very high speeds along these segments, it was believed that suburban stations would be desirable in the larger metropolitan areas to provide easier automobile access to HSR service. They would also provide more direct access to large areas of the suburban portions of the metropolitan regions.

The potential HSR routes are adjacent to three major airports, Dorval or Mirabel in the Montréal area and Pearson in the Toronto area. Initial ridership projections suggested that the potential for ridership to and from these airports would be substantial. It was therefore assumed that stations at or close to these airports should be provided, and that, in the case of Dorval and Pearson, they would also be used by suburban transit.

Based upon this rationale, the following station locations were developed:

- Québec downtown, located at the existing Gare du Palais station;
- Québec West in the Ancienne-Lorette area;
- Trois-Rivières;
- Laval in the northern Montréal suburbs;
- downtown Montréal at Central Station;

- on the south shore routing (200 km/h route) adjacent to Dorval Airport, in the Montréal western suburban area. On the base 300 km/h routing via Mirabel, westbound trains would stop at Laval and at Mirabel Airport;
- in the Ottawa-Hull area, on the 200 km/h routing, there would be one stop at the existing station. On the 300 km/h routing, a new station could be located either in Hull or south of the river in Ottawa proper;
- in or near Kingston;
- Toronto suburban east;
- Toronto downtown at the existing Union Station;
- adjacent to L.B. Pearson International Airport in the Toronto west suburban area;
- in the Kitchener/Cambridge area;
- London; and
- Windsor.

In the Windsor area the route and station location were developed so that trains could ultimately travel through to Detroit and link up with potential HSR corridors in the U.S. although the potential impact of this enhancement was not included in the scenarios analyzed in this project.

Design Standards

The routes were developed on the basis of infrastructure design standards for each of the two families of technologies.

Alignment

The design standards for alignment were developed assuming ultimate maximum operating speeds of 250 km/h for the tilting train technology and 350 km/h for the non-tilting technology. The design standards for horizontal curve radii were 2,000 m or more for the 200-250 km/h technology and 6,000 m or more for the 300+ km/h technology. With respect to grade, the same standards were used for both technologies: a desirable grade would be 2% or less with a maximum of 3.5%; in the future, with new generations of rolling stock, up to 5% might be permissible.

These design standards were used in the development of new routes except where full adherence to these standards would result in unacceptably high capital costs, or where trains would be operating at lower speeds in any case, for example, on alignments approaching station stops in urban areas. Table 3.2 gives an indication of the distances required to accelerate from stops or to decelerate from higher speeds.

Table 3.2 - Accelerating and decelerating distances

Technology	*Distance to Reach* 200 km/h	*Distance to Reach* 300 km/h	*Distance to Stop from* 200 km/h	*Distance to Stop from* 300 km/h
Tilting 200 km/h	5 km	N/A	3.8 km	N/A
Non-Tilting 300 km/h	5.2 km	16 km	4 km	9 km

Track Structure

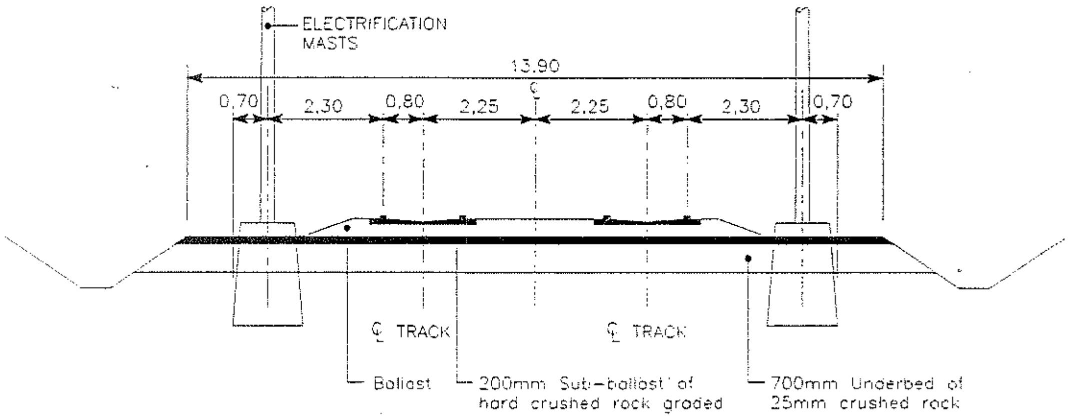
Investigation of current HSR track structures in Europe has revealed that, for new construction, there are virtually no differences in the basic track structure for the two technology families. In developing the infrastructure requirements for each technology, a typical arrangement of track structure elements has been developed based on information and drawings provided by Swedish and French HSR authorities. Figure 3.2 illustrates the track structure standard adopted with a minimum spacing of 4.5 metres between center lines of track. The track infrastructure should be a 13.90 metres.

Routing Issues

As potential corridors were examined, there were a number of issues that had to be addressed in developing actual routes. Most of these issues had to do with the extent to which HSR trains could use existing tracks and/or existing rail corridors rather than constructing entirely new lines. Much of this discussion centered around safety issues. Resolution involved extensive discussions by project staff with representatives of the Rail Safety Group of Transport Canada as well as meetings with the Federal Railway Administration (FRA) in Washington, D.C. to ensure conformity with North American standards and practices.

It was established that, for the Canadian application, each representative technology could be modified to achieve equivalence with existing

Figure 3.2 - **Typical HSR cross-section**
(meters)



FRA regulatory standards and industry practices as defined by the AAR (Association of American Railroads). This removed technology compatibility as a major factor in establishing right-of-way requirements and safety measures for shared track or shared right-of-way operation.

The same assumptions were made for both technology families in the various right-of-way scenarios since their basis is not related to technology but primarily to operating speed. This approach leads to the definition of specific infrastructure scenarios for use along the highspeed rail routes associated with an acceptable operating speed range. These scenarios and the basis for their application are outlined in the following subsection.

High Speed Rail Sharing Existing Track With and Without Special Conditions

The sharing of existing, well-maintained track by high speed rail services with conventional commuter or freight service, without any special reconstruction or operating and maintenance conditions was assumed to be acceptable provided the maximum operating speed for the high speed rail service would not exceed 160 km/h.

In a track-sharing operation scenario where high speed trains would exceed 160 km/h, it has been assumed that improvement of the existing trackage would be necessary and special operating conditions would be applied. The improvements and special conditions would relate to track construction, maintenance and inspection, signalling and train control, training and operating procedure. Based on the guidelines developed during the study, the maximum acceptable operating speed for high speed trains would be 200 km/h under these conditions.

High Speed Rail Using Existing Rail Right-of-Way

The next question to be addressed was whether dedicated HSR tracks could be included in existing railway right-of-way. Sharing a right-of-way implies accepting the costs for resolution of issues such as:

- maintaining rail access to adjacent industrial customers;
- grade separation of both high speed and conventional tracks at existing level crossings;

• construction of high speed tracks next to an operating railway; and

• relocation of existing conventional tracks to accommodate high speed tracks within the right-of-way, if land acquisition is to be avoided.

If new tracks dedicated to HSR are assumed to be placed at the minimum practical spacing of 4.5 metres, the nearest existing track would have to be diverted or closed during construction. The electrification catenary structure would have to span all tracks. Fencing could not be placed between tracks. This minimum spacing scenario would only be adopted in areas where widening of the right-of-way is constrained, or if land acquisition was very costly.

Safety and operating considerations led to the conclusion that, as with track sharing, the speed of high speed rail trains should be limited to 200 km/h on sections where additional spacing between conventional and HSR tracks is not provided.

The discussions concerning safety of high speed rail operations and the review of track separation practices employed on European and Japanese systems show that, if higher speeds are to be permitted, a minimum track separation between tracks used by conventional trains and those used by HSR of 9-10 metres would be advisable.

Applying the above assumptions for speeds above 200 km/h to the existing right-of-way in the corridor shows that sharing of this right-of-way (typically 30 metres wide) is feasible only by relocating existing single or double tracks to one side or by assuming significant widening of the right-of-way. While track relocation could be achieved in specific locations in urban areas, extensive relocation of track in rural right-of-way with many existing structures and high freight traffic volumes is not considered practical.

Given that new dedicated HSR tracks need to be located about 9 to 10 metres away from the center of existing tracks, there would hardly be any room left in an existing right-of-way for the HSR tracks. Consequently, new right-of-way would need to be acquired from adjacent land owners. Sharing right-of-way to this limited extent is therefore considered of marginal benefit because the operational issues and institutional complications associated with a sharing arrangement will likely offset any saving in land acquisition costs. Hence, freight traffic relocation and outright acquisition of the right-of-way are the only feasible solutions.

High Speed Rail Adjacent to Existing Rail Corridors

This scenario represents the case where sharing or acquisition of an existing right-of-way is not considered practical for the reasons discussed previously but where the high speed rail right-of-way would share an existing corridor in order to mitigate the impacts of establishing a new rail corridor. Generally, this is best achieved by developing a high speed right-of-way alongside the conventional rail right-of-way, thereby reducing environmental impact. However, there could be situations where the existing adjacent land use makes it more desirable to place the high speed rail right-of-way farther away from the existing corridor, particularly in urban areas.

A contiguous right-of-way arrangement assumes a new 40-50 metre high speed right-of-way alongside a typical 30 metre existing right-of-way. This arrangement avoids the institutional and operational complications of a shared right-of-way scenario and would not carry the cost premiums normally associated with construction close to an existing operating railway. The resulting separation between tracks is in the 30 metre range.

Road Crossings of High Speed Rail Right-of-Way at Grade

Extensive discussions on this matter with the Transport Canada Rail Safety Group led to the adoption of the following assumptions:

• existing at-grade crossings with present levels of protection could be permitted in areas where high speed trains will operate at speeds up to 160 km/h;

• existing at-grade crossings with improved protection could be acceptable in areas where high speed trains will operate at speeds up to 200 km/h;

- no form of at-grade crossing will be permitted in areas where the speed of trains will exceed 200 km/h; and
- new at-grade crossings of high speed rail right-of-way remote from existing crossings will not be permitted, regardless of operating speed.

The application of these assumptions led to the identification of 471 grade separations and 100 rural two-lane roads to be closed, between Québec and Windsor for the 300 km/h scenario.

Definition of Scenarios

The routing and technology studies led to the definition of the various scenarios that were to be carried forth to the various analyses. Table 3.3 presents these scenarios, followed by a brief description.

The following chapters present the results mainly for the base case scenarios and for the Montréal-Ottawa-Toronto scenarios, 200 km/h via Dorval and 300 km/h via Mirabel. Financial results of all scenarios have been developed and are presented. Any information that may help to differentiate a scenario is also presented.

Although all scenarios were analyzed for the 2005 and 2025 horizon years, results for 2005 only are provided unless more detailed information is valuable for decision making purposes.

Base Scenarios

Initially, three base scenarios were identified for the full corridor. The study was to evaluate the 200 km/h and 300 km/h technologies using existing rail right-of-way as much as possible and a 300 km/h "green field" scenario. In fact, the routing study showed that neither the full "green field" nor the exclusive use of existing right-of-way scenarios was the most practical, efficient and cost-effective option. The most representative or realistic were combinations of the new and existing right-of-way scenarios. It also became apparent that the design criteria and the cost of the infrastructure for the two technologies were similar.

This is why for most of the Corridor, the representative routes are very similar for both technologies. The access to Montréal either through Mirabel or through Dorval differentiates these scenarios.

Table 3.3 - Routing Scenarios

Base Scenarios	
QW-M-300	Québec to Windsor, through Mirabel, 300 km/h
QW-D-200	Québec to Windsor, through Dorval, 200 km/h
Montréal-Toronto	
MOT-M-300	Montréal-Ottawa-Toronto (to Pearson Airport), through Mirabel, 300 km/h
MOT-D-200	Montréal-Ottawa-Toronto (to Pearson Airport), through Dorval, 200 km/h
Alternative Services	
QW-D-300	Québec-Windsor, through Dorval, 300 km/h
MOT-D-300	Montréal-Ottawa-Toronto (to Pearson Airport), through Dorval, 300 km/h
MOT-D-300-NA	Montréal-Ottawa-Toronto (to Union Station), through Dorval, 300 km/h, no airport services
Québec-Toronto	
QT-M-300	Québec-Toronto (to Pearson Airport), through Mirabel, 300 km/h

Two base scenarios have therefore been identified.

- QW-M-300: Québec-Windsor running at 300 km/h through Mirabel;
- QW-D-200: Québec-Windsor running at 200 km/h through Dorval.

Because of higher ridership on the central section, the study of an HSR operating exclusively from Montréal to Ottawa and Toronto (MOT) was deemed necessary. Therefore results of the demand forecasts, operating plans and various analyses and impact studies were requested for this scenario. It was decided that this MOT stand alone scenario was to include the segment from Toronto Union Station to Pearson Airport as this is considered an essential link.

Two other scenarios, using the same route as the full corridor, were thus studied:

- MOT-M-300: Montréal - Ottawa - Toronto running at 300 km/h through Mirabel;
- MOT-D-200: Montréal - Ottawa - Toronto running at 200 km/h through Dorval.

Alternative Services

To evaluate the impact of serving airports, some additional variants were defined. Because the route through Dorval was slightly shorter and could therefore attract more passengers, it was decided to evaluate the possibility of operating the 300 km/h technology on the 200 km/h route between Montréal and Ottawa. The geometry is practically the same for both routes. Some adjustments in costs were made for grade separations.

Furthermore, the Montréal-Ottawa-Toronto segment was evaluated with and without the link to Pearson Airport for the 300 km/h case going through Dorval. Three other scenarios were therefore identified.

- QW-D-300: Québec-Windsor running at 300 km/h through Dorval;
- MOT-D-300: Montréal - Ottawa - Toronto (Pearson Airport) running at 300 km/h through Dorval;
- MOT-D-300-NA: Montréal-Ottawa-Toronto running at 300 km/h through Dorval but stopping at Union Station in Toronto.

The ridership, operating and infrastructure costs were adjusted to reflect the conditions of each scenario.

Québec-Toronto

The operating, capital and infrastructure costs were developed for this scenario only for the 300 km/h base case route via Mirabel. It was carried through to the financial analysis but the other impact studies were not carried through due to time and budget constraints. It was also analyzed in the cost benefit analysis. The identification used for this scenario is QT-M-300.

250 km/h and 350 km/h

Because the technologies were evolving, it was decided to obtain the basic information relative to the operating costs and ridership associated with running at 250 and 350 km/h. This information was not carried through to other studies but is available for future reference.

Conclusion

The present study, which constitutes the most intensive analysis of civil costs routing of HSR in corridor, did not define final routes for HSR but only "representative" routes. This was required to carry out more detailed system cost estimates, trip times and revenues projections. As would be expected, more study would be needed on routing, for example between Montréal and Ottawa. Options such as a route serving Mirabel and then crossing over to Ontario further west was not studied in detail.

The above mentioned scenarios provide a reasonable scope of scenarios to undertake the financial and economic analysis.

4

Ridership and Revenue

Scope and Results

The development of reliable passenger and revenue forecasts for High Speed Rail services in the Québec-Windsor Corridor is a fundamental requirement for decision making on the viability of the project. The methodology for developing the forecasts included an extensive analysis of the existing supply of transportation services and their usage by passengers in the Québec-Windsor Corridor and extrapolation of these trends to the future. Models were then developed to examine potential diversions to HSR and the possible development of new additional trips prompted by the existence of HSR. This chapter describes the assumptions and methodology that went into the forecasting effort, as well as the results.

The Steering Committee made two key decisions with respect to demand forecasting:

- three different approaches to forecasting were used and three demand forecasting consultants were retained: Sofrerail, Charles River & Associates (CRA), Transportation Economics and Management Systems Inc. (TEMS). The intention was to compare the results achieved using the different techniques and forecasters and, through comparison and reconciliation, to achieve a greater understanding of potential demand. The U.S. High Speed Rail Association guidelines for demand forecasting also recommend that a variety of approaches be used for demand forecasting. The Australian Very Fast Train project adopted a similar approach, using three different forecasting consultants;
- an extensive survey effort was undertaken in different seasons to find how the composition and volume of passenger flows vary over the year on existing modes of transportation. This was conducted in response to the perceived deficiencies of previous data collection efforts in the Québec-Windsor Corridor, which were limited to a single season.

This process resulted in the development of forecasts of ridership and passenger revenues, shown in Table 4.1, for the two base scenarios:

Table 4.1 - Ridership and revenue forecasts, 2005

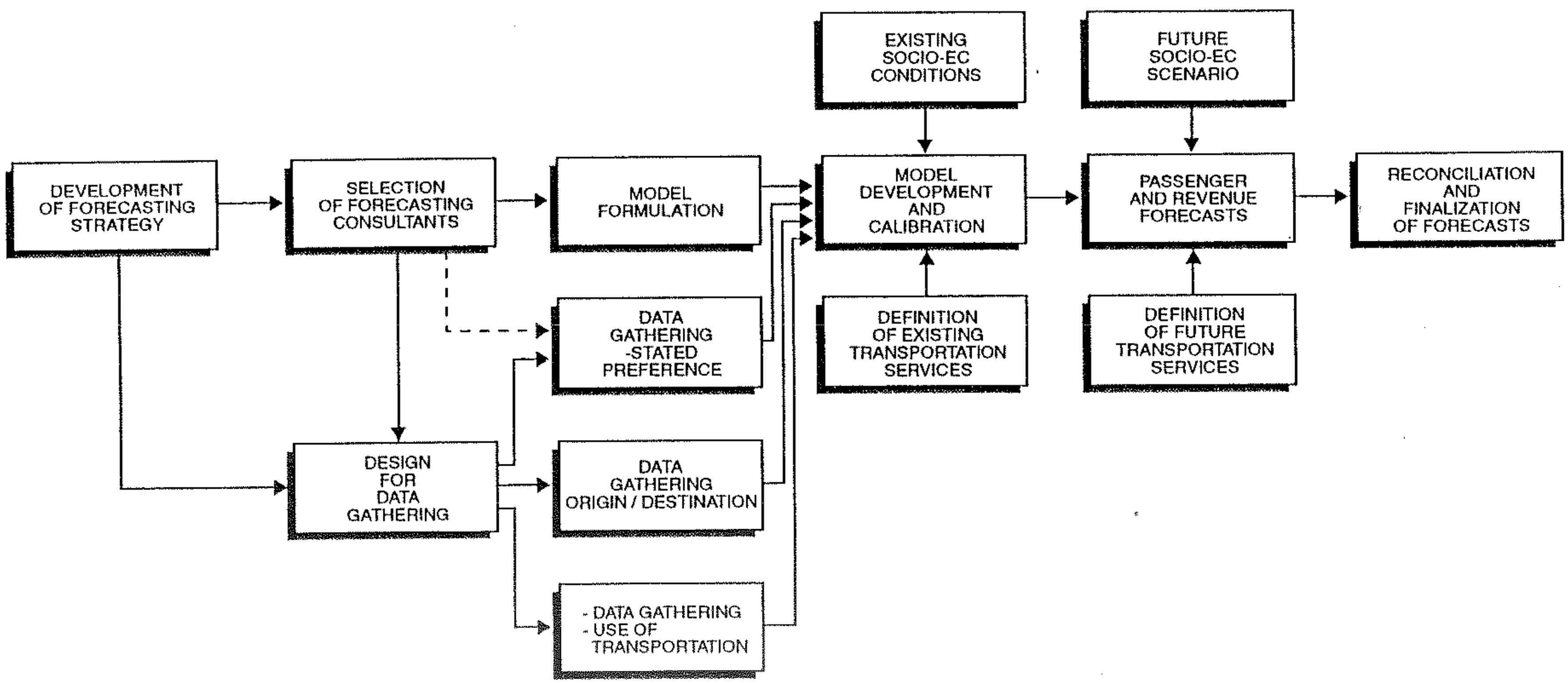
	QW-D-200	*QW-M-300*
Annual Passengers (thousands)	10,065	11,867
Revenues ($1993 millions)	694	887

Overall Strategy

Figure 4.1 shows the overall strategy used for the development of the passenger forecasts. Some notable points with respect to this process are:

- the forecasting consultants were retained early in the process so that they could provide input to the data collection process;
- the gathering of data on existing travel habits (the "origin/destination" surveys) was much more extensive than in any previous project in the Corridor;
- in addition, information on potential consumer responses to HSR ("stated preference" surveys) was collected;
- the three forecasting consultants used the same input assumptions and the same base data on travel characteristics;
- the forecasting consultants were each asked to develop an HSR fare structure that would maximize fare revenue; and

Figure 4.1 - Québec-Ontario HSR project overall market analysis strategy



• the structures of the models developed and the results achieved were compared. From this comparison, a final set of forecasts was developed.

Existing Transportation Supply

The Québec-Windsor Corridor includes the national capital, two provincial capitals and six of the ten largest metropolitan areas in Canada (Toronto, Montréal, Ottawa, Québec, Hamilton, Kitchener and St. Catharines-Niagara).

Highway Network

The cities in the Corridor are served by an extensive intercity highway system. All major cities are linked by freeways with one exception: there is no continuous freeway route between Toronto (and other points to the west) and Ottawa, although such a link is proposed by the Ontario Ministry of Transportation (MTO).

The freeway network provides a high level of service and recurring congestion is very limited except during peak periods in the two major conurbations within the Corridor, Toronto and Montréal.

Public Modes

Intercity bus services are operated on the highway network by a variety of carriers. Weekday frequencies are summarized in Table 4.2. The frequencies between major cities shown in Table 4.2 show only express runs with limited intermediate stops. In addition, there are local runs that operate on major routes providing access to smaller communities.

An extensive network of air services is also provided, mainly by Air Canada, Canadian Airlines International and their regional affiliates. The frequency of air service is also summarized in Table 4.2. In addition, there are several smaller airports in the region where scheduled and non-scheduled services are available.

VIA Rail Canada Inc. operates intercity passenger rail services along the length of the Corridor. The frequency of service is given in Table 4.2. The most intensive services are offered in the Montréal-Ottawa-Toronto triangle. Rail speeds have been improved in recent years so that the current fastest travel times are:

- Québec-Montréal 2h 42m
- Montréal-Toronto 3h 59m
- Montréal-Ottawa 1h 59m
- Ottawa-Toronto 4h 02m
- Toronto-London 1h 47m
- Toronto-Windsor 3h 35m

Table 4.2 - Public modes in the Québec-Windsor Corridor
Summer 1994 daily one-way frequencies (weekdays)

O/D Pairs	Bus	Air	Rail
Québec-Montréal	16	24	4
Montréal-Ottawa	22	15	4
Montréal-Toronto	9	44	6
Ottawa-Toronto	7	40	4
Toronto-London	13 via Hamilton 6 direct	18	5 via Brantford 2 via Kitchener
Toronto-Windsor	5	11	4

Characteristics of Existing Travel in the Corridor

Previous surveys of travel in the Québec-Windsor Corridor were undertaken in 1969 and 1988. The Ontario/Québec Rapid Train Task Force found some inadequacies in the 1988 survey, in that it covered only one season of the year and that not all the public mode carriers participated in the survey. It was therefore decided that this project would include a new collection of data on travel patterns in the Québec-Windsor Corridor. Two types of surveys were commissioned:

• origin/destination studies, which examined the current characteristics of travel in the Québec-Windsor Corridor including trip purpose, party size, and choice of modes;

• stated preference surveys, which asked passengers questions about tradeoffs between modal characteristics such as travel times, fares and frequencies. These were designed in coordination with the forecasting consultants and were based on a much smaller sample.

Origin/Destination Surveys

The purpose of the origin/destination (O/D) surveys was to establish the characteristics of travellers on the four modes of transportation available within the Québec-Windsor Corridor: the air, rail and bus common carrier modes and the private automobile. Generally, the travellers were asked the same questions for all modes: the origin and destination of each trip, the party size, the socioeconomic characteristics of the travellers and additional information on the trip itself including access modes used and access time and costs at either end of the trip. All public mode carriers and ministries of transportation within the Corridor cooperated in the survey.

The survey methodologies used differed somewhat by mode, in the following aspects:

- for the rail and bus modes, interviewers travelled aboard the vehicles. Self-administered questionnaires were handed out and collected by the interviewer. The interviewers were available to assist in answering any questions. Passengers on 234 trains and 162 bus runs were interviewed;
- for the air mode, interviewers entered the departure lounges. Self-administered questionnaires were handed out. As many as possible were collected after completion in the departure lounge. In addition, an equivalent number of mail-back questionnaires were handed out to late-arriving passengers. Passengers on 322 flights in the Corridor were interviewed;
- for the auto mode, licence plate numbers were recorded at ten locations in Ontario and Québec. The registered owners of the vehicles were traced through the licence records of the two provinces and of the states of Michigan and New York. Questionnaires were then mailed out, asking for details of the specific trip on which the automobile was observed. Only trips longer than 50 kilometres were subsequently coded.

In response to the limitations of earlier data collection efforts that measured travel behaviour in the Québec-Windsor Corridor, it was decided to analyze travel patterns for all seasons of the year. Consequently, three waves of surveys were undertaken:

- in August of 1992 to measure summer travel behaviour;
- in October/November of 1992 to represent both the spring and the fall seasons; and
- in January of 1993 to represent winter behaviour.

The largest previous O/D survey conducted in the Corridor took place in 1988. It was sponsored by VIA Rail. The number of completed surveys from that previous survey and the current project are outlined in Table 4.3.

Table 4.3 - O/D survey interviews by mode

	VIA 1988	*HSR 1992/93*
Air	4,317	12,393
Rail	6,721	13,696
Bus	862	9,152
Auto	9,285	26,227
Total	*21,185*	*61,468*

As the surveys were being conducted, information was collected on the total volumes of travellers for each mode within the Corridor. This information was then used to expand the samples to the universe of travellers within the Corridor.

Results of Origin/Destination Surveys

The total passenger market in the Corridor encompasses some 109 million person-trips per year. The auto (trips 50 km and more) accounts for 99 million. The most used public mode is air (4.1 million person trips), followed by rail (2.9 million) and bus (2.6 million).

Table 4.4 shows some characteristics of travel in the Corridor, based on the expanded results of the surveys. Table 4.5 presents some travel characteristics between specific city pairs. Some general observations are:

- auto trips (counting only those 50 km in length or more) account for 91% of the 109 million annual person-trips along the Québec-Windsor Corridor. Currently, rail carries 2.7% of all travellers;

Table 4.4 - Summary of existing travel in the Québec-Windsor Corridor

	MODE				
	Total	*Auto*	*Air*	*Rail*	*Bus*
Total Person Trips (auto trips 50km in length or more - millions of trips).	108.6	99.0	4.1	2.9	2.6
Share of Trips by Mode	100%	91.2%	3.8%	2.7%	2.4%
Purpose of Trip					
Business	21%	19%	73%	27%	17%
Non-business	79%	82%	27%	73%	83%
Duration of Trip					
Overnight	52%	50%	76%	80%	74%
Average Nights Away	1.9	1.7	5.0	4.2	3.9
Destination					
Within Corridor Area	95%	95%	84%	95%	97%
Other Provinces, Countries, or Northern Regions	5%	5%	16%	5%	3%
Party Size					
Average	1.9	2.0	1.3	1.4	1.2
Per Person Cost Per Trip (one-way)	$22	$12	$233	$50	$36

- non-business travel accounts for 78% of all trips and 95% of this non-business market travels by car;

- rail passengers are likely to be travelling for non-business reasons (73%). This is similar to the profile of bus and auto travellers. Air travel, in contrast, is largely skewed toward business travellers (73%);

- about half the individuals (52%) travelling within the Corridor are on an overnight trip. The average number of days away is 1.9 days. In the case of current rail passengers, 80% are travelling overnight, with 4.2 average number of days away from home;

- some 95% of travellers within the Corridor travel to Southern or Central Ontario/ Québec. Only 5% are bound for other provinces, other countries or northern regions of the two provinces;

- the average party size is typically quite small: 1.9 individuals. It is somewhat higher for auto travellers (2.0) and lower on public modes (within the 1.2 to 1.4 person range).

Table 4.5 shows the information developed for some of the major city pairs in the Corridor.

Forecasting Assumptions

As input for the forecasting process, the consultants used the input assumptions and information on socio-economic and travel characteristics described in the following paragraphs.

Demographic and Economic Forecasts

The first step in the forecasting process was to examine the underlying trends in population, employment and other indicators of economic activity in the Corridor. This was done by the Transport Canada Forecast Group for the various areas of the Corridor and reviewed by both provinces.

Figure 4.2 shows the population and employment forecasts for the sections of the Corridor within Ontario and Québec respectively.

Future Transportation Markets

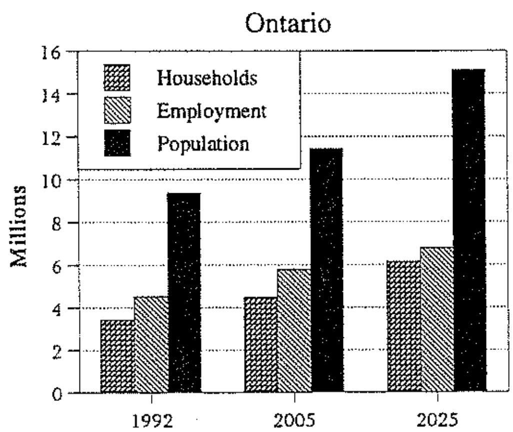
Based upon the socio-economic forecasts and trends in the usage of various modes, projections were made of the likely growth rate of various existing intercity transportation markets in the Québec-Windsor Corridor. These forecasts took into account the likely increase in north-south travel, which is not oriented along the Corridor. The forecasts of annual growth developed (without HSR) were as shown in Table 4.6, as well as the historical growth rates between 1975 and 1990.

Table 4.5 - Characteristics of travel between major cities in the Québec-Windsor Corridor (1992)

	Québec Montréal	*Montréal Ottawa*	*Montréal Toronto*	*Ottawa Toronto*	*Toronto London*	*Toronto Windsor*
Total Person Trips ('000)	6,801	4,509	2,979	2,715	4,541	1,289
Mode Split						
Automobile	91.1%	85.1%	39.9%	63.2%	91.4%	84.6%
Air (Local)	0.7%	0.8%	40.3%	24.9%	0.5%	5.0%
Rail (VIA)	2.1%	4.8%	15.8%	7.4%	4.6%	7.8%
Bus	6.2%	9.3%	4.0%	4.5%	3.4%	2.6%
Trip Purpose						
Business	24.6%	21.2%	47.2%	39.9%	25.9%	23.7%
Non-business	75.4%	78.8%	52.8%	60.1%	74.1%	76.3%
One-way Cost (per person) (in dollars)						
Automobile	13	11	22	18	10	16
Air (Local)	197	138	170	189	107	171
Rail (VIA)	47	38	70	65	32	50
Bus	32	27	52	45	26	42
Average	16	15	90	65	12	27

Source: HSR Corridor Study Travel Intercept Surveys, *Final Report (CCL).*

Figure 4.2 - Population and employment forecasts for the Québec-Windsor Corridor



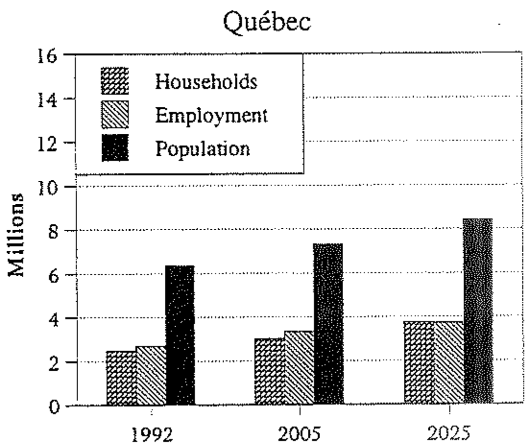


Table 4.6 - Annual growth rates (%)

	1975-1990	1992-2005	2005-2025
Corridor Auto Travel . . .	2.5	2.19	2.10
Corridor Bus Travel	-1.1	0	0
Corridor Air Travel	3.2	2.95	2.58
Corridor Rail Travel	-0.2	0	0

Future Levels of Service on Other Modes

Assumptions were also made about the future levels of service on other modes of travel, with and without the introduction of high speed rail. The main assumptions were:

- for the auto mode, travel conditions would remain essentially as in 1992 except for the construction of a controlled-access highway between Highway 401 and Ottawa between 1992 and 2005, resulting in reduced travel times between Ottawa and points west. Congestion was assumed to have no serious effect on intercity travel during the forecast period. Auto operating and capital costs would not change between 1992 and 2005 but would increase 15% by 2025;

- bus services would remain essentially as available in 1992 except for the impact of the highway improvements expected between Highway 401 and Ottawa. Effective frequencies would remain as in 1992. Fares would decrease to 95% of 1992 levels in 2005 but would return to 1992 levels in 2025;

- air services would remain essentially unchanged from those operated in 1992. There would be no change in real fares between 1992 and 2005 but they would rise to 110% of 1992 fares by 2025 because of increasing fuel costs;

- conventional VIA passenger rail services would be discontinued as the parallel HSR services are introduced. Because of the more restricted stopping pattern of HSR, this would result in the removal of passenger rail services from some intermediate points. It is expected that existing bus services will adjust their capacity to fill the void left from non-HSR via services that would disappear. For segments of VIA service that remain in operation, in the case of construction of partial lengths of the Corridor, running times would improve by 10% by 2005; frequencies and fares would not change.

HSR Travel Times

Three types of train services were foreseen:

- **local trains**, (multiple stops) which serve every station in a sector (i.e. Montréal-Québec, Montréal-Ottawa-Toronto or Southwestern Ontario). The first train in any hour was assumed to be a local train;

- **express trains**, which serve only Québec, Montréal, Ottawa, Toronto and Windsor without stopping at intermediate stations.

- **super express trains**, which operate non-stop between Montréal and Toronto (travel time of 2 hours 18 minutes).

A train performance model was used to analyze the potential running times of trains to provide input to the forecasting of ridership. The resulting estimated running times, including allowances for station stops and slack and recovery times are given in Table 4.7, for the 200 km/h and 300 km/h services .

Table 4.7 - HSR trip times
(Hours and Minutes)

	200 km/h via Dorval		300 km/h via Mirabel		300 km/h via Dorval	
	Express	Local	Express	Local	Express	Local
Québec-Montréal	1:34	1:45	1:12	1:24		
Montréal-Ottawa	0:58	1:02	0:57	1:05	0:46	0:50
Ottawa-Toronto	2:10	2:18	1:36	1:46		
Montréal-Toronto*	3:13	3:25	2:38	2:56	2:26	2:41
Toronto-London	0:58	1:11	0:41	0:58		
Toronto-Windsor	1:56	2:09	1:24	1:39		

* Including stop at Ottawa.

Trains were generally scheduled within the three major segments of the Corridor, Québec-Montréal, Montréal-Ottawa-Toronto, and Toronto-Windsor. Trains running through from one segment to another are also possible as schedules can be coordinated between segments. For the base 300 km/h Québec-Windsor scenario (via Mirabel), passengers travelling from east of Montréal to west of Montréal can transfer in Laval rather than journey from Laval to Central Station and back. In addition, a through train concept with Québec-Ottawa trains reversing at Laval was also found to be possible but, because of limited through passenger demand, practical in peak hours only.

Train Schedules

Provision was made for two classes of service, first class and economy. For the 200 km/h technology based on the X-2000, a 282-seat trainset concept was used. The 300 km/h technology train based on the TGV-Atlantique would have a total of 358 seats per trainset. Trainsets can be operated either singly or coupled together.

Representative daily schedules were developed through an iterative process based on the response of the demand models and the calculated travel speeds shown above with the capacities of the trains. Departures were scheduled from 6:00 a.m. to 9:00 p.m. The number of daily trains required were estimated as shown in Table 4.8. The on-season represents peak periods of travel during the summer months.

Despite the lower demand, the frequencies for the 200 km/h technology are higher because of the lower capacities of the 200 km/h trains.

As population and economic activity increase, the frequencies would be increased. For example, by 2025, the number of daily trips between Ottawa and Toronto is expected to increase to 38 off-season and 48 on-season for the 200 km/h system and to 39 and 49 for the 300 km/h system.

Comparison of Inputs

Based on the above assumptions on the level of service on existing travel modes and the results of HSR ridership forecasting, Table 4.9 provides a comparison of typical door-to-door travel times and costs according to trip purpose for the Montréal-Toronto run. The operating costs shown for the private auto are the marginal out-of-pocket costs paid by the driver, adjusted by party size to give a per person cost. For business trips, a full cost based on distance rates typically used for business travel, adjusted for party size.

Table 4.8 - Estimated daily one-way frequencies, 2005

	QW-D-200	*QW-M-300*
Québec-Montréal		
Off-season	14	13
On-season	17	16
Montréal-Ottawa		
Off-season	21	20
On-season	24	23
Montréal-Toronto		
Off-season	21	20
On-season	24	23
Ottawa-Toronto *		
Off-season	27	27
On-season	33	33
Toronto-London		
Off-season	16	15
On-season	19	18
Toronto-Windsor		
Off-season	8	8
On-season	9	9

* Including Montréal-Toronto trains stopping in Ottawa.

Forecasts

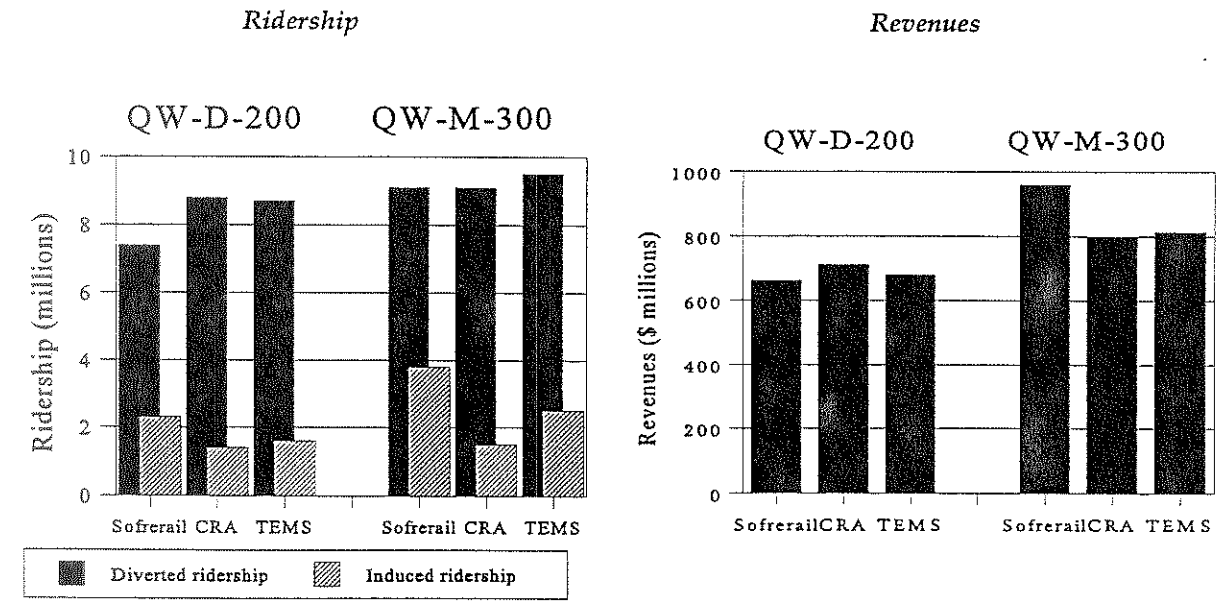
As described previously, three separate forecasting models were developed. Results for 2005 are presented in Figure 4.3. The Steering Committee reviewed and analyzed the results of these demand and revenue forecasts and found that while all of the forecasts had positive aspects, all had shortcomings either in the development of the model or in its application. Although the total diverted forecasts were similar, their source and magnitude by O-D vary widely (e.g. the degree of diversion from the auto as opposed to the degree of diversion from public modes). The projections and calculations of induced traffic differ significantly among the forecasts. There are major differences in results for some key segments (e.g. Montréal-Québec and Ottawa-Toronto) and the differences in connect air (airport feeder) traffic are significant. These differences made the final choice of one forecast a difficult one.

Table 4.9 - **Comparison of typical travel times and cost inputs, Montréal-Toronto, 2005**

Input Variable	*Local Air*	*(VIA) Rail*	*Bus*	*Auto*	*HSR* (1)
Time (Hours and Minutes)					
Access/Egress/Terminal	1:48	1:33	1:29	-	1:30
Line-Haul (In-Vehicle)(2)	1:15	4:30	6:38	6:20	2:18(3)
Departures per day	45	12	18	N/A	36
Cost (Business) ($)					
Access/Egress	36.40	19.10	15.80	-	18.60
Fare(2)	175.00	85.00	48,40	-	132.60
Operating Costs (per person)	-	-	-	122.00	-
Total Costs (Business) ($)	211.40	104.10	64.20	122.00	151.20
Costs (Non-Business) ($)					
Access/Egress	15.00	7.40	4.90	-	7.00
Fare(2)	119.00	64.00	46.60	-	98.20
Operating Costs (per person)	-	-	-	22.00	-
Total Costs (Non-Business) ($)	134.00	71.40	51.50	22.00	105.20

(1) HSR service shown in 300 km/h via Mirabel, Québec-Windsor Corridor (QW-M-300).
(2) Travel time and fares shown are weighted averages developed in the composite forecasts.
(3) HSR travel times vary by scenarios and by number of stops.

Figure 4.3 - **Results of the three forecasting models, 2005**



Unanimity on the choice of one forecast was not reached, although the necessity of using a single forecast was recognized. The governments agreed that the CRA and Sofrerail models produced the more credible results. Therefore, it was decided that an averaging of their results would be a compromise approach. It should be noted, however, that the ridership and revenue projections produced by these two firms for the Montréal-Ottawa-Toronto segment are very close and that this alleviates some of the concern about the use of averages.

The resulting composite forecasts for the year 2005 are summarized in Table 4.10 for all scenario studies. The highest ridership is achieved by the 300 km/h technology on the south shore routing between Montréal and Ottawa (via Dorval). This is true for both the entire Québec-Windsor scenario and the Montréal-Ottawa-Toronto scenarios.

Figure 4.4 shows the sources of the high speed rail ridership, that is, the mode that these travellers would otherwise have used if high speed rail were not available, for business and non-business travellers for the two base scenarios (200 km/h and 300 km/h systems/ routes for the entire Corridor). Two types of air passengers would be attracted to HSR. "Local air" passengers are those who would use HSR for their entire trip rather than air. "Connect air" passengers are those who are expected to use HSR to access an airport for a longer trip; for example, someone going from Québec to Florida might use HSR between Québec City and Dorval and then an airplane from that point. In addition to the travellers who are expected to be diverted from other modes, there are large numbers of passengers who would not otherwise make a trip in the Corridor who are "induced" by the presence of convenient and fast HSR services. Also, existing travellers who may travel more often because of the greater efficiency of the system. These trips are shown on Figure 4.4 as well.

Intra-corridor Traveling

It was found that a very high proportion of traffic is carried within one of the three segments, that is, Québec-Montréal, Montréal-Ottawa-Toronto and Toronto-Windsor. For example, in the QW-M-300 scenario, out of a total of 11,867,000 riders, 11,099,000 or 93.5% were travelling within one of these three segments and only 767,000 were travelling between segments.

2025 Ridership

Beyond 2005, ridership is expected to increase because of growing population and employment and because of higher levels of income. Between 2005 and 2025, HSR ridership is expected to increase by 53% for the 200 km/h system and 58% for the 300 km/h system.

HSR Revenues

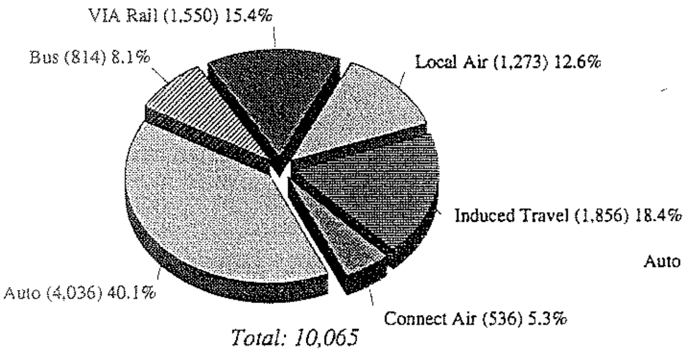
The revenue forecasts are presented in Table 4.10. These revenues include taxes (GST and provincial sales taxes) and are based upon fare structures developed by the forecasters.

Operators in the intercity transportation business have become adept at improving revenues by segregating the markets that they serve and charging the maximum fare in each market. For example, both airlines and VIA have various advance booking fares. They use this method to segregate the market of leisure travellers (who presumably have the ability to book ahead) from the business travellers (who require greater flexibility).

Forecasters were asked to use their models to "optimize" fares charged in each of the various markets to maximize revenues. They were restricted to the extent to which they could do this by the structure of the models. One of the forecasting models makes projections based on city pairs by time of day and by trip purpose (business and non-business). The other method projects travel in each market by type of trip.

Figure 4.4 - **Sources of ridership in 2005**
(thousands of riders and percentage)

QW-D-200



QW-M-300

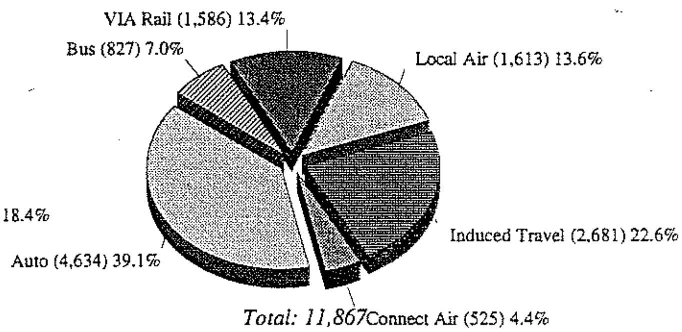


Table 4.10 - **Summary of HSR ridership and revenue forecasts for 2005**

Forecast	*Ridership (thousands)*			*Revenues ($1993 millions)*		
	Business	*Non-Business*	*TOTAL*	*Business*	*Non-Business*	*TOTAL*
QW-D-200	3,523	6,541	10,065	320	373	694
QW-M-300	4,356	7,511	11,867	429	457	887
QW-D-300	4,731	7,726	12,457	472	472	944
MOT-D-200	2,273	3,346	5,619	217	210	428
MOT-M-300	2,870	3,776	6,646	296	254	550
MOT-D-300	3,191	3,968	7,158	331	266	598
MOT-D-300NA .	2,990	3,772	6,762	310	250	560
QT-M-300	3,505	5,343	8,848	359	354	713

Note: *MOT-D-300NA does not connect with airports.*

The result of this analysis of potential fare levels are shown in Table 4.11 and compared with the fares for other modes. Generally, the projected HSR fares are considerably higher than the VIA fares but lower than air fares. The revenue forecasts shown in Table 4.10 reflect the optimized fares developed.

For the base case, revenues for the 300 km/h scenario are nearly 28% higher than for the 200 km/h scenario, although ridership is only 18% greater due to the fact that optimized fares are higher for the 300 km/h scenario. This same relation applies for the Montréal-Ottawa-Toronto scenarios.

Table 4.11 - Optimized fare comparison (1992$)

	Local Air	*VIA Rail*	*Bus*	*HSR*
Montréal-Québec				
Non-business	144	41	29	66
Business	206	54	30	87
Montréal-Ottawa				
Non-business	147	26	26	40
Business	210	43	21	67
Montréal-Toronto				
Non-business	119	64	49	98
Business	175	85	51	133
Ottawa-Toronto				
Non-business	143	57	42	89
Business	193	72	50	111
Toronto-London				
Non-business	121	26	25	38
Business	108	38	21	57
Toronto-Windsor				
Non-business	111	43	40	68
Business	177	56	40	88

Note: HSR fares shown are weighted averages developed in the composite forecasts for the QW-M-300 scenario. Fares for other modes are averages from passenger survey data.

Impact on Other Modes

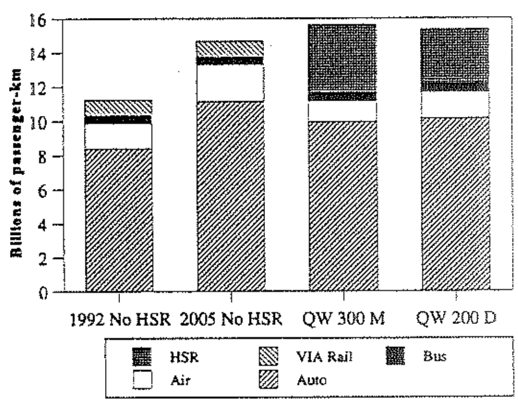
HSR will offer higher levels of service but also impose higher fares than existing VIA services. The resulting predicted impact on total passenger-kilometres in the Corridor is illustrated in Figure 4.5 (passenger-kilometres are typically used as a measure of output in the transportation industry). Total kilometres of travel will increase because of the induced travel. HSR will replace existing VIA services in the Québec-Windsor (QW) scenarios. HSR will also attract passengers from the auto and air carriers would lose 44% of their projected Corridor ridership in 2005. The bus mode will be affected in three ways. Some bus passengers will be diverted to HSR; bus will gain riders from those VIA passengers who do not want to pay the higher HSR fares; the bus mode will also attract riders from those communities that will not be served directly by HSR because of the reduced number of stations.

Other Revenues

Light Freight Revenues

The transportation of light freight, small parcels and postal services can be an attractive source of revenue for an HSR system. In France, the TGV has a number of dedicated freight services to accommodate part of this market. In Canada, small parcel services are an important source of revenue for airlines, bus operators and dedicated express freight carriers.

Figure 4.5 - Québec-Windsor Corridor intercity travel
Passenger-kilometres by mode



Three potential sources of light freight were evaluated: courier traffic, less-than-truckload (LTL) traffic and air cargo traffic moving by truck. Two types of operation were considered: specialized light freight cars on mixed trains versus dedicated light freight trainsets running during the day or at night. Similarly, two potential roles were considered for the high-speed operator: that of a courier (retailer of transportation service) versus that of a carrier (wholesaler of transportation service).

It was found that the volumes of courier and LTL traffic moving within the Québec/Windsor Corridor are considerable. The HSR operator would be more likely to succeed in this market by assuming the role of carrier or wholesaler by offering cost-effective transportation, particularly in city pairs with traffic imbalances or small volumes of courier traffic. It was found that light freight could be handled on passenger trains, although the very limited station dwell times makes this mode of operation inefficient. Any light freight HSR system should use dedicated trainsets running at night.

Light freight HSR operations on the scale required to carry the estimated traffic were developed in sufficient detail to estimate capital and operating costs. The resulting capital costs range from $91 million to $228 million depending on the scenario. Net operating revenues are estimated at $16 million at start-up for the Montréal-Toronto segment and to $49 million for the full Corridor, as presented in Table 4.12.

By 2025, these revenues are expected to increase to some $90 million (1993 $) for the two base cases (QW-D-200 and QW-M-300).

Table 4.12 - **Light freight net revenues in 2005**
(1993 $ millions)

Scenario	*QW-D-200*	*QW-M-300*	*MOT-D-200*	*MOT-M-300*
2005	49	48	17	16

Other Potential Revenues

Other potential revenues where investigated but where not retained due to the very small contribution or relatively high uncertainties.

Income generated by onboard services is expected to cover their operating expenses. Revenues generated by station concessions will be limited to approximately $1 million per year due to the limited space in the stations, and the fact that the station facilities may not be owned by the HSR operator. Revenues generated by leasing the right-of-way for communication lines or other utilities are most uncertain because of the existence of other possible routes and evolving technology.

Conclusions

Faster travel times generate more ridership and revenues. The 300 km/h technology would initially generate close to 12 million riders and revenues for the first year of operation would be close to $900 million (1993$) for the entire corridor. The 200 km/h technology would generate over 10 million riders and revenues for the first year of operation would be close to $700 million.

The Montréal-Ottawa-Toronto sector represents close to 50% of the total ridership, and Québec-Toronto approximately 75%.

Approximately 80% of HSR ridership would be diverted from other modes in the corridor. 40% would be diverted from the automobile, 18% from air, 15% from VIA Rail and 8% from buses.

The automobile mode will continue to be the dominant intercity passenger mode. Air travel within the Corridor will be reduced considerably and the bus industry will be unaffected by the introduction of HSR.

In total, the number of passengers forecasted for a HSR train is four times the existing traffic of VIA Rail in the corridor, with trip time reduced by up to half, frequency multiplied by up to 4 and greatly improved reliability because of dedicated double track.

The success of an HSR project is very dependent on the number of riders attracted. It is difficult to set a level of confidence on the ridership estimates, but the methodology used was designed to bring as much confidence as possible in this most important aspect of the project. The methodologies employed to increase the level of confidence included:

- the use of three forecasting consultants working in parallel. In fact, the consultants produced similar levels of ridership and revenue;
- the conduct of the most extensive set of surveys ever carried out in the Québec-Windsor Corridor;
- an independent review group compared the various models and analyzed the results.

No forecasting model is perfect, and each has its shortfalls. Results must be reviewed carefully, particularly when using disaggregated results. The comparative exercise has been very useful to define a proper forecast in which the Steering Committee has confidence for the current decision process.

5

Capital Costs

Scope and Results

High speed rail, as other types of railway investment, is very capital intensive. Capital costs are often the key determinants of system viability. In this project, a considerable effort was therefore made to develop reliable capital cost estimates. The developed costs for each HSR scenario are based upon the routes described in Chapter 3. The costing was based on a detailed analysis of current costs, but without field studies of soil conditions and other variables. The costs are believed to be accurate within ±20 percent.

This chapter presents an overview of these costs. For the two Québec-Windsor base scenarios, initial capital costs up to the first year of operation (2005), expressed in constant 1993 dollars, are shown in Table 5.1. These costs do not include any provincial or federal taxes, nor import duties.

Table 5.1 - Initial capital costs
(1993 $ millions)

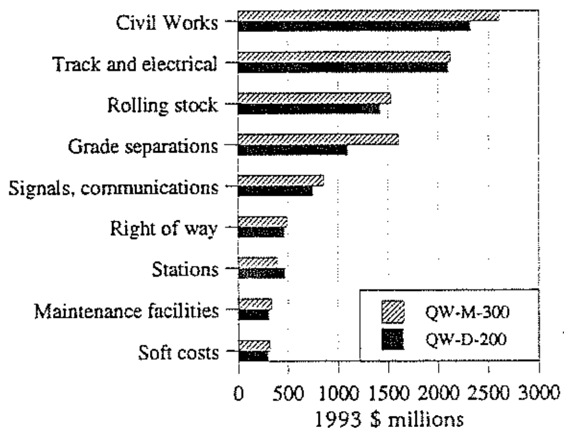
	QW-D-200	QW-M-300
Initial Capital Costs	9,278	10,254

Capital Costs of the Base Scenarios

A breakdown of total capital costs for the 200 km/h and 300 km/h scenarios from Windsor to Québec City is provided in Figure 5.1. These costs are comprehensive and include initial costs such as commissioning, allowances for administration, start-up and training. All cost categories include an allowance for contingencies ranging from 5 to 30 percent. When these various contingencies are combined, the amount included in the total is less than 10 percent.

The 200 km/h base scenario includes some at-grade road crossings. Full grade separation of the 200 km/h route would save approximately $100 million in crossing protection costs but would add $600 million for additional grade separations for a net increase of $500 million.

Figure 5.1 - Capital cost breakdown



The costs included in each subsystem item are described in the following paragraphs.

Civil Works

This subsystem comprises all work required to construct the roadbed down to the bottom of the ballast layer of the high speed rail lines, including bridge structures, viaducts over valleys and tunnels. Grade separations are covered in other subsystems. It includes the cost of clearing land, excavating cuts, hauling fill and spoil materials, compaction, providing culverts, ditches and fencing, and correcting interferences caused by pipe and wire crossings. It also encompasses the cost of capping the earthworks with a layer of top quality material to serve as a sub-ballast.

Costs associated with technical feasibility studies and the environmental evaluation of the project are also included here, as well as the cost of implementing measures to mitigate most environmental impacts.

Track and Electrification

All costs associated with providing the new high speed track structure from the bottom of the ballast to the top of rail fall under this subsystem. This encompasses provision of new main track and passing and maintenance sidings. Also included are rails, ties, ballast, fastenings, other track materials, special track materials for turnouts, switch machines, switch heaters, and bumping posts.

Removal of existing rail lines and construction of new tracks to maintain rail traffic and service to clients of the freight railways during construction are also included in this subsystem.

This subsystem comprised all costs associated with the electrification using 25 kV A.C. power. These facilities include the catenary and support structures, electrical substations, feeder lines from the electrical utilities, as well as any modification to overhead structures, to obtain necessary electrical clearances for the catenary and protection of adjacent signalling and telecommunications systems against electrical interferences.

Rolling Stock

Based on the ridership forecasts (described in Chapter 4), the fleet required for the full Québec-Windsor Corridor in 2005 is 60 trainsets with a capacity of 282 passengers for the base 200 km/h scenario (QW-D-200). The base 300 km/h scenario (QW-M-300) requires 50 trainsets seating 358, including allowances for spares and maintenance. By 2025, as traffic grows, it will be necessary to acquire an additional 19 trainsets for the 200 km/h scenario and an additional 16 trainsets for the 300 km/h technology. These additional costs are not included in initial capital costs. The initial fleets required for these and other scenarios are given in Table 5.2.

Fewer trainsets are required for the 300 km/h technology, despite the higher demand for these services, because the trainsets have greater capacity and because of their higher productivity in terms of kilometres operated per day.

Re-using existing infrastructure and track

In the routing chapter, the operating constraints relative to sharing existing tracks or right-of way were discussed. In addition to this issue, the use of existing rail roadbeds was extensively evaluated. The nature of materials, the drainage quality in the existing roadbed and its vulnerability to freeze-thaw action causing instability and potential rail movement is a key factor in assessing rehabilitation needs. A second major consideration is the requirement to convert the largely single-track existing right-of-way cross-section into the high quality double-track roadbed specified for high speed rail operations.

The conversion of existing tracks requires the removal of the existing track structure including ballast since existing rail, ties and fasteners are not considered suitable for HSR service. Some re-use of good quality ballast may be possible but his would require selection, cleaning and stockpiling. As the existing roadbed sub-ballast layer is of very variable composition and generally no more than 300 mm thick, this material would almost certainly have to be removed. Re-use of this material would require screening to remove unsuitable material and stockpiling so that it could be used as general fill for the new wider roadbed earthworks.

Widening of the existing general earthworks to accommodate the HSR double-track cross-section requires significant reworking to achieve the necessary standards for high speed rail operations. Nevertheless, savings in overall material required are likely, due to reuse of suitable existing fill.

Where dedicated high speed tracks are to be offset 8-10 metres from existing tracks in a shared right-of-way, the roadbed preparation and earthworks have been considered as new construction. It is felt that the small saving in quantities due to the overlapping of new and existing cross-sections will be entirely offset by the added complications of construction adjacent to existing operating tracks in the shared right-of-way.

Where high speed rail tracks are located 4.5 metres from existing tracks in shared right-of-way, earthworks and roadbed preparation have been measured under an item representing the works required to upgrade the existing roadbed, including widening.

Table 5.2 - Initial rolling stock requirements

Scenario	No. of trainsets required in 2005
QW-D-200	60
QW-M-300	50
QW-D-300	50
MOT-D-200	37
MOT-M-300	32
MOT-D-300	31
MOT-D-300NA	28
QT-M-300	40

No additional trainsets have been included in the fleet to serve the superpeaks - the fifteen or so days per year when demand is greatest. On those days, additional service may still be offered by extending the peak service segment of the day earlier in the afternoon and later in the day and by ensuring maximum availability of equipment through appropriate maintenance scheduling, as is done in France.

Grade Separations

This subsystem includes all costs associated with maintaining the high speed right-of-way free of potential vehicular or animal obstruction. In addition to grade separations with roads, it includes grade separated farm crossings where required and the costs for closing and/or diverting roads to avoid grade separation.

Where existing grade separations must be modified to allow for additional tracks, the cost of such work is included here. In terms of contracting for construction, all these items would typically be included with earthworks and bridges.

Where level crossings with automatic crossing protection have been considered for the project, the costs for crossing protection have been included in this subsystem so that the full costs for resolving the crossing issue (separation or protection) can be easily compared, irrespective of the adopted solution.

Signals and communications

HSR operations require sophisticated signal systems. This item covers the total cost of design-

Single versus double track

Given the lower passenger densities and train frequencies in the Québec-Windsor Corridor compared to other routes in the world, the feasibility of constructing single track rather than full double track was investigated, at least for initial operation. In order to reduce the delay caused by trains passing one another, the analysis of the comparative benefits of single vs. double track included the development of a track layout with 7.5 km-long double track sections spaced at 21 km intervals. Operational analysis indicated that each train having to enter the siding to allow a train coming the other way to pass would be delayed about five minutes, conditional upon trains meeting as scheduled. There would be longer delays if one or the other of the two trains was behind schedule. Because of this eventuality, some additional slack would probably have to be added to the schedules of all trains. A single track section also does not provide the same flexibility for scheduling all trains and for scheduled or unscheduled maintenance. In a double track system, single track running can be implemented when required.

The main advantage of a single track section is, of course, lower capital cost. Given the likelihood that the routes would have to be double-tracked within a short period, it was decided to investigate the cost implications of single track construction, with earthworks for two tracks put in place initially, including bridge foundations for the second track. Under this scenario, electrification would be built only for the single track, but all substations required for the eventual double track line would be included. Under these assumptions, including the double track passing sections, the reduction in initial capital cost was found to be close to 5% of the total capital costs.

Ultimately, it was decided that, in the base case, only the section between London and Windsor would be initially constructed with single track (with double track passing locations) because of the relatively low train density expected on this section. Since the single-track in this section had practically no effect on the schedules, it was assumed that there would be no impact on ridership or revenues.

ing, implementing and commissioning a TVM 430 signalling system for the 300 km/h system and a TVM 300 for the 200 km/h technology. An HSR system also requires communications along the entire network as well as a communication centre.

Right-of-Way Acquisition

This subsystem is intended to include all costs associated with acquiring the land required to build the project. This comprises land for new right-of-way, for widening or outright purchase of existing right-of-way, for constructing grade separations and for stations. The acquisition costs include the compensation that will be paid for loss of property value and loss of business revenue resulting from the acquisition. It also encompasses land that may have to be purchased or other expenses necessary to acquire or extinguish crossing rights. Legal and professional fees associated with the acquisition process are also included. It does not include any costs for the sharing of existing rail right-of-way.

Stations

This subsystem includes all costs associated with the construction or modification of stations. This includes the stations themselves, as well as providing track-side platforms and their access ways, services and utilities, associated roadways, parking areas, and landscaping.

Maintenance facilities

Existing VIA rolling stock maintenance facilities in Toronto and Montréal were inspected. It was found these are adaptable to HSR equipment maintenance. Therefore, the maintenance facilities are provisionally in the existing VIA locations. This item also includes the track maintenance facilities as well as yard tracks in such facilities.

Soft Costs

This subsystem includes the provision of information systems to cover a variety of functions including internal management information systems, passenger reservation systems, etc.

This item covers all costs associated with training and operations start-up. It covers the cost of commissioning and integrating all the subsystems. For example, it is common to have a period of "trial" running of new HSR systems before paying passengers are accepted. It also includes administration of the HSR system, which will have to be in place before operations begin.

Comparison of Scenarios

Table 5.3 shows total capital costs for all eight scenarios. The capital costs for the Montréal-Ottawa-Toronto scenarios are somewhat greater on a per kilometre basis for two reasons:

- they include costs such as information systems, maintenance facilities, startup costs, etc. which do not vary directly with corridor length;
- because traffic is higher on the Montréal-Toronto segment, rolling stock costs are higher.

The overall corridor cost for the 300 km/h technology includes the north shore route (via Mirabel) between Ottawa and Montréal. Use of a south shore alternative between Ottawa and Montréal, routed via Dorval, would increase the overall cost by $144 million to $10,398 million because of major civil works in the Hudson area just west of Montréal.

Table 5.3 - Comparison of scenario costs

Scenario	*Total Capital Costs* [1] *(1993 $millions)*	*Length (km)*	*Cost per km (1993 $millions)*
QW-D-200	9,278	1,228	7.56
QW-M-300	10,254	1,235	8.30
QW-D-300	10,398	1,228	8.47
MOT-D-200 ...	5,311	610	8.71
MOT-M-300 ...	5,948	629	9.46
MOT-D-300 ...	5,948	610	9.75
MOT-D-300NA	5,196	586	8.87
QT-M-300	7,806	885	8.82

(1) Excluding ongoing capital costs and capital costs (including rolling stock costs) of light freight.

Ongoing Capital Costs

The majority of the capital costs are incurred during construction; however, ongoing capital investments would be required. For example, for the base 300 km/h scenario (QW-M-300), an additional $450 million for rolling stock and $712 million for other capital costs are required over the 21 year period from 2005 to 2025.

Light Freight

For the light freight system, additional capital costs are estimated as shown in Table 5.4. An additional $150 million is required for investment in the light freight rolling stock and facilities over the 21-year period.

Table 5.4 - **Light freight capital costs to 2005**
(1993 $ millions)

Scenario	*QW-D-200*	*QW-M-300*	*MOT-D-200*	*MOT-M-300*
	173	228	91	130

Operation at Higher Speed

Although the geometry of the 200 km/h alignment is suitable for the operation of trains at up to 250 km/h, the work covered by the above estimate does not allow operation at that speed. This is because this cost is based on the use of level crossings with automatic protection where traffic volumes permit. As discussed, providing a fully grade separated infrastructure acceptable for operation at 250 km/h would imply a net increase of $500 million in capital costs. If the decision to provide a completely grade separated right-of-way was made after initial construction with level crossings, it is estimated that the added cost would be in the order of $600 million dollars.

The geometry of the 300 km/h alignment is suitable for the operation of trains at up to 350 km/h. In order to operate at that speed, some minor additional expenditure may be required. This would primarily be for noise mitigation measures in areas where the higher noise levels associated with higher speeds exceeded threshold acceptance levels. However, it is likely that, with technological advances, noise levels of subsequent generations of rolling stock could decrease and that additional investment would not be required.

Construction Schedule

Figure 5.2 presents the projected implementation schedule for the Montreal-Toronto segment. As indicated, it presumes that the Montréal-Ottawa portion of the line would be built first, since the two cities are the nearest major ridership generating centres. According to the schedule, the Montréal-Ottawa segment would take 7 years to construct and the Ottawa-Toronto segment, 9 years. Thus, Montréal-Ottawa could begin operating in 2003 and Ottawa-Toronto in 2005.

The construction period for the Montréal-Québec segment is estimated at 8 years and the Windsor-Toronto segment, at 9 years. The governing consideration when combining these four

HSR safety measures

The following safety measures have been assumed as necessary for the analyzed technology/right-of-way scenarios and are included in cost estimates:

- Security fencing would be provided to discourage both human and animal intrusion. Fencing designed specifically for wildlife habitats where larger species are present would be utilized. For areas where the right-of-way is shared with conventional rail service on tracks closer than 8m from HSR tracks, the fencing is assumed to enclose both the conventional and HSR tracks.
- If freight trains share the right-of-way, hot box, hot wheel and dragging equipment detectors would be placed no more than 25 km apart.
- Active intrusion detection devices linked to the train control system would be incorporated in the security fencing design.
- All grade separations passing over the HSR right-of-way would have intrusion detection measures along the sides of the structure and approaches to detect vehicles that have penetrated bridge parapets or guardrails. The devices would also be linked to the train control system so that an intrusion would be detected and trains stopped.

Detection systems will be incorporated to ensure the integrity of the line during occurrences such as earthquakes, rock slides, snow slides/drifting and flooding adjacent to the line resulting from beaver dams or other causes. Precedents for these types of detection do exist on HSR operations elsewhere in the world and on non-HSR systems in western Canada.

schedules is the time required for construction of the fixed railway plant, due to the need for specialized construction equipment and materials. This item should not overlap when combining the four schedules.

However, for analytical purposes and to allow flexibility to undertake comparisons of various segments, the financial and economic studies have assumed that construction of all segments would begin at the same time, although this is unlikely. This results in the following operation start-up dates for the various segments:

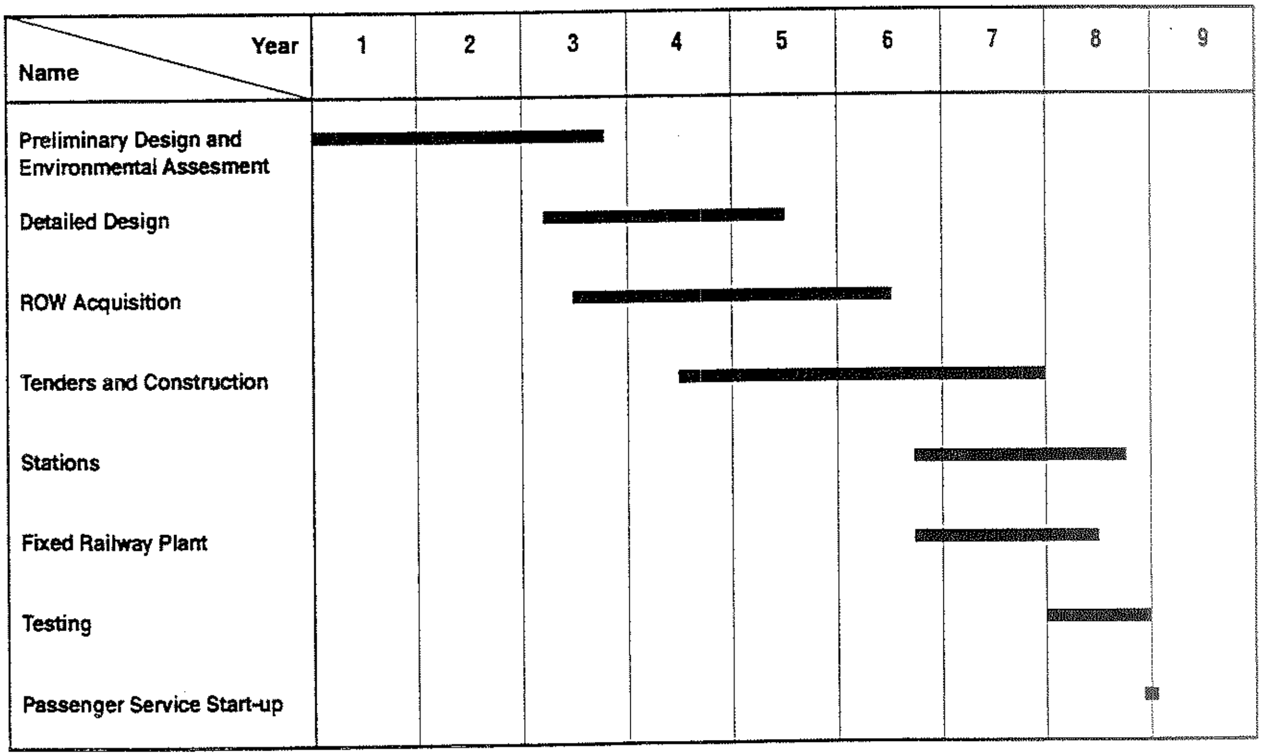
- Montréal-Ottawa 2003
- Montréal-Québec 2004
- Ottawa-Toronto 2005
- Toronto-Windsor 2005

Risk Factors

An analysis of the degree of accuracy of these estimates indicates that they should be regarded as being within a margin of error of ±20%. There are some factors that may lead to change in costs. These are:

- USE OF EXISTING RIGHT-OF-WAY. These estimates assume that the project can probably use some existing railway right-of-way. This would require the two major existing railways to share track for freight services. This may or may not be acceptable.
- LEVEL CROSSINGS. The estimates for the 200 km/h system assume that level crossings will be permitted for speeds up to 200 km/h, provided that crossing protection is enhanced. If this is not acceptable, there is a potential cost penalty to provide additional grade separations.

Figure 5.2 - Typical HSR implementation schedule



• ROUTES WITHIN URBAN ZONES. Within the urban zones, it has been assumed that in most cases existing railway right-of-way can be used. It is possible that there could be problems associated with this.

• CONTAMINATED SOILS. There is little evidence of contaminated soils along railway routes (as opposed to within yards and other facilities); therefore no specific allowance for treatment or removal of contaminated soils has been included.

• MITIGATION MEASURES. Although the unit costs and contingencies as well as some specific items are believed to cover the level of environmental mitigation generally expected for a construction of this nature, there is always a risk that the environment assessment may dictate additional mitigation measures.

• CONSTRUCTION SCHEDULE. Many very large civil engineering projects overrun the anticipated construction schedule, increasing financing costs.

• REPRESENTATIVE ROUTES. Costs have been estimated based on the selection of representative routes and potential station locations. Should these change for one reason or another, there could be impacts on the costs. Optimisation of the routes might result in savings.

• SINGLE TRACK OPERATION. In the capital cost analysis, single track operation was assumed for the segment between London and Windsor. Two other segments (Toronto-London and Québec-Montréal) were assessed for potential single track operation. While single track operation in these segments is technically and operationally feasible and could show appreciable cost savings, it was concluded that at this level of investigation, double track operation was more appropriate for the purpose of this study.

Conclusion

The total system costs, excluding inflation and financing costs, would be from $5.4 billion (1993$) to $10.5 billion, depending on the scenario. Examination of the capital cost estimates leads to the following conclusions:

• the capital costs of the 200 km/h scenarios are only slightly lower than those of the equivalent 300 km/h scenarios, and almost half the difference is attributable to the use of at-grade crossings with roads in some circumstances. This small difference is due to the finding that new track bed is required for both technologies;

• there are no significant cost differences between using existing right-of-way or new "greenfield route", since existing tracks need complete reconstruction to accommodate HSR;

• the most realistic route combines the use of existing ROW and new ROW.

Single-track could be a cost-effective solution on the Windsor-London segment.

The single track option would need to be further evaluated financially and operationally for the Montréal-Québec and Toronto-London segments.

6

Operating Costs

Scope and Results

A detailed analysis of the operations of HSR was performed based on the experience of the French, Swedish and Italian operations and on potential adaptations to the Canadian context based on VIA Rail experience. Train performance simulations were used to calculate the travel times on the representative routes.

Operating plans for both technologies were developed in interaction with the development of routes and passenger forecasts. Results relative to travel times and frequencies were presented in the chapter on ridership and revenues. This information as well as the routing studies were the base for the development of full operating plans and costs specific for each technology and each of the routing scenarios.

Operations and Maintenance (O & M) costs were developed using a "bottom up" approach, which incorporated:

- analysis of the material and labour inputs required to operate and maintain the representative technologies (obtained from European operators);
- current and projected Canadian labour productivity and cost data;
- estimates of workloads (trainset-km, seat-km, passenger-km, etc.), derived from the operating plans; and
- an understanding of the relationship between O & M costs and system, utilization and operating environment.

The result was a set of cost estimates that reflect both the general characteristics of the representative technology and the specific conditions under which the technology would be applied.

Total annual operating cost in 2005 for the base 200 km/h scenario (QW-D-200) is estimated at $259 million per year (expressed in 1993 $) and the base 300 km/h scenario (QW-M-300) at $303 million per year. Average cost per passenger for the 300 km/h system is estimated at $28.8 (1993 $) compared to $25.7 (1993 $) for the 200 km/h system.

Operating Cost Breakdown

The costs for the two base scenarios are outlined in Table 6.1.

Table 6.1 - Operations and maintenance costs for the full Corridor, 2005*

Cost category	*200 km/h system/route*		*300 km/h system/route*	
	1993$ millions	%	*1993$ millions*	%
Train Operations	32.7	12.6	43.3	14.3
Customer Services	70.5	27.2	78.5	25.9
Equipment Maintenance	34.7	13.4	45.4	15.0
Infrastructure Maintenance	60.9	23.5	72.4	23.9
Executive/Administration	24.2	9.3	24.2	8.0
Insurance/Taxes/Other	18.3	7.1	18.3	6.0
Contingency	17.9	6.9	20.8	6.9
Total O & M costs	259.10	100	302.8	100

* Excludes capital taxes.

By 2025, operating costs are expected to increase to $321 million for 200 km/h base case and to $379 million for the 300 km/h base case due to increased ridership and number of trains.

These costs do not include light freight operating costs, as the revenues for this activity are net of operating costs.

The most important assumptions and principles underlying the derivation of labour quantities and costs are summarized in Table 6.2.

Table 6.2 - Summary of assumptions concerning labour quantities and costs

Approach	*Category*
Train crew	2-person crew; hourly pay base.
Train control centre	Staffing based on time requirements (independent of technology).
Onboard services	Staffing based on number of seats, trip duration, service design.
Onboard service support	One clerical/general employee per five on-train service employees.
Station staff	2/3 of staffing assumed to be fixed, 1/3 varies with passenger throughput; baggage handling only available for connect-air passengers. Wage rate for baggage handlers 20% lower than current levels.
Telephone and counter ticket sales staff	50% of sales through third parties, 32.5% through automatic ticketing machines and the balance (16.5%) through counter transactions.
Equipment maintenance	Direct labour requirements per activity obtained from two technologies; assumption that multi-functional workforce would be in place by time HSR is deployed. Wage rate for cleaners would be 20% lower than current levels.
Infrastructure maintenance	Labour requirements derived by analysis: physical extent of system; severity of climatic conditions; rolling stock characteristics and level of system utilization. Contracting out of tamping, lining and levelling and rail grinding.
Administration	Management structure developed for a standalone operator. Staffing requirements independent of technology and speed.

Operating Ratios

The operating ratio of a rail service is the ratio of costs to revenues (including light freight). Results for the base cases as well as two Montréal-Ottawa-Toronto scenarios are presented in Table 6.3. The better results for the 300 km/h scenario indicate that although the revenues are 25.5% higher (for the full corridor), the costs increase by only 17%, therefore generating a better operating ratio (40% vs. 43%).

Results for 2025 show substantial improvement in the operating ratios as revenues increase faster than operating costs.

Labour Requirements

Table 6.4 presents the number of positions required to operate the systems. The lesser requirement in train operations for the 300 km/h technology reflects the smaller number of trainsets due to their greater capacity.

Operating Statistics

Table 6.5 gives a sample of some of the operating characteristics of the base systems. By 2025, with increased patronage of the system, load factors are expected to increase to 75%.

Table 6.3 - Operating costs and revenues
(1993 $ millions)

Scenario\ Year	*QW-D-200*	*QW-M-300*	*MOT-D-200*	*MOT-M-300*
2005				
Revenues	641	805	382	487
Costs	275	321	167	196
Op. Ratio	43%	40%	44%	40%
2025				
Revenues	1,064	1,370	640	837
Costs	329	392	202	242
Op. Ratio	31%	29%	32%	29%

Note : Costs include capital taxes
Revenues exclude GST and PST

Table 6.4 - Total HSR employment in 2005

	QW-D-200	QW-M-300
Train Operations	260	229
Customer Services	747	794
Equipment Maintenance	542	711
Infrastructure Maintenance	649	787
Administration	193	193
Total	*2391*	*2,714*

Table 6.5 - Operating statistics in 2005

	QW-D-200	QW-M-300
Route length (km)	1,228	1,235
Train trip (one-way) per year (thousands)	21.2	20.1
Trainset-km per year (billions)	16.8	16.5
Seat-km per year (billions)	4.7	5.9
Trainsets in active fleet (units)	60	50
Average trainset utilization (thousands of km per year)	280	331
Average load factor	67%	67%
Total energy consumption (gigawatt-hrs)	206	403

Conclusion

Based on the analysis of operation costs and revenues, the HSR systems will achieve very favourable operating results. These must be offset against the initial capital costs.

The operating costs of the 200 km/h system are approximately 15% lower than those of the 300 km/h system. The operating ratios of the 300 km/h are however superior by 7% due to greater ridership and revenues.

7

Legislative and Labour Issues

One of the findings of the O/QRTTF was that there should be a full examination of the current railway legislation and regulation, both federal and provincial; an assessment of the legal framework to enable the implementation and operation of HSR was also recommended. The Task Force also suggested there should be a close examination of current railway regimes to assess changes required to ensure productivity and efficiency in HSR operations.

HSR Institutional Arrangements in Other Countries

The institutional arrangements within which HSR was introduced in other countries were investigated and are reported below. The proposed institutional arrangements are presented in the financial analysis.

Japan and Europe

In Japan and in European countries, HSR has been sponsored by the State and implemented by state-owned railway companies. These systems exhibit institutional and political characteristics featuring close cooperation between:

- national governments that establish overall transportation strategy and priorities, and establish the role of HSR in a multimodal context;
- national railway organizations, which own and operate the HSR services and head the development and implementation of HSR; and
- major industrial concerns in the countries, which partner with the governments and national railways to design and build the HSR rolling stock, communications and control, electrification and other elements of rail fixed plant.

Swedish railways have been restructured in a unique fashion. The Swedish state owns the right-of-way and rail fixed plant. The Swedish National Railway Company (SJ) – a Crown corporation – operates freight and passenger services, including the HSR service between Stockholm and Göteborg. The State absorbs the costs of improving track, signalling systems, crossings and electrification while SJ is responsible for all operating costs. SJ pays a user fee to a State rail infrastructure company (Banverket) for track use based upon the equivalent level of charges paid by commercial highway users.

In Britain, similar decisions have been made to separate train operations from the building and maintenance of the infrastructure. The British government intends to privatize operations first but possibly also the infrastructure in the longer term. However, the institutional context for the planning, development, financing and operation of British Rail's existing HSR services was that of a Crown corporation wholly owned and subsidized by the British government.

United States

The U.S. context for HSR is much closer to Canada than Europe or Japan. There is no overall legislative or institutional framework to implement HSR. Although a number of potential HSR projects have been investigated, these have typically been evaluated on a project by project basis. The only HSR system operating in the U.S. is the 200 km/h speed service operated by Amtrak in the New York-Washington Corridor).

The primary HSR institutions established in the U.S. to date are commissions or authorities created by legislation to study the feasibility of HSR developments and to award and manage a franchise to finance, construct and operate HSR systems. To date, all existing HSR institutions have specified private sector financing arrangements in which the franchisee must finance the HSR initiative, possibly with some local government support.

The realities of private financing of HSR projects explain why no project has gone ahead to this date; no current project is expected to come to fruition without financial contribution from the public sector at the federal, state or municipal level, or some combination thereof. It appears that such public support may have to be substantial.

Legislative Issues

Federal vs. Provincial Jurisdiction

Given the interprovincial character of an HSR system in the Québec-Windsor Corridor, an HSR undertaking would be subject to federal legislation and regulatory jurisdiction. This would occur even if separate companies were to build and operate the system in Ontario and Québec or if separate ownership structures were to be adopted for the fixed plant and operating entities. Some independent suppliers (e.g., caterers) could be subject to provincial legislation.

Federal Legislation

Relevant legislation includes:

- RAILWAY ACT. Governing the establishment and operation of any railway, the Act currently provides an adequate regime. Under the *Railway Act*, the National Transportation Agency has to authorize land acquisition and construction of facilities. The *Railway Act* mechanisms for approbation of new railways and necessary expropriations have advantages over other alternatives despite the possibility of lengthy hearings. The *Railway Act* provides an adequate framework for dealing with level crossing and farm crossing disputes. It was concluded that the *Railway Act* does not create any material barrier to the construction or operation of an HSR system.
- CANADIAN ENVIRONMENTAL ASSESSMENT ACT. This legislation would likely apply to an HSR project and would require an environmental assessment of the project.
- EXPROPRIATION ACT. This Act provides an alternative basis for acquisition of and compensation for private property needed for railway construction.
- NATIONAL TRANSPORTATION ACT OF 1987. Existing statutory provisions will not prevent the carriage of freight traffic by HSR. Section 112 requires compensatory rates to be charged for railway freight. This would apply to any freight business that the HSR operator might undertake.
- OTHER FEDERAL STATUTES will also apply including the *Railway Safety Act*, the *Railway Relocation and Grade Crossing Act*, the *Financial Administration Act*, etc.

Provincial and Municipal Legislation

As previously noted, it is very likely that the entire HSR business would be treated as a federal undertaking and subject to federal legislation. However, an examination of relevant provincial railway legislation was conducted. This showed that these regimes would introduce no substantive impediments.

It is generally held that provincial or municipal land use jurisdictions do not apply to federal undertakings. Provincially chartered railways may be subject to provincial and municipal land use controls. These controls may raise barriers to the construction and operation of a provincial HSR system on new right-of-ways, particularly in urban and developed agricultural areas.

Environmental Assessment Process

All three jurisdictions involved, Ontario, Québec and the federal government, have environmental assessment acts. While most railways are under the jurisdiction of the federal government, there are a number of ancillary works that will require provincial approval. In addition, any provincial funding would also require a provincial environmental assessment (EA). It was agreed that the environmental assessment process should probably take the following form:

- determine the common elements of the EA process;
- undertake joint federal/provincial environmental assessment procedures in each province.
- if necessary, hearings should be held concurrently in each province;
- the same type and level of detail should be considered in the environmental impact statement in each jurisdiction. This implies that the environmental impact statement must respond to the information requirements of all three jurisdictions involved.

Labour Issues

Legislative Framework

Federal labour legislation (the Canada Labour Code) will apply in practically every instance to the construction and operation of HSR in the corridor. Besides governing the collective bargaining process, the Code also deals with successor rights and technological change in the workplace. Avoidance of successor rights under federal legislation would require the creation of an entirely new HSR enterprise totally separate from existing federally regulated railways. The sale of even a portion of one of the federally regulated railway's business to the HSR enterprise may invoke the successor rights provisions of the Code. In any event, the unions can be expected to try to protect their existing membership and influence, no matter how the HSR enterprise is established.

Constraints in Existing Railway Collective Agreements

There are a number of conditions in the existing collective agreements that would constitute impediments to the operation of an HSR system:

- PAY SYSTEM. Under current collective agreements, running trade employees are paid on a mileage-based system. This is a complex system that leads to relatively high compensation for engineers and conductors. Applied to an HSR operation, it would become prohibitively costly.
- TRAIN CREW SIZE. Since 1988 VIA trains have been operating with a four-person crew – two engineers, one conductor and one assistant conductor. VIA is now attempting to negotiate a two-person crew (i.e., one engineer and one conductor). Progress is being made on this initiative, though the unions currently resist the implementation of such changes.
- SHOP CRAFTS. The principal issue here is the lack of work flexibility in shops resulting from the multiplicity of unions. It appears that this problem will gradually be resolved with the recent merger of the shop craft unions.
- WAGE LEVELS. Canadian rail workers are among the highest paid transportation employees, and are generously paid in comparison with wages at Amtrak.
- UNION REPRESENTATION. There are now currently ten different unions representing CN, CP and VIA employees, even after a recent merger of the shop craft unions.

Most, if not all of the constraints identified above are expected to be eliminated through negotiation of collective agreements. Positive change is already underway with respect to union representation and running trade crew size. Further rationalization of union representation within the Canadian railway industry should also take place.

The other constraints will come under extreme pressure as Canadian railways continue efforts to reduce costs in order to survive in a highly competitive market. Railway management representatives mention that the mileage-based pay system is on the negotiating table and should be eliminated within the next couple of years. Wage levels will also come under pressure in future collective agreement negotiations.

Labour Practices in Other Countries

Labour practices in American and French railway passenger services were studied. The key finding from this work was that both countries use an hourly-based pay system for passenger running trade employees, while the mileage-based system is used in Canada. With respect to crew size, there is less of a divergence. VIA is fast approaching the presence of only one locomotive engineer in the cab and its requirements in the deployment of conductors are actually less stringent than those of Amtrak.

Proposed Labour Practices for HSR in the Corridor

HSR operations costing in this study has been based on the assumption that existing labour practices will not impede productivity and that productivity can reach the levels achieved in other countries. Therefore, it was assumed that two-person train crews, one engineer and one conductor, would be used and that the current mileage-based pay system will be replaced by an hourly-based system by the time HSR is introduced.

Conclusion

A thorough review of legislation has shown that there are no impediments to the introduction of HSR in Canada although some specific regulatory standards would likely have to be developed. The current constraints in collective agreements are expected to be eliminated through negotiation. Positive changes are already under way relative to train crew size.

8

Financial Analysis

Scope

A complete financial analysis was undertaken of the eight HSR scenarios previously mentioned. The purpose of this analysis was to examine the financial viability of HSR in the Québec-Windsor Corridor, determine the maximum extent and means by which the service can be offered and financed by the private sector and define the financial involvement required from governments to implement HSR.

To determine the HSR project's financeability, numerous consultations were held with the project finance specialists of the Banque Nationale de Paris (BNP), Canadian investment banks and Canadian Schedule banks. In addition, several project financing structures for North American transportation projects were researched. A well-known debt rating agency based in New York was consulted to ascertain the criteria upon which various financing structures and instruments are rated. The process of testing against private sector financial market criteria enabled the financial experts to narrow down the financing structures to those which could prove to be achievable in the marketplace, while respecting the preestablished federal, Québec and Ontario governments' objective of minimizing the annual and aggregate public sector financial commitment to the project.

Each scenario was initially examined under three types of ownership options, as a wholly-public enterprise, as a public-private partnership and as a private enterprise. This latter option was not retained due to its unfinanceability, which was demonstrated in the earlier stages of the financial analysis.

For public-private partnerships, the types of investment were separated into those that could reasonably be financed by the private sector with the remainder being financed by the public sector.

Inputs to the Financial Analysis

Table 8.1 summarizes the key inputs to the financial analysis.

Revenues

The most important source of revenues is passenger fares. The derivation of these was discussed in Chapter 4. The fare revenues used in the financial analysis differ slightly from those shown in Chapter 4 because federal and provincial taxes (including GST) as well as commissions (for example those of travel agents who sell rail tickets) have been deducted. Net revenues from light freight are also shown in Table 8.1.

Capital and Operating Costs

The capital costs described in Chapter 5 and the operating costs (with the addition of capital taxes) outlined in Chapter 6 are summarized in Table 8.1.

In addition to the capital costs expressed in constant dollars, the financial analysis took into account interest during construction and inflation at 3% per year. This was done because project financing requires that all the required financing, including credit available to cover cost of inflation and contingencies, be available and committed prior to the commencement of construction. When these are taken into account, the total financing requirements to 2005 increase to the amounts shown in Table 8.2.

Table 8.1 - Key input variables
(1993 $millions)

Scenario	*QW-D-200*	*QW-M-300*	*QW-D-300*	*MOT-D-200*	*MOT-M-300*	*MOT-D-300*	*MOT-D-300NA**	*QT-M-300*
Revenues in 2005								
Passenger fares	592	757	805	365	471	511	471	606
Light freight	49	48	48	17	16	16	16	31
Revenues in 2025								
Passenger fares	972	1,280	1,362	605	803	882	813	1,030
Light freight	92	90	90	35	34	34	34	59
Initial Capital Costs (to 2004)								
HSR	9,278	10,253	10,398	5,311	5,949	5,948	5,197	7,805
Light freight	173	228	228	91	130	130	130	191
On-going Capital Costs								
HSR	1,047	1,162	1,228	605	711	731	672	889
Light freight	108	150	150	51	58	58	130	86
Operating Costs								
In 2005	275	321	326	167	196	200	189	255
In 2025	329	392	402	202	242	249	232	312

* No airport connection

Table 8.2 - Total financing requirement in current dollars (up to 2005)
($ millions)

Scenario	*QW-D-200*	*QW-M-300*	*QW-D-300*	*MOT-D-200*	*MOT-M-300*	*MOT-D-300*	*MOT-D-300NA*	*QT-M-300*
Initial Capital Costs 1993$	9,450	10,481	10,626	5,402	6,079	6,079	5,327	7,996
Inflation Costs (3%)	3,134	3,446	3,476	1,773	1,986	1,969	1,733	2,619
Capitalized Interests during construction	3,860	4,414	4,559	2,229	2,574	2,653	2,351	3,403
TOTAL	***16,444***	***18,341***	***18,661***	***9,404***	***10,639***	***10,701***	***9,411***	***14,018***

Residual value

The residual value was estimated for the purpose of Internal Rate of Return calculation (IRR) using the capitalized earnings approach, thereby applying a capitalization factor to year 2035 earnings and deducting therefrom the estimated replacement cost of the project assets at that time. The replacement cost deduction attempts to provide a measure of the financial risk that parts of the project will, for a variety of reasons, be rendered technologically or competitively obsolete at some future date; hence investors and lenders will reduce their valuations of residual value to take into account such possible risks. A financially conservative estimate of the replacement cost of assets, equivalent to 65% of their original cost, fully inflated through to 2035, has been included in the financing plan.

Risk Sharing Among Private and Public Sectors

By any measure, a HSR venture in Canada will be judged by private sector investors and lenders as being of very high risk.

Given the hurdles that this HSR project must overcome, the project would be rated as a particularly high risk during the pre-construction, construction and initial operating periods. This will have a direct and adverse effect on the project's ability to attract private sector capital at the outset.

As project cost uncertainties are reduced over time, the overall project risk would decline. As an operating history develops, the financial risks of relying solely upon revenue forecasts would of course also decline. This is consistent with other transportation infrastructure projects around the world, where we find that the financial attractiveness, and therefore financeability, of the projects improve over time as usage increases and cash flows improve. Ultimately, when sufficient operating experience is gained, lower "utility-type" returns at much lower levels would be sought from investors. As an example, in the case of Eurotunnel, which is only now commencing its operations, returns in the 10% to 12% (after tax) are still considered adequate for new investors. Initial investors, of course, expected higher returns, given the higher relative risk at the outset of that project.

Ownership Options

The design of an optimal ownership option was based on the following financing plan objectives:

- private sector financing of capital costs should be obtained to the maximum extent that net operating revenues of the project can support;
- public sector financing of construction costs is to be structured to minimize up-front government funds, while retaining mechanisms for public sector control over the invested funds;
- private sector participation would be through fully taxable entities;
- dividends to the owners will be paid from operating cash flow generated by the project; and
- the rate of return on invested capital will be a function of the level of risks and responsibility.

Two ownership options were analyzed in detail: a public-private partnership and a wholly-public enterprise. The public-private partnership was recommended since it satisfied the objective of maximizing private sector participation.

When analyzing potential private involvement, it was realized that the project would be seen as a high risk because of uncertainties in:

- the time frame to obtain environmental and regulatory approvals;
- construction costs; and
- potential revenues.

The assignment of roles and responsibilities has been explored as well as the associated sharing of risks among the parties, taking into account the manner in which HSR might be financed. Some components of the project are more amenable than others to private sector financing.

Maximization of private sector participation was done by:

- splitting the equity participation between private and public stakeholders;
- assigning the fixed infrastructure investment to the public sector, to be financed by private sector borrowing with a public sector guarantee;
- assigning, for the most part, the equipment and technology investment to the private sector and including subordinate debenture loans and project finance bank borrowing; and
- making the public sector responsible for financing of the construction period interest.

Alternatively, the public sector could take on the entire project on its own account. This "Crown construct and Crown operate" option would likely maximize the public sector's rate of return but would involve substantially higher direct government borrowing and would not fulfill the objective of maximizing private sector participation.

In the context of continuing pressures to contain government spending, and considering the size of the required up-front investment, a wholly-public sector option is likely to be contrary to current transportation policies given pressures to contain government spending. Nevertheless, Internal Rate of Return for the wholly-public scenario should serve as a useful point of reference for comparison with other ownership options.

Potential Contractual Scheme

A potential contractual scheme as presented in Figure 8.1 would include:

• A PUBLIC FINANCING ENTITY. The public sector would incorporate a public financing entity, likely a crown corporation, to finance and own the infrastructure and civil works. Once completed, the public financing entity would lease the infrastructure and civil works to the construction and operations company. The public financing entity would obtain its financing from private sector institutional investors.

• CONSTRUCTION AND OPERATIONS COMPANY. A construction and operations company would be incorporated under joint ownership of the private and public sectors to manage the full scope of the project during the construction and operations phases. This jointly owned company would raise financing for the equipment and technology cost, and subsequently would operate the HSR services and lease the infrastructure and civil works from the public financing entity.

Roles for the public and private sectors for each major phase of the project could be:

• PLANNING AND APPROVALS PHASE. There would have to be a great deal of public sector involvement in this phase. For example, the necessary integrated multimodal planning, routing, land use planning, National Transportation Agency approvals, and environmental approvals are all processes primarily driven by the public sector.

• LAND ACQUISITION PHASE. This phase can be envisioned as either a public or private sector undertaking, but in all probability land acquisition will prove to be controversial and problematic. Even if skilfully executed, many landowners can be expected to resist surrendering their properties. In the circumstances, it may prove more expedient that land acquisition be handled by public agencies.

• DETAILED DESIGN, CONSTRUCTION, COMMISSIONING PHASE. The components of this phase could largely fall in the domain of the private sector. Even if the HSR system were a wholly public sector enterprise, much of this activity would normally be contracted to the private sector.

• OPERATIONS PHASE. Numerous combinations of participants could collectively form an effective HSR operations unit. Potential participants include VIA Rail (for most functions); an existing off-shore HSR operator (possibly for train operations and passenger services); airlines for customer services (reservations, ticketing, sales and marketing); freight railways (for fixed plant maintenance, train operations and control); and equipment manufacturers (for equipment maintenance).

Financing Plan for the Public-Private Partnership

The resulting type of public-private partnership that would most likely maximize private sector capital is outlined in Table 8.3. The maximum extent of private sector risk and thus involvement in this project has been estimated at between 22.5% and 28.6%, depending on the scenario.

The resulting use and sources of funds is illustrated in Table 8.4 for the Québec-Windsor 300 km/h scenario via Mirabel.

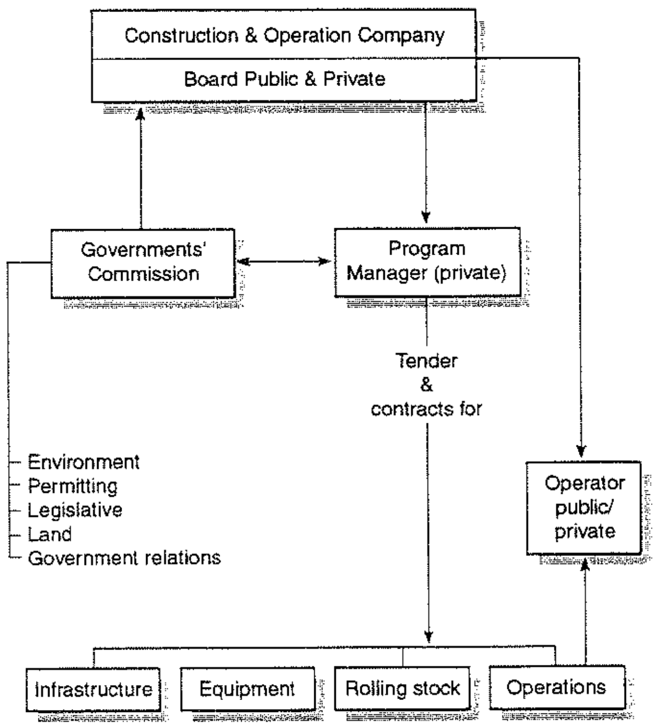
During the pre-construction period, the most likely form of financing would be an equity injection by private sector sponsors and a grant or equity by public sector sponsors. This would most likely be followed by quasi-equity (e.g. convertible debentures) for the financing of initial construction period costs.

During the construction period, as indicated in Table 8.4, infrastructure and civil works would be financed by private sector institutional investors in the form of infrastructure and civil works notes yielding a rate of 9% per year. This obligation would be secured by a government guaranteed annual infrastructure and civil works subsidy, commencing in the first year of full operations, that would be designed to repay fully the infrastructure and civil works notes over a period of 35 years. Hence the financial analysis analyzed results over a 40-year horizon. The notes would be issued through the public financing entity.

Table 8.3 - Public-private partnership financing structure

Type of financing	*Approximate percent of total project costs*	*Sources of funding*	*Financial return*		*Government backing*
			Type	*Source*	
Equity	1.5%	Sponsors ("stakeholders")	Dividends and capital gain	Project cash flow	Partial
Convertible subordinated debentures	7.2%	Private sector investors	Interest, dividends and capital gain	Project cash flow	No
Project finance debt	20.6%	Commercial banks	Interest - floating rate	Project cash flow	No
Debt supported by guaranteed annual government subsidy	45.7%	Private sector institutional investors	Interest - fixed rate	Initially, consolidated revenue fund, ultimately fully serviced from project cash flow by way of infrastructure and civil works lease	Yes
Construction period government interest subsidy	25.0%	Consolidated revenue fund - government	None	n/a	Yes
Total financing	*100%*				

Figure 8.1 - Potential HSR contractual scheme



Equipment and technology, excluding interest costs, could be financed by the private sector. Equipment and technology notes would be issued to commercial banks and would be secured against the related assets. These notes would bear interest at 11.5% per year and would be repayable on an increasing annual scale over the 15-year period following the completion of the construction period.

Moreover, convertible subordinate debentures would be secured so as to ensure that the debt to equity ratio would not exceed 4 to 1 in respect of the equipment and technology notes. Investors' returns, assumed at 9% per year, would be in the form of base and participating interest to be received during the operating phase, and eventually by way of dividends subsequent to conversion.

Table 8.4 - Use and sources of funds for the QW-M-300

Share of financing			*Project cost and financing*
Type	*Source*	*Amount ($ millions)*	
			Infrastructure and civil works
Capitalized interest subsidy	Governments	3,310	Land and right-of-way
			Earthworks/subgrade
Guaranteed infrastructure notes (9%)	Institutional investors[1]	9,149	Stations
			Maintenance facilities
			Other accommodations
Equity	Private Sector Sponsors (50%) Governments (50%)	196	Bridges
			Grade separations
			Track
			Deferred start-up and other costs
			Capitalized interest and inflation adjustment
Sub-total		*12,655*	
			Equipment and technology
Capitalized interest subsidy	Governments	1,104	Power distribution system
			Signals
Equipment and technology notes (11,5%)	Commercial banks	3,209	Communications
			Light freight
			Rolling stock
Convertible unsecured debentures (9%) commencing during operating phase	Private investors	1,295	Capitalized interest and inflation adjustment
Equity	Private Sector Sponsors (50%) Governments (50%)	78	
Sub-total		5,686	
Total		*18,341*	

(1) Backed by government guaranteed annual contribution.

During the operating period, the construction and operations company would lease the infrastructure and civil works assets from the public financing entity and would be wholly responsible for servicing the equipment and technology notes. Excess cash flow would be used to pay dividends to shareholders, including governments (or interest to holders of subordinated debt), to make infrastructure and civil works lease payments to the public financing entity, and to pay interest on the convertible subordinate debentures.

During the same period, the public financing entity would service the infrastructure and civil works notes by way of the infrastructure and civil works subsidy or contribution. As the project becomes profitable, the guaranteed infrastructure and civil works annual subsidy would effectively be reduced by the amount of the infrastructure and civil works lease payments and by dividends to be received by the public financing entity's equity in the construction and operations company.

Financial Results

Financial results outlined in Table 8.5 indicated that under a public-private partnership, the nominal rates of return for the public sector range from 2.6% to 7.1%, including tax revenues which increase the IRR by approximately 4%. This compares to rates of return ranging from 9.4% to 12.3% after taxes for the private sector. Given that the financial experts estimate that private sector involvement requires a minimum rate of return of 12%, then the MOT-D-300 scenarios (with and without an airport connection) are the only two scenarios that attain this threshold.

By modifying the distribution of cash flows (as between the public and the private sector), it is possible to adjust the projected rate of return for the private sector for any of the scenarios envisaged to 12%.

This would potentially enable each of the scenarios to be both viable and financeable from the private sector's perspective, although at the expense of the public sector, while still maintaining a public-private partnership structure. However, such a skewing of cash distributions would weaken the relationship between risk and reward. While the private sector IRR is fixed at 12% in this analysis, the public sector IRR would decline, except for the best case scenarios, i.e. the MOT-D-300 scenarios. For all other scenarios, the public sector IRR would be less than 3.5% including tax revenue and becomes negative if tax revenue are excluded. For the MOT-D-300NA scenario, the public sector IRR would increase from 7.13% to 8.27% while the private sector IRR would decline from 12.34% to 12%.

The financial analysis concluded that, except for the 200 km/h scenarios, governments more than fully recoup their investment (on an undiscounted basis) within the first 30 years of operations. On a discounted basis, at 9%, which is the assumed government's long-term borrowing rate for the purpose of this study, and considering the conservative estimate of the residual value the governments end up paying a net contribution to the project. Should HSR proceed, it is highly likely that the interest rates at which a project is financed will differ from those used in the analysis. It must however be remembered that the real interest rate is high from an historic perspective, and inflation is relatively low.

Figure 8.2 illustrates the cash flows resulting from a public-private partnership for the MOT-D-300 scenario, which achieves an internal rate of return of 6.65% for the public sector and 12.15% for the private sector. As indicated, by year 2017, the public sector begins to receive positive cash inflows and ultimately recoups all invested funds on an undiscounted basis.

Table 8.5 - Results of financial analyses

Scenario	*QW-D-200*	*QW-M-300*	*QW-D-300*	*MOT-D-200*	*MOT-M-300*	*MOT-D-300*	*MOT-D-300NA*	*QT-M-300*
Project Capital Cost								
Constant $ (1993$ millions)	$9,451	$10,482	$10,626	$5,402	$6,079	$6,078	$5,327	$7,996
Inflated and fully financed ($ millions)	$16,444	$18,341	$18,661	$9,404	$10,639	$10,701	$9,411	$14,018
Public-Private Partnership Internal Rates of Return								
Public sector (1)	2.57%	4.56%	5.23%	3.20%	5.42%	6.65%	7.13%	5.49%
Private sector	9.38%	10.79%	11.15%	9.66%	11.15%	12.15%	12.34%	11.04%
Ranking	8	6	5	7	3	2	1	4
Public-private partnership financeability	No	No	No	No	No	Yes	Yes	No
Project Financing								
Maximum % of Private sector risk and financing	22.7%	25.3%	26.5%	22.5%	25.4%	27.4%	28.6%	26.0%
Ranking	7	6	3	8	5	2	1	4
Private Partners Fixed Rate of Returns								
Public Sector	< -7.5%	1.65%	3.36%	< -7%	2.74%	7.19%	8.27%	2.52%
Private Sector	12%	12%	12%	12%	12%	12%	12%	12%
Ranking	8	6	3	7	5	2	1	4
Public-private partnership financeability	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wholly-Public Financing								
Rates of Return	4.83%	6.58%	7.10%	5.20%	6.91%	7.86%	8.18%	6.80%
Ranking	8	6	3	7	4	2	1	5

(1) Includes tax revenues.
Note : The viability and financeability findings apply only to the private sector and are based on the assumption that the private sector will have an investment rate of 12% after taxes.

Sensitivity Analyses

The financial analysis is based on a number of assumptions with respect to costs, revenues, interest rates, etc. Table 8.6 shows the sensitivity of the results for the MOT-D-300 scenario as expressed by rates of return to changes in the various input assumptions.

The comparison of sensitivities of the public and private sectors IRR's demonstrates the greater sensitivity of the public sector to variations in some of the major inputs of the financial analysis. This is particularly the case of real interest rates and construction costs due to larger share of capital costs supported by the government. All results are most sensitive to operating revenues.

Conclusion

On the basis of the financial analysis, the following conclusions were reached:

• the project, taken as a whole, represents a high financing risk for each party involved;

• a wholly-owned private sector option is neither viable nor financeable, as the private sector's cost of funds would significantly exceed the HSR project's financial returns, regardless of the considered scenario;

• public sector risk and financial support would be minimized if construction, operating and financing risks were to be shared with the private sector;

Figure 8.2 - **Québec-Windsor HSR project, Trend analysis 1995-2025**
MOT-D-300NA

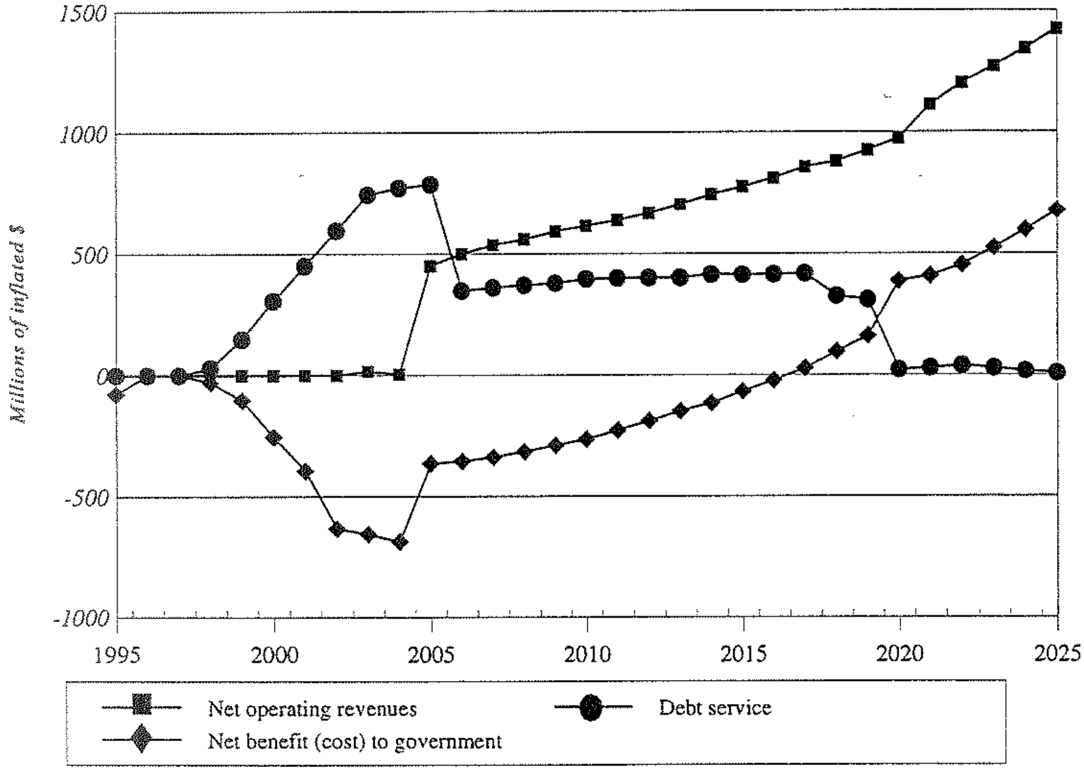


Table 8.6 - **Results of the sensitivity analysis for the MOT-D-300 scenario**
Internal rates of return

Public	*Private*	*Pessimistic*		*Optimistic*	*Private*	*Public*
6.65	12.15		Base Case		12.15	6.65
5.41	12.09	+ 1%	Real interest rates	- 1%	12.20	7.97
6.48	12.05	+ 10%	Operating costs	- 10%	12.26	6.83
5.25	11.78	+ 20%	Construction costs	- 20%	12.42	8.12
4.67	11.69	0	Terminal value	+50% (1)	12.46	7.29
5.29	11.84	+ 1 year	Construction period	- 1 year	12.45	8.09
4.73	10.99	- 10%	Operating revenues	+ 10%	12.97	8.01
2.01	10.12		Combination: revenues: ± 10%; construction costs: ± 20%; construction period: ± 1 year)		13.49	11.45

(1) 50% means that the 2035 replacement costs are reduced to 32.5% of inflated original costs.

• a wholly-owned public sector option would provide the public sector with higher financial returns than would public-private options. However, this would require the public sector to underwrite 100% of all risks and construction costs;

• the returns on the project are most sensitive to variations in construction costs, the duration of the construction period, project revenues and to the terminal value of the project, with real interest rates potentially a major factor;

• regardless of the public-private scenario envisaged, government financial support for the project will likely equal or exceed 70%;

• the 300 km/h technology options are clearly financially superior to the 200 km/h technology options;

• a Dorval routing is clearly financially superior to a Mirabel routing;

• the full Québec City-Windsor corridor option is financially inferior to the Montréal-Ottawa-Toronto and the Québec City-Toronto corridor options;

• applying public-private ownership structure in the base case financing plan (which is designed to minimize the public sector participation in the financing and construction risks), only the 300 km/h Montréal-Ottawa-Toronto (via Dorval) options would be both viable and financeable from the private sector's perspective. It is possible that a 300 km/h Québec City-Toronto (via Dorval) option could also be viable and financeable from the private sector's viewpoint;

• acceptance of construction and financing risks by the private sector is optimized on the Montréal-Ottawa-Toronto corridor;

• the private sector would not be interested in underwriting the costs of infrastructure and civil works; its interest will lie almost exclusively in sharing construction and financing risks relating to the equipment and technology;

• the private sector financial support for the project could range from 22.5% to 29.0%, depending on the public-private scenario that would be envisioned;

• it is expected that the public sector would more than fully recoup its investment (on an undiscounted basis) within the first 30 years of operation. On a discounted basis, at 9%, which is the assumed government's long-term borrowing rate for the purpose of this study, and considering the conservative estimate of the residual value, the governments end up paying a net contribution to the project. Should HSR proceed, it is likely that the interest rates at which a project is financed will differ from those used in the analysis. It must however be remembered that the real rate of interest is high from an historical perspective while inflation is relatively low;

• by modifying the distribution of cash flows (between the public and private sectors), it is possible to adjust the projected internal rates of return for the private sector to 12% for any of the scenarios considered. This would possibly enable each of the scenarios to be both viable and financeable from the private sector's perspective, while still maintaining a public-private partnership structure. However, such skewing of cash distributions would weaken the relationship between risk and return;

• if the income and capital tax revenues were to be excluded from the calculation of the internal rates of return for the public sector, it would affect the results in a negative way by approximately 4% in each case, and;

• the internal rates of return are very sensitive to changes in assumptions, as both the public and private sector investors would share only in the project's residual cash flows (after payment of project debt service).

9

Socioeconomic Impacts

The construction and operation of a major high speed rail system will have a number of long-term impacts beyond the direct financial results that must be considered when examining the overall social costs and benefits of such a system.

Impact on Other Modes

HSR will draw its users mainly from other modes. This diversion will affect both the operators of the other modes and the governments responsible for or supporting the other modes of transportation. This impact has been investigated for all modes.

Government Support of Transportation

Current levels of government revenues and expenditures on each mode were estimated for the various segments of the Québec-Windsor Corridor. These were extrapolated into the future using several key assumptions including:

- the indebtedness of all levels of government will force governments to increase revenues and decrease expenditures;
- there will be increases in hydrocarbon fuel prices after the year 2005;
- "known" vehicle technologies will be used over this period, although a number of improvements will be made;
- enhancement of the corridor network capacity will be attained mostly through operational improvements. Some additional facilities will be required, such as new runways at Pearson and Québec City airports and some limited improvements in the corridor intercity road system;
- possible deregulation of the intercity bus industry.

From these assumptions, the trends in annual government support on a per passenger-km basis were analyzed. The bus and auto modes are estimated to contribute more in taxes and user fees than all levels of government pay out for support of the automobile in terms of intercity travel. As shown in Table 9.1, this trend is expected to continue and, in fact, both modes are expected to contribute even more in the future. The rail mode is subsidized directly through VIA Rail Canada Inc. The air mode is subsidized through government expenditures on airports and air navigation and other services that are not recovered from user fees. The subsidy to the air mode is expected to decrease on a per passenger-km basis between now and 2005.

Table 9.1 - Projected annual government support in the corridor without HSR
(1992 $ millions)

Year	*Bus*	*VIA Rail*	*Air*	*Auto*	*Total*
2005	-0.6	72.9	59.2	-56.7	73.8
2025	-1.2	48.2	63.9	-228.1	-117.2

Note : Excludes accident and pollution costs

The current government revenue surplus over expenditures from inter-city auto users is expected to increase dramatically. As a result, total government support in the Corridor is expected to fall from $75 million in 2005 to become a surplus of $117 million in 2025.

The incremental effect of the construction of an HSR line on annual government support varies by mode and by HSR scenario. In the case of rail, the savings include operating subsidies and capital reinvestment. The introduction of HSR has no impact on the requirements for intercity roads, nor does it have an impact on airport construction. Net impacts are summarized in Table 9.2.

Table 9.2 - Incremental effect of HSR on annual government support in the corridor
(1992 $ millions)

Scenario	*Bus*	*Rail*	*Air*	*Auto*	*Total*
2005					
QW-M-300	-	-72.9	20.5	9.1	-43.3
QW-D-200	-	-72.9	16.5	7.7	-48.8
MOT-M-300	-0.2	-51.8	16.0	3.9	-32.1
MOT-D-200	-0.2	-52.3	12.9	3.2	-36.4
2025					
QW-M-300	-	-48.2	53.5	32.3	37.6
QW-D-200	-	-48.2	44.5	27.1	23.4
MOT-M-300	-0.3	-31.8	43.1	14.7	25.7
MOT-D-200	-0.4	-32.7	35.3	11.9	14.1

The net results show that HSR reduces government support requirements for other modes in 2005 but increases them in 2025. This occurs because inter-city auto users provide net revenue to the provincial and federal governments and the diversion of all users to HSR reduces this net flow, increasing government support requirements. The air mode is similarly affected. The diversion of travellers does not reduce the infrastructure costs but does affect government revenues.

Impact on Carriers

Impacts on the rail mode were included in the analysis of government support. Estimates of the impact of HSR on the potential profitability of the bus and air carriers are shown in Table 9.3.

The impact on the bus mode is expected to be negative for a full corridor implementation but positive for the Montréal-Toronto scenarios. In these cases the bus carriers gain passengers from conventional rail passengers who switch to bus because of higher fares on the HSR system or because their local communities are no longer served by rail.

The loss of Corridor traffic would be a significant shock to the airlines. For example, Air Canada currently derives approximately a quarter of its domestic revenue from operations in Ontario and Québec. Although route profitability cannot be determined from publicly available data, industry specialists suggest that Corridor traffic is more profitable than some other business segments.

Air carriers would continue to provide service within the Corridor if HSR is implemented. However, they would need to significantly adjust their operations to remain viable. Airlines can be expected to reduce their number of daily departures, and in some cases switch to smaller aircraft. They would also need major reductions to overhead and administrative costs.

For example, for the Québec-Windsor 300 km/h scenario, the reduction in contribution to overhead and profit of the air carriers, as shown in Table 9.3, is $170.7 million in 2025. When avoided investment is taken into account, the net loss drops to $99.1 million per year, which represents 14% of total operating costs. These $99.1 million could be reduced by further decreases in operating costs through efficiency improvements.

Table 9.3 - Incremental annual impact of HSR on overhead and profit
(1992 $ millions)

Scenario	*Bus*	*Air*
2005		
QW-M-300	-1.3	-121.5
QW-D-200	-1.2	-123.7
MOT-M-300	0.9	-96.7
MOT-D-200	1.1	-98.4
2025		
QW-M-300	-1.9	-170.7
QW-D-200	-1.6	-180.0
MOT-M-300	0.3	-137.1
MOT-D-200	0.5	-151.6

Industrial Impacts

The potential industrial benefits of implementing an HSR route in the Québec-Windsor Corridor were investigated as well as a proposed strategy to maximize these benefits. Industrial benefits are the direct employment, income and profits achieved through increased industrial activity. Industrial benefits would result from the Canadian industry's participation in the project and its further participation in U.S. and other potential international HSR projects.

Canadian Industry Participation in HSR

Canada has developed a strong, fully integrated, internationally competitive rail supply industry that mainly serves the North American conventional passenger rail and mass transit markets. The Canadian industry includes engineering, manufacturing and assembly of rail cars and locomotives, vehicle components, power supply and distribution equipment, signal equipment, communications equipment and rail and track components. Canadian industry is considered world-class for state-of-the-art conventional rail technology.

As HSR is not a revolutionary technology but rather an amalgamation of state-of-the-art components, Canadian industry can have a major participation in HSR. The technology transfer process to achieve a high-level Canadian content for an HSR project in the Québec-Windsor Corridor is not technically difficult, but costs are constraining. There is some need to adapt HSR technology to Canadian standards and climatic conditions. The cost of adapting HSR technology is estimated at roughly $20 million to cover some 40 potential research and development projects.

With appropriate industrial strategy measures and some technology transfer, it was estimated that Canadian firms could supply an estimated 85% of manufactured components for an HSR project. The distribution of the manufacturing activity would be in the order of 45% in Ontario, 35% in Québec and 5% in the rest of Canada, with the remaining 15% being imports.

The choice of technology has been found neutral relative to the Canadian content of the project, as both representative technologies (200 km/h and 300 km/h) will require the same approximate value of manufactured components and face the same Canadian sourcing options. Similarly, various routing scenarios of HSR development would not have an impact on the Canadian industrial capability, Canadian content or distribution of marketing activity.

Export Potential

Although Canadian industry has done well in the U.S. market, "Buy America" requirements continue to represent a significant obstacle to Canadian HSR exports. The mere presence of a Buy America requirement acts as an incentive for prime contractors of potential U.S. projects to consider only U.S. producers even where the Buy America requirements would permit purchases on non-U.S. goods. Since NAFTA continues to exclude Buy America provisions, the possibility of Canada gaining preferential treatment under Buy America is unlikely.

Opportunities for Canadian exporters exist, however, through waivers to the Buy America requirements. After analysis of the Buy America act and its provisions, and after an evaluation of non-legislated local content rules, it is estimated that foreign firms would be eligible to compete for 50% of the U.S. HSR market for components and services above the rail.

There is little export opportunity regardless of technology. Potential Canadian exports of HSR components and services with the different types of technologies are presented in Table 9.4. A Canadian HSR tilt technology project could potentially generate Canadian exports of components and services of $860 million over 20 years. A non-tilt technology could lead to additional exports of $500 million for 20 years. Without such projects, Canadian exports are estimated at $260 million .

It has been estimated that only six new HSR projects are expected to be built in the U.S. in the next twenty years. Most of these projects would use tilt technology on existing tracks as much as possible. There are no current plans to build new ROWs for non-tilt technology.

Tilt technology was seen as having more potential in foreign markets and therefore more opportunity for Canadian participation.

Table 9.4 - Total estimated Canadian exports of HSR components and services

Canadian project scenarios	*Total Exports Over 20 Years (1993$M Can.)*		
	U.S.	*Other international*	*Total*
With Canadian Project & Tilt Technology (200 km/h)	640	220	860
With Canadian Project & Non-Tilt Technology (300 km/h)	330	170	500
Without Canadian Project	190	70	260
Maximum Net Project Related Exports	450	150	600

Possible HSR Industrial Strategy

To maximize the potential benefits to Canada of an HSR project, the elements to consider in the development of an industrial strategy are:

- TECHNOLOGY CHOICE. From an analysis of markets for both types of technologies, it was concluded that the tilt train (200 km/h technology) has more potential for encouraging Canadian exports. This is the only strategic element related to the choice of technology;
- TIMING OF THE CANADIAN PROJECT. To ensure that potential export-related benefits are maximized, the Canadian project should be undertaken before the commissioning of the next HSR project in the United States (after the current Northeast Corridor project between Boston and Washington);
- COMPETITION. International tenders should be invited for all subsystems, without being restricted in any way to Canadian industries. However, the development of Canadian prime contractors in the electrification, communications and signalling fields should be encouraged and supported;
- CANADIAN PRIMES. Canadian prime contractors in electrification, communications and signalling should be encouraged and supported to compete for all international projects.
- INDUSTRIAL BENEFITS AGREEMENTS. Each bid should be required to include an industrial benefits plan that would outline the expected benefits and how they would be achieved. This plan should address Canadian content, technology transfer, Canadian participation in international projects, adaptive R&D and other project-related and unrelated industrial benefits;
- GOVERNMENT SUPPORT PROGRAMS. Current public sector industrial support programs should be reviewed. Programs specifically related to industrial development, export promotion and R & D should be used to strengthen Canadian capabilities and HSR technology;
- R&D STRATEGY. Specific areas of R&D should be investigated to strengthen Canadian industry. They include the development of distinctive Canadian technology in HSR tilting, turbine locomotives, signalling and communications.

Impacts on Urban Systems

The potential impacts of an HSR line on urban systems in the Québec-Windsor Corridor were examined. Because of the qualitative nature of this analysis, it could not be specific to a particular technology or scenario.

High speed rail will reinforce the Québec-Windsor Corridor as Canada's primary urban area. However, other factors such as immigration, free trade, the Auto Pact, etc. will have far more significant impacts on urban systems and settlement patterns. Most importantly, an HSR line will not substantially alter the Corridor's relationship to other areas in Canada and the United States since the Corridor already has a highly developed inter-community transportation network. HSR will, however, enhance the Corridor and make it more attractive to visitors.

HSR will tend to reinforce the general trend towards larger urban areas. However, the magnitude of this centralizing effect can vary significantly depending on how well HSR stations are linked by other transportation services to communities not directly served by HSR. There are also pressures for larger urban areas to decentralize, a trend that HSR could facilitate.

HSR Station Location

Commercial interest (passenger ridership) and urban redevelopment potential generally suggest that downtowns are preferable as HSR station locations in larger communities because:

- central business districts contain dense concentrations of potential HSR riders;
- economic activity in the core is more likely to involve intercity passenger travel;
- downtowns focus major tourist attractions;
- downtown-to-downtown service is the HSR's key competitive advantage over other modes; and
- development pressure will be focused in the core area, thus enhancing the potential real estate value increases that an HSR station might trigger.

HSR stations are sometimes seen as developmentcatalysts, but the findings suggest this is true only in certain circumstances. HSR stations are likely to focus or accelerate existing market pressure rather than create new market pressure. Development potential next to HSR stations will have to be supported by active marketing efforts and effective use of public land holdings.

The effect of station location on real estate prices would also be modest, except in cases where HSR stations are in areas with a well established market for development. The location of an HSR station is less significant in smaller communities because access is less of an issue. There, ease of travel and shorter core-fringe distances mean that the station location is less important than whether or not HSR service is available.

Impacts on individual urban areas

WINDSOR. HSR impacts on Windsor would be modestly positive, but by no means as important to the community as a healthy automobile sector.

LONDON. HSR would improve London's accessibility to other centres in southern Ontario. However, the net benefit of this improvement is likely to be mitigated by the fact that the HSR provides a modest rather than a dramatic improvement in accessibility to Kitchener and Toronto, which are located less than 200 km away from London.

KITCHENER. Kitchener-Waterloo has a very high rate of intercity travel, mostly to Toronto, and HSR would provide improved service along the key Highway 401 corridor. Kitchener-Waterloo will continue to grow and to have a strong economy with or without HSR. HSR would, however, accelerate development in the vicinity of the station. HSR will also reinforce Kitchener's strong links to Toronto.

TORONTO. Toronto is one of the focal points for intercity passenger travel within the Québec-Windsor Corridor. A total of 26 million trips are made between Toronto and other major urban areas within the Corridor. HSR, to the degree that it brings other Corridor communities "closer" to Toronto, will tend to reinforce Toronto as a centre of social and economic activities. There is some potential for the HSR to increase Toronto's commutershed (to Kingston, London and Kitchener-Waterloo) but the anticipated HSR fare structure is likely to limit the magnitude of this effect.

KINGSTON. Kingston is not a large community compared to the other HSR centres but it plays an important role both as a regional centre for eastern Ontario and as an important institutional centre. The increase in accessibility brought about by the HSR for Kingston would be very significant as the City currently has less developed air service to other Corridor centres.

OTTAWA-HULL. Ottawa-Hull has important relations with all other centres of the Corridor and HSR will strengthen these links. Ottawa-Hull's strength as a business, tourism and government centre will be reinforced by the increased ease of intercity access brought about by HSR.

MONTRÉAL. The outlook for Montréal is positive, and this community will continue to have an important influence within Québec and Canada based on both its economic and cultural significance. Montréal has extensive relations with other communities, particularly with Québec City and Ottawa-Hull. HSR would benefit both the business and tourist sectors of Montréal's economy as it will facilitate the expansion of their markets.

TROIS-RIVIÈRES. Trois-Rivières is a manufacturing and natural resources-oriented region which has experienced a relative decline in its economic importance. HSR will have a limited effect on the outlook for Trois-Rivières for two important reasons. First, HSR would provide only a modest improvement in accessibility to the region. Most people will continue to drive to Montréal, a 142 km trip. Secondly, Trois-Rivières' economic structure would not significantly benefit from HSR; business service, tourism activities and institutional functions are not primary components of the regional economy.

QUÉBEC CITY. Québec is an important regional service centre and the provincial capital. HSR would have a positive effect on Québec City, particularly as a result of its increased accessibility to Montréal. Although Québec could lose out to Montréal in some areas of specialized services, HSR could also help retain some government or other activities that might otherwise move to Montréal. Québec's attraction as a tourist destination will clearly benefit from an improved level of accessibility with other Corridor centres.

Long Term Environmental Impacts

Scope and Objectives

One of the O/Q RTTF recommendations was to undertake a more detailed assessment of the environmental costs and benefits associated with the introduction of HSR. The specific objectives of this study are to identify the long term environmental impacts of HSR and quantify them as much as possible, for inclusion in the cost-benefit analysis. This was to include direct and indirect impacts on biophysical systems and social elements that are important to the justification of a choice between HSR and other approaches to intercity passenger services. The comparative analysis therefore investigated not only the HSR technologies under study but also a conventional multi-mode development scenario (without HSR), in which existing conventional passenger transportation modes develop to satisfy projected demand for intercity transportation.

The quantified environmental and socio-economic factors analysed include:

- energy consumption
- air pollution
- public safety
- land use and natural ecosystems

The non-quantified factors include:

- noise and vibrations
- mobility
- regional economic development
- location of economic activity.

The findings presented hereafter are based on quantitative outputs produced by the various component studies, including the traffic forecasts for the various modes of transportation with and without HSR.

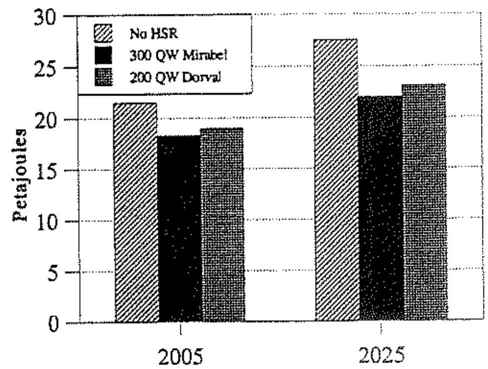
The impacts on regional economic development and location of economic activity are presented in other sections of this chapter.

Energy consumption

Investment in HSR would contribute to reduce the anticipated increase in energy consumption for intercity transportation in the corridor. By the year 2025, annual energy consumption in the corridor associated with the conventional multi-mode scenario would be reduced by 20% in the case of the 300 km/h HSR scenario and by 16% in the case of the 200 km/h HSR scenario.

Additional environmental benefits associated with the use of local renewable energy sources, such as hydroelectricity, would be limited to the section of the HSR corridor located in the Province of Québec, where hydroelectricity is the dominant energy option. Figure 9.1 presents the inter-city travel energy consumption in the corridor, with and without HSR.

Figure 9.1 - Impact on energy consumption



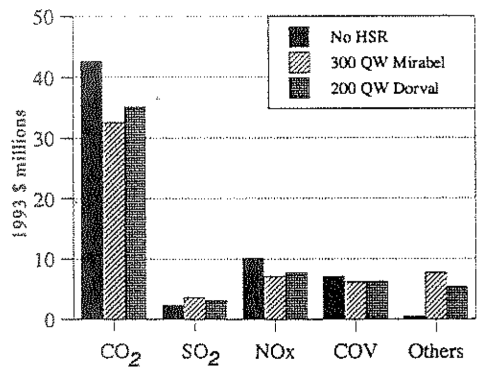
Air pollution

Atmospheric emissions contributing to the greenhouse effect (CO_2 and CO) would be reduced by the introduction of HSR. By the year 2025, annual emissions of carbon dioxide and carbon monoxide related to intercity travel within the corridor would drop by 24% and 11% with the introduction of the over 300 km/h technology and by 18% and 10% with the 200 km/h technology.

Atmospheric emissions contributing to low level ozone and urban smog (NOx and VOCs) would also diminish. By the year 2025, annual emissions of nitrous oxides related to intercity travel within the corridor would drop by 31% in the case of the 300 km/h technology and by 25% in the case of the 200 km/h technology. Volatile organic compounds would be reduced by 13% and 11% respectively for the 300 and 200 km/h systems.

Because of atmospheric emissions resulting from thermal power generation in Ontario, investment in HSR would lead to an increase in emissions contributing to acid rain and to urban smog (SO_2 and SP). By 2025, annual emissions of sulphur dioxide and suspended particles would respectively increase by 46% and by a factor of 15 for the over 300 km/h technology, and by 28% and a factor of 10 in the case of 200 km/h technology, relative to the conventional multi-mode scenario. The impact on these various air pollution emissions in 2025 are presented in Figure 9.2.

Figure 9.2 - Impact on air pollution emissions in 2025



Public safety

Because existing HSR systems have experienced no fatalities, investment in HSR would contribute to reduce the anticipated number of fatalities and injuries related to intercity travel within the corridor. The impact on public safety is shown in Figure 9.3. By 2025, the annual number of fatalities would be reduced by 31% in the case of the over 300 km/h technology and by 30% in the case of the 200 to 250 km/h technology. The annual number of severe injuries would be diminished by 12% for the over 300 km/h technology and by 10% for the 200 to 250 km/h technology. Most of these reductions are due to reduced automobile traffic and elimination of at-grade road crossings.

Figure 9.3 - Impact on public safety

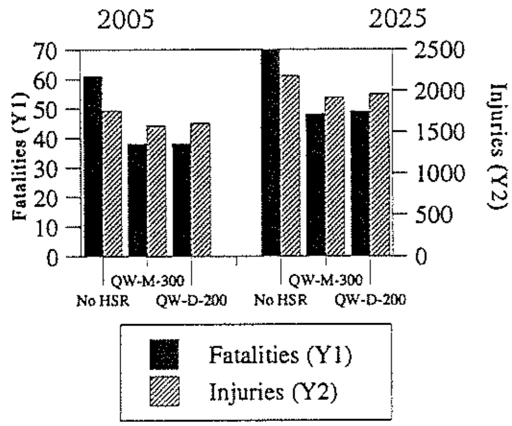


Table 9.5 presents the total monetary value of fatalities and injuries.

Table 9.5 - Total monetary value of death and injuries (1993$ millions)

	2005	2025
No HSR	233	280
QW-M-300	183	225
QW-D-200	186	231

Land use and natural ecosystems

Preliminary routing studies have identified environmentally sensitive areas. Although appropriate planning can reduce the intrusion of HSR within these areas, there could still be some impacts with respect to the loss of environmentally sensitive areas, barrier effects for terrestrial fauna, the quantity and quality of surface and ground water, and the integrity of aquatic and terrestrial habitats. Appropriate mitigation measures, as defined by the environmental assessment studies, would minimize these impacts. Some of these costs have been included in the costing of the routes.

Similar planning and mitigation measures can also minimize impacts with respect to crop losses on high quality land, to the loss of land in rural and urban communities as well as in commercially valuable natural resources areas, to barrier effects in inhabited areas, and to the disposal of potentially contaminated soils in existing and future rail rights-of-way.

The total monetary value of lost crops on high quality agricultural lands (classes 1 and 2) over the life of the project as a result of implementation of HSR have been estimated at $130.3 million (1993) in the case of the over 300 km/h scenario and at $111.6 million (1993) in the case of the 200 km/h scenario. These losses would occur as land begins to be purchased.

Noise and Vibration

One major environmental problem associated with HSR is the aerodynamic and wheel/rail noise level. Wheel/rail noise exists at speeds under 200 km/h. Above 200km/h, aerodynamic noise becomes the dominent factor. Although there is considerable effort from suppliers to reduce noise levels, appropriate mitigation measures would be required and have been costed in the infrastructure capital investments.

Mobility

Although HSR would generally increase mobility within the corridor and offer services to persons with disabilities, it would reduce access in smaller communities due to the closing of several conventional rail stations.

Conclusion

The environmental and socioeconomic analysis carried out for the study confirms that investment in high speed rail in the Québec-Windsor corridor would represent a slight benefit for the human and natural environment. The analysis also confirms that investment in the over 300 km/h technology would lead to greater environmental and socioeconomic benefits than investment in the 200 km/h technology.

Economic Impacts

Objectives

The economic impact study evaluates the direct, indirect and induced effects of implementing HSR on output, employment and income for the Canadian economy as well as for the economy of Québec and Ontario. More than aggregate implications are measured, since the analysis takes into account the industries that would supply HSR as well as the fact that HSR would displace conventional rail and other transportation services operated by businesses, in addition to household use of the automobile.

Methodology

Two econometric models were used to assess HSR impacts, a national level model and a provincial level model. They include a detailed disaggregation of the economy, which allowed the incorporation and evaluation of results from other component studies on impacts on other modes, including the conventional rail mode.

Key Findings

Given the financial support required from governments, the Steering Committee decided that this additional financial support would be funded by correspondingly reduced capital expenditures on the part of the federal government and the governments of Québec and Ontario. This assumption has a crucial effect on the economic impacts of HSR. Sensitivity of the results to deficit financing has also been evaluated.

Since an HSR system would shift economic resources, this reallocation of resources in the private economy would be approximately balanced from the year 2004 onwards. Under such circumstances, one should expect that total output, employment and real incomes in the economy would be little changed. This has been confirmed by the detailed economic analysis.

During the construction period (1995 to 2003), which will require additional employment and other real economic resources, real output and other measures of economic activity are increased significantly. However, during the operating period, the size of the economy would be reduced to levels of activity below those that would otherwise prevail because of reduced spending on other capital expenditures, VIA Rail subsidies and reduced air carrier investments. Table 9.6 presents some key findings, which are discussed hereafter.

Real Output Impacts (GDP)

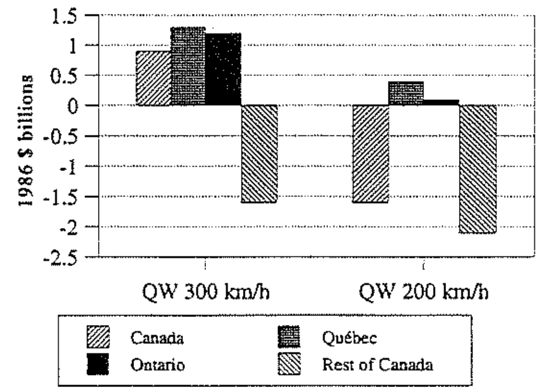
For Canada, in the 300 km/h scenario, cumulative changes in real output measured by GDP at factor cost would be of the order of $0.9 billion (1986) over the 1995-2020 time horizon. This cumulative change varies enormously during the construction and operating phases. During the construction phase (1995 to 2003), real output impact would be $5.8 billion (1986) whereas it would be of -$4.8 billion (1986) during the operating phase (2004 onwards). The same trend reversal applies to impacts in Québec and Ontario.

For Canada again, in the 200 km/h scenario, cumulative changes in real output measured by GDP at factor cost would be negative at -1.6 billion of 1986 dollars over the 1995-2020 time horizon. During the construction phase (1995 to 2003), real output impact would be $5.1 billion (1986) whereas it would be of -$6.7 billion (1986) during the operating phase (2004 onwards). For Québec and Ontario, the net cumulative impact of HSR is marginally positive at $0.4 billion (1986) over the 1995-2020 period for Québec and at $0.1 billion (1986) for Ontario over the same period. The same trend reversal from construction to operating period applies to impacts in Québec and Ontario.

Table 9.6 presents the impact on the Canadian GDP for the base case scenarios as well as for the MOT-D-300 scenario. Figure 9.4 presents the cumulative impacts on GDP for Canada, Québec, Ontario and the rest of Canada. Negative impacts in the rest of Canada result from a shift in government expenditures. This is directly attributable to the assumption that the federal government would contribute to the project by reducing its other capital expenditures.

The scale of these cumulative impacts within the global size of the economy are judged to be insignificant. The peak expansion of overall economic activity (and employment) during the construction phase should reach at most 0.4% and 0.3% in Ontario and Québec, for three to four years into the next century. In this sense only does HSR have a significant impact.

Figure 9.4 - Cumulative impacts on output from 1995 to 2020



Employment Impacts

In Canada, for the 300 km/h scenario, cumulative changes in employment would be of the order of 43,700 person-years over the 1995-2020 time horizon. This cumulative change varies dramatically during the construction and operating phases. During the construction phase (1995 to 2003), employment creation effect would amount to 107,600 additional person-years whereas it would be negative (-63,800 person-years) during the operating phase (2004 onwards). The same reversal of trend applies to employment impacts in Québec and Ontario.

For Canada, in the 200 km/h scenario, cumulative changes in employment would be of the order of 14,600 person-years over the 1995-2020 time horizon. During the construction phase (1995 to 2003), employment creation impact would amount to 95,500 additional person-years whereas it would be negative (-81,000 person-years) during the operating phase (2004 onwards). The same trend reversal from construction to operating period applies to employment impacts in Québec and Ontario.

Figure 9.5 presents the cumulative impacts on employment from 1995 to 2020 (in the two base case scenarios for Canada, Québec, Ontario and the rest of Canada).

Figure 9.6 displays, for the 300 km/h base scenario, the annual impact on employment, which mirrors the output effects.

Table 9.6 -Economic impacts, key findings

	1995-2003	2004-20	1995-2020
Total GDP at Factor Cost (1986$ billions)			
QW-M-300	5.8	-4.8	0.9
QW-D-200	5.1	-6.7	-1.6
MOT-D-300	3.2	-1.5	1.7
Employment (000)			
QW-M-300	107.6	-63.8	43.7
QW-D-200	95.5	-81.0	14.6
MOT-D-300	61.1	-29.0	32.0
Public Sector Debt (1986$ billions)			
QW-M-300	-4.1	-2.5	-6.6
QW-D-200	-3.7	-0.6	-4.3
MOT-D-300	-2.4	-2.5	-4.9

Figure 9.5 - Cumulative impacts on employment from 1995 to 2020

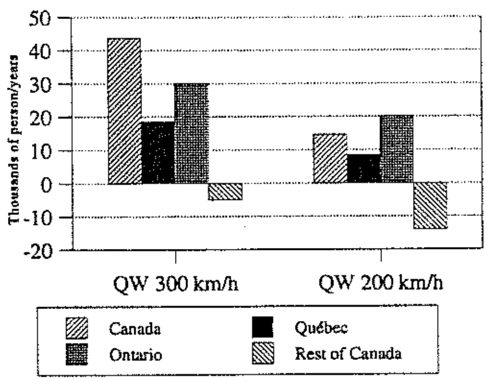
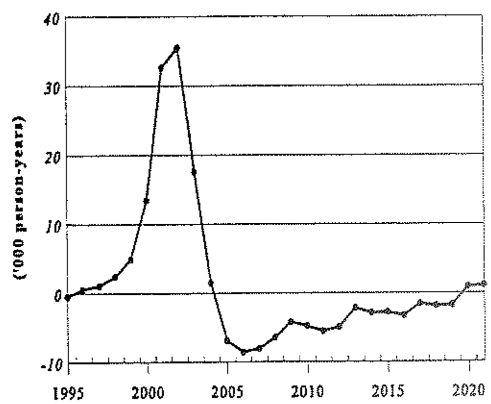


Figure 9.6 - Total impact on employment in Canada (QW-M-300)
1995-2020



Comparative Analysis

The scale of the impacts during the construction phase is sensitive to the length of line and speed of the proposed HSR. The full corridor (Québec to Windsor) scenarios require more investment resources and generate more domestic output than do the Montréal-Toronto scenarios. The over 300 km/h scenarios, similarly, require more resources and generate more domestic activity than do the 200 km/h scenarios.

During the operating phase, the reductions in overall activity in other sectors are partly symmetrical to positive HSR impacts during the operating phase. Reductions in economic output are larger for the full corridor scenarios. However, because the 200 km/h scenarios are less viable financially, reduced government capital spending to fund larger net contributions to the operating company produce larger negative impacts than for the over 300 km/h scenarios.

Concentration of Impacts

Since HSR spending is concentrated in infrastructure, which in turn is highly concentrated in construction of the rail lines and associated facilities, real economic impacts during the construction phase will be highly concentrated in Québec and Ontario. Equipment procurement targeted in Central Canada reinforces this. Finally, since induced spending is disproportionately directed to consumer durables, Central Canada, as the location of such production, also benefits.

Government Capital Formation

As noted before, as operations of HSR begin, and over the 2004-2020 period, additional economic resources required to operate HSR are approximately offset by reduced private spending for other modes of transportation. That is, private demand and economic activity are largely neutral for total output, and involve only reallocations of resources to alter the mode used by passenger traffic. Accordingly, results during this period are dominated by reduced government capital formation. Soon after 2003, these reductions are relatively large, but diminish as the net financing requirements of the HSR operating company move towards zero.

Cost/Price, Domestic, Income and Tourism Impacts

No substantial impacts on aggregate costs or prices are anticipated, and throughout most of the operations phase, there are small, but continuing negative effects on household and business incomes. Given the cost/price effects, no generalized impact on the foreign trade in travel services is anticipated. Reduced domestic incomes suggest that, within Canada, demand for restaurants, accommodation and recreational services would diminish, which suggests a small reduction in prospects for the tourism industry. By 2020, however, level of activities in this and all other industries, will have returned to those of the base case (without HSR).

Public Sector Balances

Over the full 25 years, results show that public sector balances would be cumulatively improved. Stocks of debt should be reduced by $6.6 billion (1986) for the 300 km/h scenario and $4.3 billion (1986) for the 200 km/h scenario. For the public sector as a whole, this follows from the fact that positive effects on balances of a strengthened economy during the first decade reduce their succeeding interest payments by more than the annual deficits emerging during the operations phase.

Sensitivity to Debt Financing

Table 9.7 presents results of a government funding financed through debt expansion. Real output is increased over the operations phase, at the expense of growing government deficits and increased foreign borrowing. For the full corridor 300 km/h scenario, the stock of debt would increase by $8.2 billion (1986), compared with a reduction of $6.6 billion (1986). For the national economy, the increase in GDP is 55% to 60% higher during construction and cumulated over 1995-2020, the effect is approximately 10 times larger. Employment would increase by 192,000 jobs, instead of 43,700.

Table 9.7 -Economic impacts, sensitivity to debt financing

	1995-2003	*2004-20*	*1995-2020*
Total GDP at Factor Cost (1986$ billions)			
QW-M-300	8.5	1.5	10.0
MOT-D-300	4.8	1.3	6.1
Employment (000)			
QW-M-300	155.5	37.2	192.8
MOT-D-300	89.9	15.5	105.4
Public Sector Debt (1986$ billions)			
QW-M-300	-1.8	10.0	8.2
MOT-D-300	-1.1	3.6	2.5

Conclusion

On balance, the economic analysis indicates that HSR should have visible, if modest, positive impacts on economic output, employment and income for about a decade.

HSR has no significant implications for productivity or the structure of the economy outside the transportation services, and there are no permanent impacts on growth potential or prospects.

10

Cost-Benefit Analysis

Scope and Results

Another recommendation of the O/Q RTTF was to undertake a full cost-benefit analysis of the impacts of introducing HSR in order to have a fair and detailed assessment of the project's economic viability. The specific objectives of this study were to evaluate the economic viability of HSR both from the point of view of Canadian society as well as from the Ontario and Québec government perspective. For these reasons, two different models were developed: the Canadian model, a classical cost-benefit model, where all costs and benefits related to Canadian society are taken into account, and a provincial model, which considers the project from the point of view of Québec and Ontario. This latter model combines costs and benefits from the point of view of the provincial governments and their constituents.

Because the methodology for this analysis was developed at the outset, all studies were designed to provide as many quantitative inputs as possible for the cost-benefit analysis.

Table 10.1 outlines the main results of the analysis using an 8% discount rate for the six main scenarios analysed, in terms of net present value (NPV) for both the Canadian and provincial models.

Methodology

Cost-benefit analysis compares the economic costs associated with the implementation of a project over a given period with the economic benefits it generates, using the dollar as unit of measurement. The time horizon considered in the present cost-benefit study is 30 years, from 1995 to 2025. This type of analysis compares economic costs and benefits from the point of view of society, taking into account the social opportunity cost of resources that would be used in the project. These costs and benefits are then brought back to the same reference period through discounting. In the present study, all costs and benefits were brought back to 1995. The resulting net present value becomes the criteria by which the project's economic viability is established. If the net present value is positive, the benefits it generates are higher than the costs, and the project is viable from the point of view of society.

Table 10.1 - Net present value at 8% discount rate
(1993 $ millions)

Scenarios	*NPV Canada*	*Rank*	*NPV Québec*	*Rank*	*NPV Ontario*	*Rank*
QW-M-300	683.5	4	-166.2	5	171.4	4
QW-D-200	-319.7	6	-222.1	6	-531.7	6
QW-D-300	1,186.8	2	122.6	2	260.9	3
MOT-M-300	687.9	3	-53.0	4	283.0	2
MOT-D-200	82.7	5	6.9	3	-212.5	5
MOT-D-300	1,284.8	1	245.1	1	430.1	1

Note: Québec and Ontario results come from different models and therefore do not add to Canada results.

To measure the full impact of a project on the welfare of society, cost-benefit analysis compares the project under study with a reference situation (without HSR) and determines whether the project yields marginal benefits greater than marginal costs. This type of analysis therefore strives to achieve an optimal allocation of resources.

Since the objective of the analysis was to evaluate the project both from the point of view of Canada as a whole and from the point of view of the two main provinces who would be funding it, two different models were developed, as mentioned previously. The main costs and benefits for the Canadian model are as follows:

- investment costs for HSR and light freight trains;
- savings in investment costs in VIA Rail;

- operating costs for HSR and light freight trains and station concessions;
- savings in Via Rail operating costs;
- exchange rate premium;
- negative environmental externalities;
- operating revenues (including taxes) for HSR and for light freight trains and station concessions;
- consumer surplus;
- residual values;
- direct, indirect and induced labour externalities;
- positive environmental externalities; and
- variations in costs and revenues of other competing modes (air and road) as a result of implementation of HSR.

Most of the above-listed variables were provided by the component studies or were derived using input from the component studies. Exchange rate premiums as well as direct, indirect

Consumer surplus

The concept of consumer surplus is based on economic theory at the level of individual consumers. The demand for a commodity (such as a good or a service) is related to the cost of the commodity. It is almost always true that as the cost decreases, demand will increase. The reason for purchasing a commodity is that, for some combination of reasons, an individual perceives the value of the commodity to be at least as great as the cost. The perceived value of the commodity minus the cost of the commodity is referred to as the "consumer surplus" of that individual. For example, a person might be willing to pay $150 for a train trip from Montréal to Windsor, but if the ticket costs only $125, he would have a "consumer surplus" of $25. If a person perceived the value of the trip to be less than $125, he would decline to purchase the ticket.

If the cost of the train trip from Montréal to Windsor were lowered to $105, our individual would experience a net increase in benefit of $20, because he or she was willing to "pay" at least $125 in order to make the trip. It is easy to extend this principle to the total market, because we know that all people making the trip when it costs $125 were willing to "pay" at least that much, thus they have each received an increase of $20 in benefit. In addition, this decrease in cost would have attracted more train travellers; in this case, the people that valued the trip at less than $125 but more than $105. It is usual to assume that the new riders value the trip at an average value of $115, giving the new travellers an average consumer surplus of $10 (half the value of the increase for the other travellers).

In applying this concept to HSR, generalized costs have been used. Generalized costs include the cost of access and can include the monetary equivalent value of access time, waiting time and travel time. In addition, it can include the monetary equivalent of modal constants which represent the relative attractiveness of different modes. For example, if a consumer was to feel that the value of riding a train is worth $10 more than riding a bus because of considerations such as comfort, reliability, etc., then this value of the modal constant could also be included in consumer surplus calculations. The values of the modal constants were developed in the calibration of the forecasting models.

The precise definition of the monetary values to be included in consumer surplus is subject to discussion. This concerns particularly the value of waiting times which according to some forecasting models are half the frequency or the mode of travel (air, bus, rail). Some may argue that passengers arrive just in time for their flight or train and that any change in frequency does not affect the generalized costs. There is also no unanimity concerning whether the values of modal constants should be included.

Because of these issues, the following alternative definitions of consumer surplus have been used in the cost-benefit analysis :

- a base case including monetary costs (of fares and access costs), the value of travel time and wait time savings;
- an optimistic case including monetary costs, the value of travel time and wait time savings, and the value of the modal constants;
- a conservative case for sensitivity purposes with zero consumer surplus.

Table 10.2 presents the total values in 1993$ for each scenario and the net present value of the consumer surplus.

Table 10.2 - Consumer Surplus (1993$ millions)

Scenario	*Total value*	*NPV*
QW-M-300	6,671.9	1,360.7
QW-D-200	4,685.2	976.4
QW-D-300	7,850.7	1,607.5
MOT-M-300	4,662.2	943.2
MOT-D-200	3,353.1	696.7
MOT-D-300	5,717.4	1,164.1

and induced labour externalities were calculated in the cost-benefit study, consumer surplus being a distinguishing feature of the cost-benefit analysis.

The provincial models analyse the impact on the Québec and Ontario collectivities and on their respective provincial governments' finances. Therefore, the contributions that the two provinces would have to provide to fund the project are very important and are taken into account.

The main provincial costs and benefits are as follows:

- the direct and indirect provincial (Québec and Ontario) contributions to HSR; the indirect contribution being the provincial share of the Federal contribution to HSR;
- savings in the provincial contribution to the federal subsidy to Via Rail;
- foreign exchange premiums attributable to Québec and Ontario;
- variations of the provincial contributions to the subsidies to other competing modes;
- negative environmental externalities attributable to Québec and to Ontario;
- fiscal impacts on Québec and Ontario;
- consumer surplus attributable to Québec and Ontario;
- residual value attributable to Québec and Ontario;
- direct, indirect and induced labour externalities due to HSR attributable to Québec and Ontario;
- loss in labour externalities attributable to Québec and Ontario as a result of reduced Via Rail service; and
- positive environmental externalities attributable to Québec and Ontario.

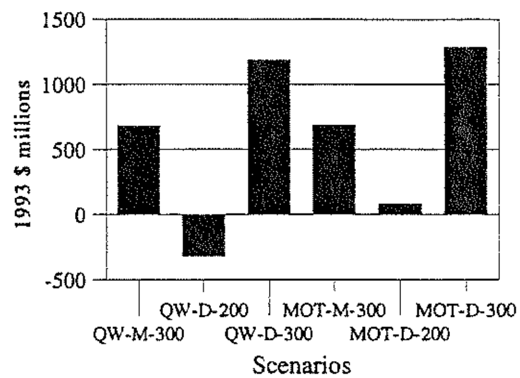
Impacts on other competing modes include impacts on airlines, the bus industry and on automobiles. Investigation into these revealed that there would be no impact on infrastructure investments for other modes, but that there would be impacts on their operating costs, revenues, levels of subsidies and investment in equipment. This impact has not been considered in the main results of the benefit-cost analysis, on the assumption that the long-run unit costs of the industries would not be adversely affected. However, recognizing that there is debate over this, the impact on other modes has been calculated as part of the sensitivity analysis.

Canadian Model Results

The discount rate is a very important factor in the cost-benefit analysis. The federal government uses a 10% discount rate in all their analyses. A 7% discount rate was suggested by the consultants in charge of the benefit-cost analysis as it approximates the real rate of interest on borrowed funds in the financial analysis. Also, this rate is used by Hydro-Québec in evaluating large hydroelectricity projects. The three governments agreed on a discount rate of 8% to be used as the base case for the purposes of this study.

Figure 10.1 outlines the main results of the study in terms of net present value (NPV) for the Canadian model.

Figure 10.1 - Net present value
(Canadian model, base case)



At an 8% discount rate, with a consumer surplus in the range of $21 per passenger, all scenarios under study are economically viable except the 200 km/h scenario covering the entire Québec-Windsor Corridor. The most economically viable scenario is the 300 km/h scenario covering the Montréal-Toronto segment with a routing through Dorval (MOT-D-300), with a net present value of $1,284.8 million (1993). This is followed by the same scenario covering the entire Québec-Windsor Corridor (QW-D-300) which has a net present value of $1,186.8 million (1993).

Other major results are as follows:

- the 200 km/h scenarios are clearly inferior to the 300 km/h scenarios;
- routing through Dorval is clearly superior to routing through Mirabel;
- scenarios covering only the Montréal-Toronto segment are clearly superior to those covering the entire Québec-Windsor Corridor;
- inclusion of the impacts on other competing modes reduces the economic viability of all scenarios; and
- summary analysis of the Québec-Toronto scenario at 300 km/h through Mirabel reveals that this scenario yields a higher net present value than the Québec-Windsor or Montréal-Toronto 300 km/h scenarios through Mirabel, but lower net present value than the 300 km/h scenarios with routing through Dorval.

Net operating revenues are the largest benefits for all scenarios studied. They represent from 62% to 68% of total benefits, according to the various scenarios under study. This is followed by consumer surplus, which represents from 17% to 23% of benefits. Together, they account for 79% to 91% of benefits and are by far the most important. Next is residual value, which represents from 10% to 12% of overall benefits and labour and environmental externalities, which make up from 3% to 6% of total benefits.

On the cost side, net investment costs represent an overwhelming 86% to 92 % of total costs. The relative share of net operating costs ranges from 7% to 13 %, for a total investment and operating costs share of 99%. Other economic costs are foreign exchange premium, and labour and negative environmental externalities.

Provincial Results

Figures 10.2 and 10.3 present the main results of the study in terms of net present value (NPV) for the provincial models.

These results assume that the investments in HSR would be supported in proportions of 50% by provinces and 50% by the Federal government. For interprovincial segments, provincial investments would be shared proportionally to the length of track built in each province and the relative origin of forecasted passengers. Any change in these assumptions would modify the results of these provincial models.

For Québec

At the Corridor level, at an 8% discount rate, only the 300 km/h scenario with a Dorval routing is viable. At the level of the Montréal-Toronto segment, both the 200 km/h and the 300 km/h scenario with a Dorval routing are viable. As indicated in Figure 10.2, the most economically viable scenario is the 300 km/h scenario covering the Montréal-Toronto segment with a routing through Dorval, with a net present value of $245.1 million (1993). This is followed by the same scenario covering the entire Québec-Windsor Corridor ($122.6 million - 1993).

Other major findings include:

- the 200 km/h scenarios are clearly inferior to the 300 km/h scenarios;
- routing through Dorval is clearly superior to routing through Mirabel; and
- scenarios covering only the Montréal-Toronto segment are clearly superior to the ones covering the entire Québec-Windsor Corridor.

Consumer surplus is an important benefit for all scenarios under study for Québec. This benefit ranges from 43% to 62 % of the total benefits. This is followed by residual value, the relative share of which ranges from 18% to 29%. Together, these two benefits represent between 72% and 81% of total benefits. Fiscal impacts come in third position with a relative weight of 13% to 17%. Finally, labour and environmental externalities account for 5% to 12% of benefits.

On the cost side, the net government contribution to HSR represents an overwhelming 98% of total costs, the rest being made up of exchange rate premium and negative environmental externalities.

Figure 10.2 - Net present value
(Québec model, base case)

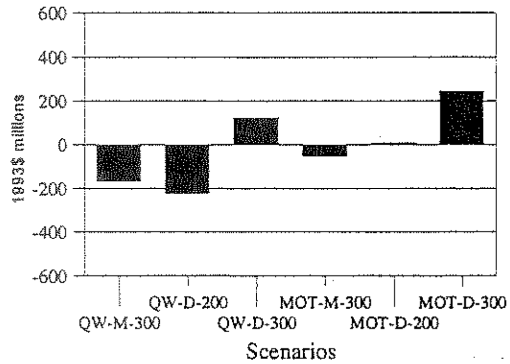
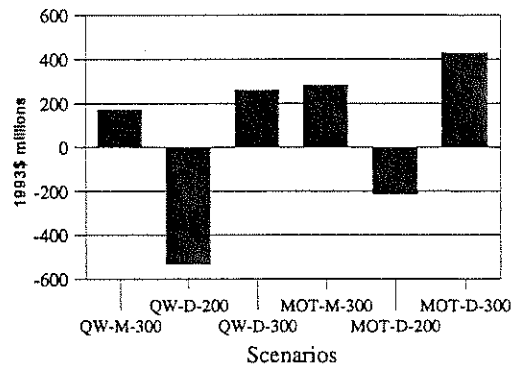


Figure 10.3 - Net present value
(Ontario model, base case)



For Ontario

At the Corridor level, at an 8% discount rate, all scenarios except the 200 km/h scenarios are viable, as indicated in Figure 10.3. The most economically viable is again the Montréal-Toronto 300 km/h scenario through Dorval with a net present value of $430.1 million (1993). This is followed by the Montréal-Toronto 300 km/h scenario with a Mirabel routing.

Other major findings include:

- the 200 km/h scenarios are clearly inferior to the 300 km/h scenarios;
- routing through Dorval is clearly superior to routing through Mirabel; and
- scenarios covering only the Montréal-Toronto segment are clearly superior to the ones covering the entire Québec-Windsor Corridor.

Consumer surplus represents from 52% to 58% of total benefits. This is followed by residual value, which accounts for 20% to 22% of total advantages. Together, they make up 75% to 80% of all benefits. Fiscal impacts come in third position with a relative weight of 9% to 12%. Finally, labour and environmental externalities account for the remainder, that is between 10% and 15% of total benefits, according to the scenario under study.

On the cost side, for Ontario, the net provincial contribution to HSR accounts for 98% of all costs, the remainder being the exchange rate premium and negative environmental externalities.

Sensitivity Analyses

Sensitivity analyses with respect to the following parameters were undertaken:

- the discount rate (7% and 10%, 8% being the base);
- residual value (low and high, medium being the base);
- level of consumer surplus (zero and high, medium being the base);
- revenues (±10% from original forecast); and
- investment costs (±10% from original forecast).

Given the very low level of labour and environmental externalities, no sensitivity runs were done on these variables, as they would not have had any significant impact on the results. The sensitivity analyses were performed on the base results, which exclude impacts on other modes as well as on results that include impacts on other modes.

Results of these analyses suggest that:

• Results are most sensitive to variations in the discount rate, the level of consumer surplus, investment costs and revenues.

• Inclusion of the impacts on other modes reduces the economic viability of all scenarios in the Canadian model but has the reverse effect at the provincial level. This is due to the nature of the provincial models, in which the only marginal costs considered are subsidies to other modes. Since the latter will drop because of HSR, this cost reduction improves the viability of all scenarios.

To illustrate the above results, Table 10.3 outlines the results of the sensitivity analyses on the MOT-D-300 scenario, which is the most economically viable for Canada, Québec and Ontario, with and without the impacts on other modes.

Québec-Toronto

An NPV of $762.5 million (1993) has been estimated for the QT-M-300 scenario. These results are superior to the full corridor 300 km/h scenario through Mirabel $693.5 million (1993). The Québec provincial results show a negative NPV of $40.7 million (1993) compared with -$166.2 million for the full corridor. The Ontario provincial results are of $154.3 million compared with $171.4 million for the full corridor.

Major Findings

In summary, the major findings of the cost-benefit study are the following:

Routing is very important, as results show that routing through Dorval is always superior to routing through Mirabel;

The 300 km/h technology produces economic results that are superior to the ones obtained with the 200 km/h technology;

The discount rate is a very important factor in the cost-benefit analysis. The federal government uses a 10% discount rate in all their analyses. A 7% discount rate was suggested by the consultants in charge of the benefit-cost analysis as it approximates the real rate of interest on borrowed funds in the financial analysis. Also, this rate is used by Hydro-Québec in evaluating large hydroelectricity projects. The three governments agreed on a discount rate of 8% to be used as the base case for the purposes of this study.

Table 10.3 - Results of sensitivity analyses on the MOT-D-300

Net present values (1993$ million)

	Canada	*Québec*	*Ontario*
Without impact on other modes			
Base results	1,284.8	245.1	430.1
Variations in discount rate			
10%	206.1	122.8	106.8
7%	2,176.6	349.7	721.6
Variations in consumer surplus			
Zero	120.7	- 87.6	- 401.2
High	1,904.8	495.9	799.4
Variations in costs			
+ 20%	546.3	107.5	- 12.1
- 20%	2,015.7	381.5	868.5
Variations in revenues			
- 10%	803.3	41.9	- 133.1
+ 10%	1,730.5	448.1	992.5
With impacts on other modes			
Base results	841.7	247.7	467.7
Variations in discount rate			
7%	1,649.0	352.8	766.6
10%	- 110.6	124.7	133.3
Variations in consumer surplus			
Zero	- 322.4	- 85.0	- 363.6
High	1,461.7	498.6	836.9
Variations in costs			
+ 20%	103.2	110.1	25.5
- 20%	1,572.6	384.2	906.1
Variations in revenues			
- 10%	380.6	44.6	- 92.0
+ 10%	1,267.1	450.5	1,026.5

The impact on the other modes, and in particular the air industry, has not been included in the base case estimate, as there is considerable debate about whether the unit costs of the airline industry would be adversely affected in the long run. If the impact on the other modes is taken into account, the economic viability of all scenarios would be reduced.

Under the base assumptions of an 8% discount rate and a consumer surplus in the range of $21 per passenger, all scenarios, except the QW 200 km/h, are viable. The scenario which yields the highest economic return for Canada as well as for the provinces of Québec and Ontario is the Montréal-Toronto 300 km/h scenario with a Dorval routing, with a net present value (NPV) of $1,284.8 million (1993) for Canada, of $245.1 million (1993) for Québec and of $430.1 million (1993) for Ontario. This yields the best economic performance by far.

At a discount rate of 8%, all scenarios except for the QW-D-200 scenario had a positive NPV. When the discount rate is increased to 10%, only one scenario remains viable, MOT-D-300, with the NPV falling from $1284 to $206 million (discounted dollars). If the 10% discount rate is combined with either an increase in costs or a decrease in revenues, then all scenarios are no longer viable, including the MOT-D-300 scenario.

If the discount rate is reduced to 7%, the results of all scenarios show a positive NPV. The NPV of the MOT-D-300 scenario increases to $2177 million (discounted dollars). Even if the 7% discount rate is combined with an increase in costs or a decrease in revenues, all the 300 km/hr scenarios remain viable.

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Risks, Assumptions and Sensitivities

Any megaproject the size of the Québec-Windsor HSR project, whether it be for the entire corridor or for the Montréal-Toronto segment, entails a number of risks and uncertainties. In this case, the lack of experience with HSR in North America and particulary in Canadian climatic conditions creates uncertainty in the ridership and revenues, in the construction and maintenance of such a high quality roadbed and in operations in our winter conditions. Several studies focused on these specific issues, which were known at the outset of the study to evaluate the feasibility and risks, provide appropriate contingencies or evaluate the sensitivity of the results to various parameters.

The intent of the study was not to undertake a detailed engineering feasibility study from an engineering perspective. The objective was to define representative costs and revenues. All problems were not to be resolved, although in each case resolution had to be known as possible. In many circumstances, assumptions were made. This was done in view of the fact that, as for any project of this type, detailed feasibility studies and R&D would be required before implementation. Such studies would be required to finalize the routing, undertake an environment assessment and provide more detail and precise cost and revenue estimates to secure the public and private financing requirements. However, these studies are not expected to substantially change the results of the current studies.

All efforts have been made to provide an objective evaluation rather than a promoter's perspective. In addition to the consultants who undertook the studies, the three governments thoroughly reviewed the methodologies, input assumptions and results. The major railways, suppliers and operators were consulted, particulary on the issues of construction and operating costs. The overall demand forecasting strategy was designed to produce reliable forecasts with the use of three renowned forecasting firms and the largest database ever.

Because of this process, the Steering Committee has a high degree of confidence in the results of the studies. It believes that the overall results provide a sufficient degree of precision to enable a recommendation on whether or not governments should decide to initiate and/or support HSR in the Québec/Windsor corridor.

However, it is important to recall the major risks and uncertainties as well as summarize results of the sensitivity analyses of the various component studies.

Passenger and Revenue Forecasts

Major Risks

Project viability depends on ridership and revenue projections. Although public modes of transportation already attract 9.5 million passengers in the corridor, there is always a potential doubt about the attractiveness of introducing a new transportation service, especially the first HSR service in North America. For these reasons, the overall forecasting methodology was intended to increase reliability. Three forecasters, with three independent approaches, were directed to use a common set of input assumptions. These were related to existing and future conditions on other modes of transportation. Based on their results, the Steering Committee decided to select neither the highest nor the lowest forecast but an average of two.

The financial advisors to the project, La Banque Nationale de Paris (BNP) endorsed the use of an average forecast and indicated that, in their present form, none of the forecasts would be adequate to secure project financing from financial institutions. Financial institutions would still require additional studies and/or audits during their appraisal process before making a decision to finance the project. However, it was of course recognized that the project had not reached the stage where funds must be raised for implementation. Therefore, governments will base their respective decision on the information presently available.

Major risks related to the forecasts are :

- COMPETITIVE RESPONSE FROM THE AIRLINES. In the present study, it has been assumed that airfares would remain at the same relative levels. In the short term, the airlines' response could be very aggressive. But, in view of recent competitive battles in the Montréal-Toronto corridor, it has been assumed that in the long term, the airlines could not sustain significantly lower prices. Competitive action such as fare reductions and the duration of such a response could have varying levels of effects on both HSR and airlines revenues. Connect air and local air generate close to 18% of the ridership.

- DIVERSION FROM AUTOMOBILES. As in the case in many other industrial countries, Canadians are undoubtedly attached to their cars. Will they react as the forecasters have predicted on the basis of generalized costs and stated preference assumptions? The forecasters concluded that diversions from automobiles could account for 32% to 47 % of the 300 km/h system ridership. For the purpose of the study an average of 39 % was used.

- INDUCED DEMAND. Induced demand depending on the scenario represents 18% to 23% of forecasted ridership. History has shown that improvements in transportation (trains, cars, airplanes, freeways) have always increased demand and mobility. It is difficult to say how Canadians will react to this new mode. The forecasters have diverging views as results range from 10% to 30%.

- MARKET SURVEY. Although a very comprehensive market study was conducted in the corridor, some of the markets were not analyzed. For example, O/D data was not available for the Québec/Trois-Rivières segment, trips to Mirabel airport, or for short term inter-city car rental users.

- CONGESTION NEAR URBAN AREAS. An important element of intercity travelling time is road congestion in and near urban areas. In the present study, it has been assumed that congestion would remain at the same levels as it is today. Road congestion could increase and encourage shifts to HSR.

- TRIP TIMES, FREQUENCY AND SPEED ISSUES. For the purpose of this study, current HSR operating speeds have been used. However existing technologies have a potential of running at much higher speeds, which would reduce travelling times and thus could increase revenues. For example, increasing the speed from 200 to 250 km/h would result in 20% more revenue, 10% higher operating cost and increase on total system investment cost of 5 % due to the elimination of level crossings. A speed increase from 300 to 350 km/h would increase revenues by 10% and operating costs by 6 %. Increasing frequency by three trips a day would result in an average increase in ridership of 4% to 10 %.

- SUBURBAN STATIONS. Total system costs include suburban stations and HSR travelling times include stops at these stations.However, the advantages or disadvantages of stopping at these stations were not fully evaluated.

Sensitivities

In order to evaluate the impact of variations in the passenger and revenue forecast, sensitivity analyses concentrated on the financial and cost-benefit analyses.

In the financial analysis, a reduction in revenues of 10 % would leave the public sector internal rate of return (IRR) (including tax revenue) positive in all scenarios except QW-D-200, but less than 4% except for the two MOT-D-300 scenarios, while the private sector IRR would fall below the 12 % hurdle rate in all cases. In the most financially attractive scenario, MOT-D-300NA, the private sector IRR would fall from 12.34% to 11.20%, while the public sector IRR would fall from 7.13% to 5.27%. On the other hand, with a 10% increase in revenues, public sector IRR would be above 4% in all scenarios. In addition to the two MOT scenarios, the private sector (IRR) would also be above 12% for the QW-

D-300 scenario. For the most financially attractive scenario, the private sector IRR would increase to 13.14%, while the public sector IRR would increase to 8.45 %.

In the cost-benefit analysis, a 10% reduction in revenues for the base case would leave both 200 km/hr scenarios with a negative Net Present Value (NPV) at an 8% discount rate. All other scenarios would remain positive, although the NPV would be reduced by at least 35% in all cases. For the best scenario, the NPV decrease from $1284 to $803 million(discounted dollars). On the other hand, an increase in revenues of 10% would make all scenarios viable at an 8% discount rate and would increase the NPV by at least 35% in all cases. For the best scenario, the NPV increases to $1731 million (discounted dollars).

Initial Capital Costs

Major Risks

There are two mains issues:

- cost of adaptability;
- accuracy of initial cost estimates.

Adaptability

Although the study focused on the use of representative technologies that are already in commercial service, none of these operate in the Canadian climatic and regulatory environment. The studies and discussions with suppliers, operators and regulatory authorities indicate that although a number of research and development subjects have been identified, HSR technology could be adapted to the Canadian climatic and regulatory environment. Some costs are included in the capital costs. There are however a number of issues that would need to be resolved:

- adaptation to North American rolling stock standards: although technologies do not presently comply with North American vehicle standards ABB and Bombardier have committed themselves to meeting those standards;
- feasibility of modifying other existing regulations and the introduction of performance based standards;
- undertaking and completing a number of R&D subjects: i.e. minimizing noise and vibration.

Initial Capital Costs

In developing capital costs, numerous assumptions have been made which would need to be confirmed in the planning stages of this project such as:

- use of existing rail right-of-way, particulary in the urban areas;
- treatment of grade crossings, speed limits and road closures;
- land use conflicts;
- requests for route changes and additional stations;
- environmental approvals and mitigation of environmental impacts;
- contaminated soils.

Costs are believed to be accurate within a range of ±20% due to the fact that no field studies of soils conditions were undertaken.

Provisions have been included in the cost estimates for these issues. Major risks that must be considered include:

- RIGHT-OF-WAY IN URBAN AREAS. Use of existing right-of-way in urban areas, although achievable, would be conditional to the rationalization of CN, CP and commuter operations. Should this not materialize, additional costs would be incurred.
- ENVIRONMENT. Some environmental mitigation measures have been included in the cost estimates but there are environmental aspects, such as the presence of contaminated soils that have not been studied in detail since we are not at the detailed engineering stage. The presence of large quantities of such soils would increase removal and disposal costs. The same would be true for other environmental aspects closely related to location of the tracks.
- REPRESENTATIVE ROUTES. Costs have been estimated based on the selection of representative routes and potential station locations. Should these change for one reason or another, there could be impacts on the costs. Optimisation of the routes might result in savings.

• SINGLE TRACK OPERATION. In the capital cost analysis, single track operation was assumed for the segment between London and Windsor. Two other segments (Toronto-London and Québec-Montréal) were assessed for potential single track operation. While single track operation in these segments is technically and operationally feasible and could show appreciable cost savings, it was concluded that at this level of investigation, double track operation was more appropriate for the purpose of this study.

Sensitivities

In order to evaluate the impact of a possible variation in the initial capital costs, sensitivity analyses concentrated on the financial and cost-benefit analyses.

In the financial analysis, an increase in the initial capital costs of 20% would still leave the public sector IRR (including tax revenue) positive for all scenarios, although all scenarios, except the MOT-D-300 scenarios would earn less than a 4% return. The private sector IRR would fall below the 12% hurdle rate in all cases. In the most financially attractive scenario, MOT-D-300NA, the private sector IRR would fall from 12.34% to 11.97%, while the public sector IRR would fall from 7.13% to 5.80%. On the other hand, with a 20% decrease in initial capital costs, the public sector IRR would be above 4% for all scenarios but the two MOT scenarios still would be the only ones with a private sector IRR above 12%. In the most financially attractive scenario, the private sector IRR would increase to 12.59%, while the public sector IRR would increase to 8.56%.

In the cost-benefit analysis, with an increase in the initial cost of 20% for the base case, all scenarios except the MOT-D-300 scenarios would no longer be viable at an 8% discount rate. For the best scenario, the NPV decreases from $1284 to $546 million (discounted dollars). On the positive side, a decrease in initial cost of 20% would make all scenarios viable at an 8% discount rate and would increase the NPV by at least 57% in all the cases. For the best scenario, the NPV increases to $2016 million (discounted dollars).

The impact of a one-year variation in the construction period was also considered in the financial analysis. Its impact would be similar to a 20% change in initial capital costs. In the MOT-D-300 scenario, a one-year reduction in the construction period would increase the public sector IRR from 6.65% to 8.09% while the private sector IRR would increase from 12.15% to 12.45%. An increase in the construction period of one year would reduce the public sector IRR to 5.29% while the private sector IRR would drop to 11.84%.

Operating Cost

Major Risks

More detailed forecasts would enable an HSR authority to produce optimal operating scenarios. However, only the test of time will permit a complete knowledge of the true operating and maintenance costs. Estimates provided by the consultants have been thoroughly reviewed by HSR operators and Canadian railways. Contingencies have been included, although final results may vary. An HSR will nevertheless generate a substantial operating surplus.

Major risks related to the operations are the following:

• RAILWAY LABOR PRACTICES. Changes have already begun, which would likely make it possible to accommodate the needs of HSR.

• MAINTENANCE ACTIVITIES. The largest uncertainty is the extent of maintenance activity required to maintain the high quality track structure on the year-round basis required for reliable HSR operation.

• OPTIMISATION. Some efforts were made in the forecasting exercise to optimise revenues on the basis of fares. However, at this level of investigation, no analysis was conducted to similarly optimise operating profits in relation to predicted passenger volumes.

Sensitivities

In order to evaluate the impact of a variation in operating costs, a sensitivity on the impact on the financial analysis of a 10% change in operating costs was evaluated first. The impact of a change in operating costs is not significant, with all scenarios substantially less sensitive to changes in operating costs than to changes in operating revenues and initial capital costs. Based on this, no further sensitivity analyses were conducted.

Financial Projections

Considerable effort was made to present fairly the financial projections relating to each scenario under study. However, revenues and costs are subject to uncertainty, as they are subject to a number of factors and assumptions. The scope of the project, accuracy of estimates, changing financial markets, economic cycles, inflation, investor and lender perceptions, changing legislative context, evolving preferences of the travelling public are issues that can influence financial results.

Major Risks

Important financial elements that are not within the control of the project are changing financial markets, economics cycles, inflation and investor's and lender's perceptions. For example, a yearly inflation rate of 3 % adds $3.4 billion to the initial cost of $10.5 billion (1993$), while financing costs add another $4.4 billion, bringing the total to $18.3 billion (current dollars) spent until 2005 for the full Québec-Windsor corridor; this represents a 75 % increase over the initial constant dollar cost. Any significant change in such elements could have a large impact on the financial results.

Other major assumptions that could affect the financial results (in addition to those noted previously in the sections on ridership, initial capital costs and operating costs) are:

• INTEREST RATES. For the purpose of the financial analysis, it has been assumed that private sector loans are based on the federal government's long-term borrowing rate that was approximately 9% at the time the analysis was undertaken. For example, the infrastructure and technology notes, which are backed by governments guarantees, are set at 9% (50 base points above the long-term borrowing rate). Should HSR proceed, it is very likely that the interest rates at which the project is financed will differ from those used in this analysis. While the real interest rate is high from an historic perspective, inflation is relatively low. It must be remembered that it is not possible to predict, with any degree of certainty, future capital market conditions or the expectations of future investors.

• RESIDUAL VALUE. Changes in the residual value would have a reasonably important impact on the value of the IRR. The residual value used is designed to provide a measure of the financial risks (i) that parts of the project, for a variety of reasons, could be rendered technologically obsolete at some future date, and (ii) that private sector lenders and investors will heavily discount the residual value, regardless of its validity since it is so far in the future. In considering this, the financial consultants included what they believed to be a financially conservative estimate of the replacement cost of the project's assets, equivalent to approximately 65% of the original cost (including interest during the construction period), fully inflated through to the year 2035. While this approach may be appropriate in determining the private sector's internal rate of return, there is more of a debate regarding the determination of the public sector's internal rate of return. While some analysts may see merit in attributing a lower replacement cost, thus resulting in a higher residual value, others believe that the approach followed by the financial consultant might also be appropriate for the public sector.

• INSTITUTIONAL OPTIONS. A number of institutional options were not analyzed, which could lead to higher or lower returns for governments.

• PHASING. For analytical purposes, it was assumed that for both the Québec-Windsor and Montréal-Ottawa-Toronto scenarios, the entire line would be constructed at the same time to permit start-up of operations on the full segment simultaneously. A phased construction approach on smaller segments, which is most probable, was not considered at this level of analysis.

Sensitivities

In addition to changes in operating revenues and costs, and initial capital costs which have already been discussed, the impact on the financial projections of variations in interest rates, the residual value, and a combination of the most significant variables was also analyzed.

An increase of 1 % point in interest rates would have a much greater impact on the public sector than on the private sector, as the public sector covers 71% to 78% of the project costs and risks. While the public sector IRR would be positive, it would be under 4% for both 200 km/hr scenarios and all Québec-Windsor scenarios. For the private sector, the IRR would decrease slightly for all scenarios, but the MOT-D-300 scenarios would remain above 12%. In the most financially attractive scenario, the IRR for the public sector would decrease from 7.13% to 5.94% while the IRR for the private sector would decrease from 12.34% to 12.28%. On the other hand, a reduction of 1% point in interest rates would result in a public sector IRR that would be above 4 % for all scenarios while the private sector IRR would increase slightly but would not result in any noteworthy change. In the most financially attractive scenario, the public sector IRR would increase to 8.41% while the private sector IRR would increase to 12.36%.

Changes in the residual value would have a reasonably important impact on the calculation of the IRR, particulary for the public sector. With a zero residual value, the public sector would earn a rate of return of less than 4 % (including tax revenue) for all scenarios except for the MOT-D-300 scenarios, while the private sector would earn a rate of return less than 12 % for all scenarios. In the most financially attractive scenario, the public sector IRR would decrease from 7.13 to 5.13 and the private sector IRR would decrease from 12.34 to 11.84 %. On the other hand, using a residual value with a replacement cost of 32.5% of project cost (65% was used for the base case), the public sector would earn an IRR above 4 % (including tax revenue) for all scenarios, while the IRR for the private sector would not change substantially. For the most financially attractive scenario, the public sector IRR would increase to 7.68 % and the private sector IRR would increase to 12.62 %.

To this point, only changes in individual variables have been analysed. It is also important to understand the impact when more than one variable changes. With this in mind, a sensitivity analysis incorporating a 10% decrease in revenues, a 20% increase in construction costs and a one-year delay to the construction period was undertaken for the financial projections. The public sector IRR would fall to less than 4% in all cases and would be negative for the 200 km/hr scenarios and the QW-M-300 scenario, while the private sector IRR would be under 12% for all scenarios. In the most financially attractive scenario, the public sector IRR would fall from 7.13% to 2.67 % while the private sector IRR would fall from 12.34% to 10.34%. On the other hand, with an increase in revenues of 10%, a decrease in cost of 20% and a one-year reduction in the construction period, the public sector IRR would be above 10 % for all but the 200 km/hr scenarios and the QW-M-300 scenario, while the private sector IRR would be above 12% for all but the 200 km/hr scenarios. In the most financially attractive scenario, the public sector IRR would increase to 11.97%, and the private sector IRR to 13.62%.

It is important to note that financial returns to the public sector are more affected by changes to key variables than are returns to the private sector.

Cost-Benefit Analysis

In addition to the risks identified and the sensitivity analysis undertaken on variations in revenues and costs (initial capital costs and operating costs), sensitivity analyses on other key variables affecting the cost-benefit analysis were also conducted in order to test the robustness of the results and further assess the risk associated with the project.

The cost-benefit results are more sensitive to variations in the discount rate (rates of 7% and 10% were tested), consumer surplus estimates (-100%, +75%), initial capital costs (± 20%) and revenues (±10%). Sensitivities to initial capital costs and revenues have been discussed previously.

Consumer surplus was estimated as the difference between generalized cost (which includes costs of fares and access costs, and the monetary equivalent of the value of access time, travel time and wait time) for passengers travelling in the corridor with or without HSR. Although the approach to estimating consumer surplus is fairly standard, there are difficulties in accurately estimating its value. For the QW-D-300 scenario, the consumer surplus was evaluated at $21 per passenger. Some economists are of the opinion that such elements as comfort and convenience should be included in the calculation of consumer surplus. With the inclusion of these elements, the average value is estimated at $35 per passenger. On the other hand, others may be of the opinion that the only relevant elements of consumer surplus could be captured in passengers' modal choice decisions through difference in fares, without taking into account access/egress costs and overall journey time savings. For these reasons, sensitivity analyses were conducted at $35 (upper bound will vary by scenario) and zero consumer surplus value.

The results of the cost benefit analyses are very sensitive to this variation in consumer surplus. With a zero value for consumer surplus, only the MOT-D-300 scenario remains viable. The NPV falls from $1284 million to $121 million (discounted dollars). With the upper boundary consumer surplus estimate, all scenarios are viable, with the NPV of the MOT-D-300 scenario increasing to $1905 million.

Since the impact of changing the residual value had a significant effect on the financial analysis, it was also examined in the context of the cost-benefit analysis. In this case, it did not change results appreciably.

At a discount rate of 8%, which was used for the base case, all scenarios except for the QW-D-200 scenario had a positive NPV. When the discount rate is increased to 10%, only one scenario remains viable, MOT-D-300, with the NPV falling from $1284 to $206 million (discounted dollars). If the 10% discount rate is combined with either an increase in costs or a decrease in revenues, then all scenarios are no longer viable, including the MOT-D-300 scenario.

If the discount rate is reduced to 7%, the results of all scenarios show a positive NPV. The NPV of the MOT-D-300 scenario increases to $2177 million (discounted dollars). Even if the 7% discount rate is combined with an increase in costs or a decrease in revenues, all the 300 km/hr scenarios remain viable.

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Major Findings, Conclusions & Recommendations

The present studies have addressed most of the issues raised by the Ontario/Québec Rapid Train Task Force. Although there are a number of uncertainties and risks that could be reduced should HSR proceed to the implementation phase, the current studies have provided enough information to the Steering Committee to enable it to recommend whether or not the Governments of Canada, Ontario and Québec should initiate and/or support the development of HSR in the Québec Windsor corridor.

The main findings of the component studies are outlined hereafter.

Technology

Existing HSR systems are the fruit of considerable amount of R&D and reflect the state of the art, particularly in the areas of railway vehicle design and signalling, as well as track and infrastructure standards. HSR is adaptable to Canadian conditions. However, Canada would need to invest in some R&D as current European R&D does not address our specific needs.

Routing

The present study did not define final routes for HSR but only "representative" routes, in order to carry out more detailed cost estimates, trip time and revenue projections. For example, more study is needed on routing between Montréal and Ottawa. Options such as a route serving Mirabel and then crossing over to Ontario further west were not studied in detail.

Total system costs between Québec and Windsor (some 1200 km) are estimated at $9.5 billion for the 200 km/h system and at $10.5 billion for the 300 km/h system. Costs for the Toronto-Montréal segment (over 600 km) are estimated at $5.4 billion and $6.1 billion respectively for the 200 km/h and 300 km/h systems. The Québec-Toronto, 300 km/h scenario would cost $8 billion.[1]

In order to provide year-round high speed operation, existing tracks and roadbed need complete reconstruction.

There is no significant difference in cost between using existing rail right-of-way and new "green field" routes.

There are no significant differences in costs between 200 km/h and 300 km/h routes. The capital cost differences that do exist are primarily due to the use of level crossings, which reduces the costs by $500 million on the 200 km/h route.

Single track could be a cost-effective solution on the Windsor-London segment. The single track option would need to be further evaluated financially and operationally for the Montréal-Québec and Toronto-London segments.

Operations

Representative technologies were chosen to provide operating plans and system costs based on actual data. The representative technology for the 300 km/h system was the TGV-Atlantique as produced by GEC-Alsthom. For the 200 km/h system, the X-2000 technology produced by ABB was chosen.

Travel times would be significantly improved over existing VIA Rail services. For example, between Québec and Montréal, a trip time of 1 hour and 12 minutes could be achieved, and

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[1]For the Québec-Windsor 200 km/h scenario, a yearly inflation rate of 3% adds 3.0 billion and financing costs during construction period add a further $4.0 billion for a total of $16.5 billion spent up to 2005. Using the same assumptions, the Québec-Windsor 300 km/h scenario adds up to $18.3 billion while the Toronto-Montréal segments add up to $9.4 billion and $10.7 billion for the 200 and the 300 km/h systems, respectively. Similarly, the Québec-Toronto 300 km/h scenario would add up to $14.0 billion.

between Montréal and Toronto through Ottawa, a trip time of 2 hours and 18 minutes would be feasible with a 300 km/h system. This compares to VIA's current fastest travel times of 3 hours and 59 minutes between Toronto and Montréal and 2 hours and 46 minutes between Québec and Montréal.

The nature of an HSR operation would be different from current VIA Rail operations in the corridor. Frequencies offered on all origin-destinations within the corridor would be significantly increased over existing VIA Rail services and would be comparable to air frequencies. Investment in HSR would offer the opportunity to improve intercity transportation in the corridor. However, some communities that are currently served by VIA Rail will not be served by an HSR system.

In the first year of operation, operating costs are in the range of 40% of operating revenues. HSR would generate a substantial operating surplus which could improve over time as ridership increases.

Ridership and Revenues

The intercity passenger market in the corridor in 1992 totalled some 109 million person-trips; automobiles accounted for 99 million trips, air for 4.1 million, followed by rail with 2.9 million and bus with 2.6 million.

HSR could attact over 10 million riders per year in 2005 on a 200 km/h system and close to 12 million for the 300 km/h system in the Québec/Windsor corridor. In 2025 the number of passengers would be 15 and 19 million respectively. The Montréal-Ottawa-Toronto segment represents close to 56% of total corridor ridership, and the Québec-Toronto scenario approximately 75%.

Approximately 80% of future HSR travellers could be diverted from other modes in the corridor. Those being diverted from automobile would account for 40% of HSR ridership, 18% from air (local and connecting flights), 15% from VIA Rail and 8% from buses. Induced traffic (trips that would not have been made without HSR) generated by this new service could represent approximately 23% of the ridership for the 300 km/h system, compared to 18% for the 200 km/h system.

Even with HSR, the automobile mode would continue to be the dominant intercity passenger transportation mode in the corridor.

Approximately 60% of the 300 km/h system patronage is non-business and 40%, business. Business ridership, however, would generate approximately 50% of revenues.

In constant 1993$ revenues for the first year of operation, for the 300 km/h system (for the entire corridor) in 2005 would be $900 million and $700 million for the 200 km/h. In 2025 revenues would be $1.5 billion (1993$) and $1.2 billion respectively.

Impact on Other Modes in the Corridor

The levels of diversion of travellers from their existing modes to HSR, would not reduce the requirements for road or airport infrastructure investments.

Air carriers could lose 44% of their projected corridor ridership in 2005. The reduction to contribution to overhead and profit when taking into account avoided investments would be approximately $99 million per year (1993$).

The impact on the bus industry's overhead and profits is expected to be slightly negative (-$1 million) for a full corridor implementation and slightly positive for a Montréal-Toronto scenario ($1 million)

In the long term, the impact on government support of other modes, excluding the effect of accident and pollution costs, is negligible. Reductions in annual subsidies to VIA Rail are counterbalanced by losses from passenger contributions through taxes in the automobile and air modes.

Environmental Impacts

Positive impacts of HSR in the corridor could be a reduction of the anticipated intercity transportation energy consumption in the corridor by nearly 20% by 2025, and a reduction of atmospheric emissions contributing to the greenhouse effect (CO_2 and CO) and to low level ozone and urban smog (NO_X and VOC).

To date, HSR has experienced no fatalities. Based on this, HSR could contribute to reducing the anticipated number of fatalities by 30% and injuries by 12% relative to intercity transportation that would otherwise occur along the corridor.

HSR could lead to negative impacts with respect to crop losses on high quality agricultural lands, particularly between Montréal and Québec and between Toronto and Windsor, to the loss of land in rural and urban communities and to barrier effects in inhabited areas.

In Québec, HSR would result in a decrease of emissions leading to acid rain and urban smog (SO_2 and SP) but overall, due to the age of some thermal electric power generation in Ontario, electrified HSR would increase those emissions.

The use of proper mitigation measures could reduce the impact related to the noise levels. The more sensitive areas would be those adjacent to new routes. The introduction of overnight HSR light freight services could also cause some disturbances.

A joint federal/provincial environmental assessment process could be necessary in each province.

Urban Systems

HSR would reinforce the Québec-Windsor corridor as Canada's primary urban area.

HSR would reinforce the general trends towards larger growth in metropolitan areas.

Industrial Impacts

Canada has developed a strong, fully integrated, internationally competitive rail supply industry which could supply 85% of manufactured components of an HSR system, regardless of the technology.

Most new HSR projects in the U.S. are expected to be built using an incremental approach, with tilt technology on existing tracks.

There is little export opportunity regardless of technology. A Canadian HSR tilt technology project could potentially generate Canadian exports of components and services of $860 million over 20 years. A non-tilt technology could lead to additional exports of $500 million for 20 years. Without such projects, Canadian exports are estimated at $260 million .

Economic Impacts

On balance, HSR should have perceptible, if modest, positive impacts on economic output, employment and income for about a decade. In the long term, HSR by itself has no significant implications for productivity and there are no permanent effects on growth potential.

If government funding for HSR was financed through reallocation of capital expenditures by the federal government and the governments of Québec and Ontario, there would be the following impacts:

- HSR would have modest impacts on total output, employment and real income. Over 25 years, for the full 300 km/h corridor scenario, 43,700 person-years of employment, or an average of 1,750 jobs per year, would have been created and government debt would be reduced by $6.5 billion (nominal);
- there would be mixed impacts on employment and output. For example, employment would increase by approximately 10,500 jobs per year over the construction period. Approximately 3,400 jobs per year would be lost over the operating period from 2004 to 2020;
- generally, economic impacts would be concentrated in Québec and Ontario, where most of the activity would take place;
- impacts on the tourism industry would be negligible.

If government funding was financed through expansion of its debt, real output would be increased over the course of the operating phase, but at the expense of a cumulative increase of $8.3 billion (constant) in government debt and increased borrowing from foreign sources. Over 25 years, 193 000 person-years of employment, or an average of 8,000 jobs per year, would be created if the full corridor was built.

If financed through reallocation of funds, the scale of the impacts during both the construction and operations phases is sensitive to the route segment and technology. For example, for the MOT-D-300 scenario, 32,000 person-years of employment would be created over 25 years and the public sector debt would be reduced by $4.9 billion (constant).

If financed through expansion of debt, 105,000 jobs would be created, but at the expense of an increase of $2.6 billion (constant) in government debt.

Legislative and Labour Issues

There are no legislative barriers to implementation of HSR.

Labour constraints that could prevent cost-effective operations are expected to be eliminated through changes in collective agreements.

Financial results

Total system cost between Québec City and Windsor for the 300 km/h technology is $10.5 billion (1993). A yearly inflation rate of 3% adds $3.4 billion for a total cost of $13.9 billion. Financing costs during the construction period adds a further $4.4 billion for a total cost of $18.3 billion spent up to 2005.

Total system cost between Québec City and Windsor for the 200 km/h technology is $9.5 billion (1993). A yearly inflation rate of 3% adds $3.0 billion for a total cost of $12.5 billion. Financing cost during the construction periods adds a further $4.0 billion for a total cost of $16.5 billion spent until 2005.

A wholly private project is not feasible.

In a public-private partnership, the private sector could support up to a maximum of 28.6% of the capital costs with a financial IRR of up to 12.3% after taxes (20.5% before taxes).

The public sector could attain a financial internal rate of return of up to 7.13% on its investment, including tax revenues or an IRR of 3.6% excluding tax revenues.

The financial analysis concluded that governments more than fully recoup their investment (on an undiscounted basis) within the first 30 years of operations. On a discounted basis, at 9%, which is the assumed government's long-term borrowing rate for the purpose of this study, and considering the conservative estimate of the residual value, the governments end up paying a net contribution to the project. Should HSR proceed, it is likely that the interest rates at which a project is financed will differ from those used in the analysis. It must however be remembered that the real rate of interest is high from an historical perspective while inflation is relatively low.

By modifying the distribution of cash flows (as between the public and the private sector), it is possible to adjust the projected rate of return to 12% for the private sector for any of the scenarios considered. This would potentially enable each scenario to be both viable and financeable from the private sector's perspective, although at the expense of the public sector, while still maintaining a public-private partnership structure. However, such a skewing of cash distributions would weaken the relationship between risk and reward.

With the private sector IRR fixed at 12%, the public sector IRR would decline, except for the best scenarios, i.e., the MOT-D-300 scenario. The public sector IRR would be less than 3.5% including tax revenue and negative excluding tax revenue for all other scenarios. For the MOT-D-300NA scenario, the public sector IRR would increase from 7.13% to 8.27%, while the private sector IRR would decline from 12.34% to 12%.

A wholly-owned public sector option would provide the public sector with higher financial returns than would public-private options. However, this would require the public sector to underwrite 100% of risks and construction costs.

The 300 km/h system is clearly financially superior to the 200 km/h system.

Dorval routing is clearly financially superior to Mirabel routing.

The full Québec-Windsor corridor options are financially inferior to the Montréal-Toronto and the Québec-Toronto corridor options.

The scenarios yielding the highest financial returns are the Montréal-Ottawa-Toronto 300 km/h scenarios through Dorval.

The Québec-Toronto 300 km/h via Mirabel scenario yields returns to both the private and the public sector which are similar to the MOT-M-300 km/h scenario. It is quite possible that a 300 kph Québec City-Toronto (via Dorval) option would also be viable and financeable from the private sector's viewpoint.

The returns on the project are most sensitive to variations in construction costs, the duration of the construction period, project revenues and to the residual value of the project.

Cost-Benefit Analysis

Should governments choose to invest in an HSR system, they would expect to receive, in addition to a reasonable financial rate of return, an acceptable social and economic return on their investment. The returns would vary depending on the discount rate used.

The discount rate is a very important factor in the cost-benefit analysis. The federal government uses a 10% discount rate in all their analyses. A 7% discount rate was suggested by the consultants in charge of the benefit-cost analysis as it approximates the real rate of interest on borrowed funds in the financial analysis. Also, this rate is used by Hydro-Québec in evaluating large hydroelectricity projects. The three governments ageeed on a discount rate of 8% to be used as the base case for the purposes of this study.

With a discount rate of 8% and a consumer surplus of approximately $21 per passenger, all scenarios are economically viable except for the 200 km/h full corridor scenario. At a 10% discount rate (federal government hurdle rate), only the MOT-D-300 scenario would be viable. At a 7% discount rate, all scenarios would be viable.

Operating revenues, consumer surplus and residual value account for close to 95% of all benefits whereas total investment and operating costs account for 95% of the costs. Other economic costs and benefits are marginal.

The cost-benefit analysis concurs with the financial analysis in concluding that the Montréal-Toronto 300 km/h scenario through Dorval yields the highest returns. The net present value (NPV) is estimated at $1.3 billion at an 8% discount rate.

The 300 km/h system is economically more attractive than the 200 km/h system.

A Dorval routing is always superior to a Mirabel routing.

The full Québec-Windsor corridor options are economically inferior to the Montréal-Toronto scenario and the Québec-Toronto corridor through Mirabel option, for which the NPV is estimated $762 million.

Consumer surplus has been estimated for the 300 km/h scenario, at an average of $21 per passenger, for a total of close to $250 million in 2005 for the Montréal-Toronto 300 km/h scenario through Dorval.

The impact on the other modes, and in particular the air industry, has not been included in the base case estimate, as there is considerable debate about whether the unit costs of the airline industry would be adversely affected in the long run. If the impact on the other modes is taken into account, the economic viability of all scenarios would be reduced.

Sensitivity analysis plays an important role in the decision making process. In the cost-benefit analysis, the economic viability of the project would be most affected by changes in operating revenues (±10%), consumer surplus calculations (-100% to +75%) and construction costs (±20%). At an 8% discount rate, the viability of all scenarios would be greatly affected, with the exception of the MOT-D-300 km/h. This scenario would remain viable in all cases with respect to a change in each of these variables.

If a 10% discount rate is combined with either a decrease in revenues, an increase in costs or the lower boundary of the consumer surplus, all scenarios would no longer be viable. If a 7% discount rate is combined with the same sensitivities, all 300 km/h would remain viable.

Conclusion

The main objective of this study undertaken by the governments of Canada, Ontario and Québec was to decide whether they should decide to initiate and/or support the development of a high speed rail system in the Québec/Windsor corridor. All the component studies within the framework of the feasibility study were carried out to help the governments in this decision. The following conclusions can be drawn from them:

- HSR is technically feasible;
- HSR would provide a useful addition to transportation infrastructure but would require significant resources;
- an HSR system at 300 km/h is in all respects superior to a system at 200 km/h;
- an HSR system would not reduce needed government investments in infrastructure in other modes;
- HSR could not proceed without significant government financial resources;
- there is little export opportunity regardless of technology;
- the Montréal-Ottawa-Toronto segment represents the best scenario. Québec-Toronto is next but was not analyzed to the same level of detail;
- some scenarios could be economically and financially viable depending on accuracy of projections with respect to: construction cost, ridership and revenues, interest rates, discount rate and actual inflation;
- from an environmental point of view, HSR would improve public safety, and decrease air pollution, but would have a negative impact on land use;
- the study did not assume a long term aggressive response from airlines; more work would be needed on this aspect.

Recommendation

Based on these conclusions, the Steering Committee recommends that any future work should only consider very fast technology.

The following conditions must be satisfied before any further work is undertaken:

- the initiative for the next stage lies with the private sector, who should put up at least 50% of the next phase of the project;
- the private sector must agree to take on all project risks (construction risks and management of a high speed rail operation) if the project goes ahead to implementation;
- in view of the fiscal situation of governments and because, according to the study, 70% to 75% of the cost would have to be paid by the public sector, governments should indicate if they are prepared to proceed with the next phase, taking into account demand for other transportation and infrastructure investments;
- the governments would also take into account the rate of return of the project.

If all these conditions are met, the next phase would include the following elements:

- system design optimization;
- environmental assessment and approval;
- preliminary engineering;
- ridership and revenue forecast;
- necessary regulatory approvals such as safety, etc.

Even if the above conditions cannot be satisfied, the Steering Committee suggests that the governments revisit the project in three to five years.

APPENDIX A

List of Component Studies

Data Gathering

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APPENDIX B

List of Abbreviations

AAR	*Association of American Railroads*
ABB	*Asea Brown Boveri*
BNP	*Banque Nationale de Paris*
CRA	*Charles River Associates*
FRA	*Federal Railway Administration (in Washington, D.C.)*
FS	*Italian State Railways*
GDP	*Gross Domestic Product*
HSR	*High Speed Rail*
ICE	*InterCity Express*
IRR	*Internal Rates of Return*
LRC	*Léger, rapide, confortable*
LTL	*Less than Truckload*
MOT-D-200	*Montréal-Ottawa-Toronto (to Pearson Airport), through Dorval, 200 km/h*
MOT-D-300	*Montréal-Ottawa-Toronto (to Pearson Airport), through Dorval, 300 km/h*
MOT-D-300-NA	*Montréal-Ottawa-Toronto (to Union Station), through Dorval, 300 km/h, no airport services*
MOT-M-300	*Montréal-Ottawa-Toronto (to Pearson Airport), through Mirabel, 300 km/h*
MTO	*Ministry of Transportation of Ontario*
NPV	*Net Present Value*
O/D Survey	*Origin/Destination Survey*
O & M	*Operations and Maintenance*
O/QRTTF	*Ontario/Québec Rapid Train Task Force*
QT-M-300	*Québec-Toronto (to Pearson Airport), through Mirabel, 300 km/h*
QW-D-200	*Québec-Windsor through Dorval, 200 km/h*
QW-D-300	*Québec-Windsor, through Dorval, 300 km/h*
QW-M-300	*Québec-Windsor through Mirabel, 300 km/h*
ROW	*Right-Of-Way*
SJ	*Swedish State Railways*

SNCF	*Société nationale des chemins de fer*
TEMS	*Transportation Economics and Management Systems Inc.*
TGV	*Train à grande vitesse*
TGV-A	*Train à grande vitesse - Atlantique*

APPENDIX C

List of Government Contributors to the HSR Study

Mentioned are contributors from each of the governments. The Steering Committee would like to thank all other persons from each of the governments who have contributed in any extent to one phase or the other of this project.

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