Calgary / Edmonton High Speed Rail

An Integrated Economic Region

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THE VAN HORNE INSTITUTE

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It should be emphasized that all participants contributing in-kind services have done so on the clear understanding that this will not result in sole or preferred procurement of goods and services in the event the project proceeds to implementation. However, nor does this involvement exclude their consideration in future procurement of goods and services.

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

STUDY BACKGROUND & MAIN CONCLUSIONS

Interest in developing a high speed rail link between Calgary and Edmonton dates back to the late 1970s. In the mid-1980s and in a 1995 update, the Alberta government investigated the feasibility of high speed rail based on a new, dedicated right-of-way using electrified "TGV type" technology. Both times, the reviews concluded that the project was pre-mature due to its high cost and ridership risk as sufficient demand for the service, while forecast in the future, did not exist at that time.

Within the last three years, renewed interest in high speed rail emerged, spurred by Alberta's strong population and economic growth over the last decade and technological advances since the mid-1980s. Responding to this interest, The Van Horne Institute at the request of the Alberta government initiated a new high speed rail pre-feasibility study.

The current study makes reference to and builds upon key elements of the previous 1980-1985 work and its 1995 update but also differs and improves upon these past works by including:

- primary market research on actual travel, traveller attitudes and travel attributes valued by travellers that can be projected to the population as a whole with statistical confidence;
- consideration of new technologies;
- direct participation of Canadian Pacific Railway (CPR) in consideration of its corridor as an alignment option; and,
- actual commercial and operational data and costs from VIA Rail, Bombardier Transportation and CPR.

The study's main conclusions are that:

- high speed rail would bring significant benefits to the Calgary-Edmonton corridor and Alberta as a whole, including between $3.7 and $6.1 billion in benefits to users, in jobs and employment income and additional tax revenues for Alberta and the federal government, as well as significant qualitative and other benefits in support of Alberta's future economic growth;
- sufficient demand exists <u>today</u> to support a high speed rail service offering about two hours or less travel time between Calgary and Edmonton;
- the two route/technology alternatives investigated are technically feasible to construct and are able to offer travel time of two hours or less required by prospective riders; and,
- projected ridership and revenues are able to cover the system's operating costs and, depending on the route/technology chosen, repay all or most of the system's capital cost within 30 years.

The following summarizes the key sections of the report and their findings that support these conclusions.

CONTEXT FOR HIGH SPEED RAIL

The Calgary-Edmonton corridor is the fourth largest and most rapidly growing urban region in Canada and is expected to continue to experience strong economic and population growth for the foreseeable future. The corridor is also an important contributor to Alberta's 20-year economic development strategy aimed at diversifying the economy and increasing knowledge-based high value jobs because, like elsewhere, economic growth in new knowledge-based economies occurs in urban regions. In pursuing this economic development strategy, Alberta has the significant advantage of being debt free and thus able to support investments in infrastructure to stimulate future economic growth.

Economists have identified traffic congestion and urban sprawl as problems that need to be addressed if the Calgary-Edmonton corridor is to reach its full potential[1]. Investments in transportation are key to dealing with these challenges. While Alberta plans to spend up to $1 billion on road improvements to enhance the north-south flow of goods and people in the corridor, investment in rail, which carries 42 percent of the provinces exports, has been distinctly lacking.

Experience elsewhere with high speed rail suggests that it could be an important contributor to Alberta's future economic development. Not only would it increase transportation choice, promote price competitivity and add inter-city capacity, it has the potential to reshape growth and development, strengthen the flow of trade and labour between cities in the corridor and transform international perceptions of the region.

[1] TD Economics, *The Calgary-Edmonton Corridor*, Special Report, April 2003

ROUTE/TECHNOLOGY ALTERNATIVES

The study reviewed a wide range of proven rail technology options and then narrowed the list to those capable of providing a two hour or less inter-city trip time (i.e., those capable of speeds of 200 km/hr or higher), which market research revealed as critical to attract passengers. Two route/technology alternatives were then investigated and were found to be technically feasible, namely:

- upgrading the existing CPR line to permit mixed freight and high speed passenger rail service based on Bombardier's *JetTrain* technology (CPR alternative).

- constructing a largely new or Greenfield line dedicated to high speed rail service with shared access via the CPR corridor into downtown Calgary and Edmonton that uses either *JetTrain* technology or 300 km per hour electrified "TGV type" trains (Greenfield Non-Electric and Electric alternatives).

Conservative assumptions were adopted for procurement, construction and infrastructure requirements to avoid under-estimation of costs. Thus, opportunities exist in the next phase of project development to consider potential cost savings relative to service performance, operating cost and other trade-offs. The key features of the two route/technology alternatives are as follows:

CPR Alternative Highlights

- 310 km in total length based on the existing CPR right-of-way.
- Realignment to eliminate 22 curves and reduce the sharpness of 47 others
- Acquisition of 108 to 309 hectares of land, depending on whether land between the new and old alignments needs to be acquired.
- Construction of two new tracks 14 feet (14.3 m) on either side of the existing line and removal of the existing line to create a new double track mainline with crossovers every 10 to 13 km.
- Replacement of storage tracks scattered throughout the line with two new support yards to maintain freight storage and servicing capabilities.
- Centralized Traffic Control of the entire line, including junctions at branchlines.
- Closure of 72 public level crossings, grade separation of 46 others and improved protection of all remaining public level crossings as well as provision for private crossing closures, consolidation and/or re-routing.
- 119 km of new fencing of both sides of the line.

Greenfield Alternative Highlights

- 294 km in total length, of which 38.5 km use CPR and provincially owned right-of-way and are common to both the CPR and Greenfield alternatives and 255.5 km is new dedicated alignment.
- Acquisition of a 255.5 km of new right-of-way varying in width from 30 to 150 m depending on location and requiring 1,430 hectares of land.
- Construction of two tracks 4.3 m apart to create a new double track mainline with crossovers every 20 km.
- Central Traffic Control (CTC) for its entire length.
- Construction of 12 new bridges to cross rivers and various watercourses as well as 47 grade separations with existing roads and railway tracks.
- All roads that are not grade separated with Highway 2 and thus severed are assumed to be severed by the Greenfield alignment, requiring acquisition of 1,211 ha of land.
- Installation of 256 km of 1.8 m fencing on both sides of the right-of-way.
- Electrification of the line in the case of the "TGV type" technology.

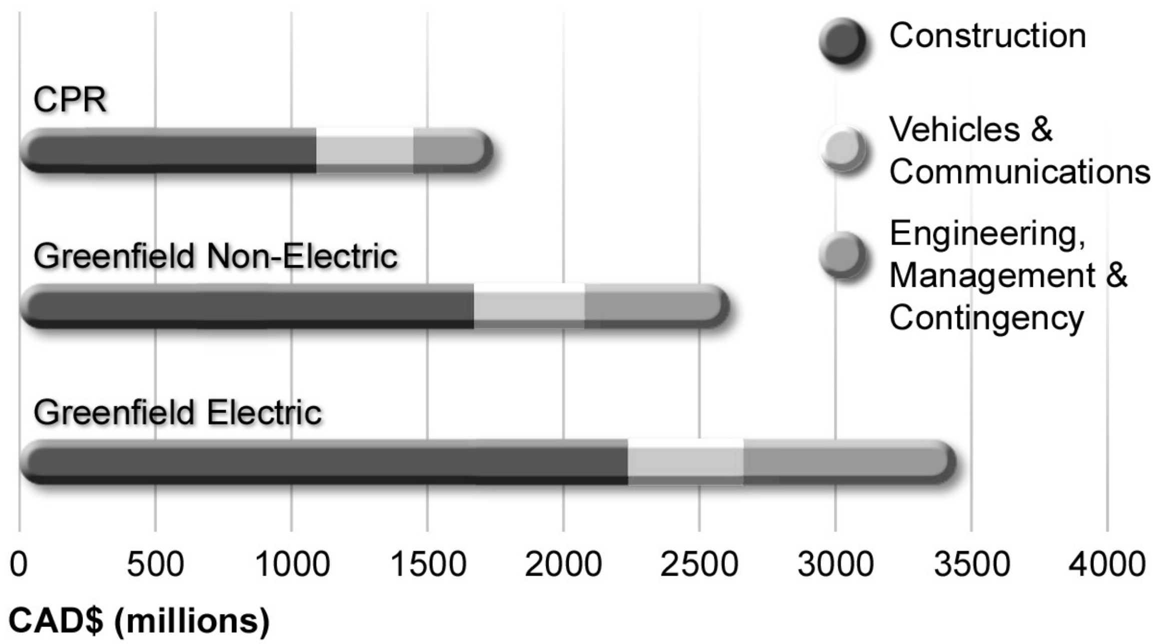
STATIONS AND FACILITIES

Both route/technology alternatives include five stations serving downtown Calgary; suburban Calgary/Calgary International Airport; Red Deer; suburban Edmonton either near the Edmonton Ring Road or in proximity to Edmonton International Airport; and downtown Edmonton. They also include a maintenance facility for regular train maintenance, servicing and repairs, as well as a satellite facility to carry out cleaning activities, inspections and light repairs prior to train departures.

All of these facilities assume representative locations based on practical considerations (i.e., proximity to key destinations, access and implications to track infrastructure) for costing purposes. However, final site selection is left to future phases of project development when such factors as maximum ridership potential, land values, station access requirements, implications to track infrastructure and alternative methods of facility delivery (i.e., leasehold arrangements with developer partners, sale of air rights) can be fully considered.

CAPITAL COST

The total capital cost for the CPR alternative is estimated to be $1,712 million compared to $2,610 million for the Greenfield Non-Electric and $3,413 million for the Greenfield Electric alternatives. The cost of electrification constitutes the primary cost difference between the two Greenfield alternatives, whereas the cost difference between the Greenfield Non-Electric and CPR alternatives is mainly attributable to the more extensive rail infrastructure work required to acquire and construct the Greenfield's new dedicated alignment. Construction expenditures would be spread over five years for the CPR alternative and six for the two Greenfield alternatives due to the more extensive work required.



Capital cost estimates were developed based on the extensive experience and practical knowledge of actual current costs, in many cases directly in Alberta, by CPR, Canac, VIA Rail and Bombardier Transportation. To ensure consistency in the estimates for the alternatives, and that the overall project cost was comprehensive and reasonable relative to other similar projects, the capital costs were reviewed and corroborated by an independent expert in rail project costing (Anthony Steadman & Associates).

RIDERSHIP AND REVENUE FORECASTS

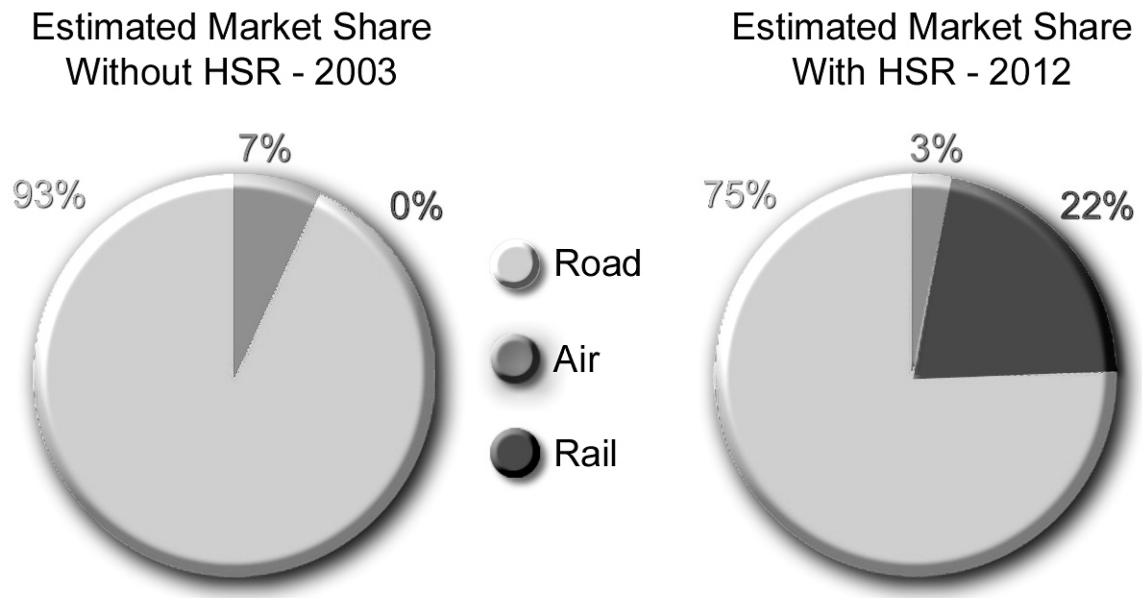
The study determined that sufficient demand exists today to support a high speed rail service. This conclusion differs significantly from the previous 1980s studies, which indicated that, while demand at that time was insufficient, projected ridership by the late 1990s would support high speed rail. The current study appears to corroborate these past predictions.

Market research indicated that between 5.2 and 6.6 million one-way person trips were made between Calgary and Edmonton in 2003 and another 2.4 to 3.7 million one-way person trips were made between Red Deer and Calgary/Edmonton. Had high speed rail service as outlined in the table below been in operation in 2003, the forecasts predicted that high speed rail would have carried 1.7 to 2.0 million total passenger trips depending on the route/technology alternative chosen, which represents a 22-28 percent market share of all trips.

COMPARISON OF RIDERSHIP BASE YEAR(2003 – BASED ON MIDPOINT LOW/AVG)

	CPR	Greenfield Non-Electric	Greenfield Electric
CALGARY – EDMONTON			
One-Way Departures - Weekday - Weekend	10 5	10 5	10 5
Travel Time	2hr 10 min	1 hr 46 min	1 hr 30 min
One-Way Price – Business - Non-Business	$57.50 $48.50	$57.50 $48.50	$57.50 $48.50
C-E Annual Passengers (‘000)	**1,320**	**1,540**	**1,668**
RED DEER-CALGARY/EDMONTON			
One-Way Departures - Weekday - Weekend	10 5	10 5	10 5
Travel Time	65 min	53 min	45 min
One-Way Price – Business - Non-Business	$35 $35	$35 $35	$35 $35
RD – C/E Annual Passengers (‘000)	**363**	**363**	**363**
Total Annual Passengers (‘000)	**1,683**	**1,903**	**2,031**

Business trips comprise roughly half of the forecast high speed rail ridership (52%). Almost three-quarters of forecast high speed rail riders are currently car users. Still, this represents a relatively small proportion of car trips and leaves the car as the dominant travel mode with a 68-73 percent share of the total travel market. The rest of high speed rail riders are current air and bus travellers, particularly those traveling for business.



The estimate of high speed rail ridership was developed using market research carried out expressly for the study by Ipsos-Reid and two proven demand forecasting models. In addition, a series of methodology decisions were purposely adopted to ensure that the estimates are conservative.

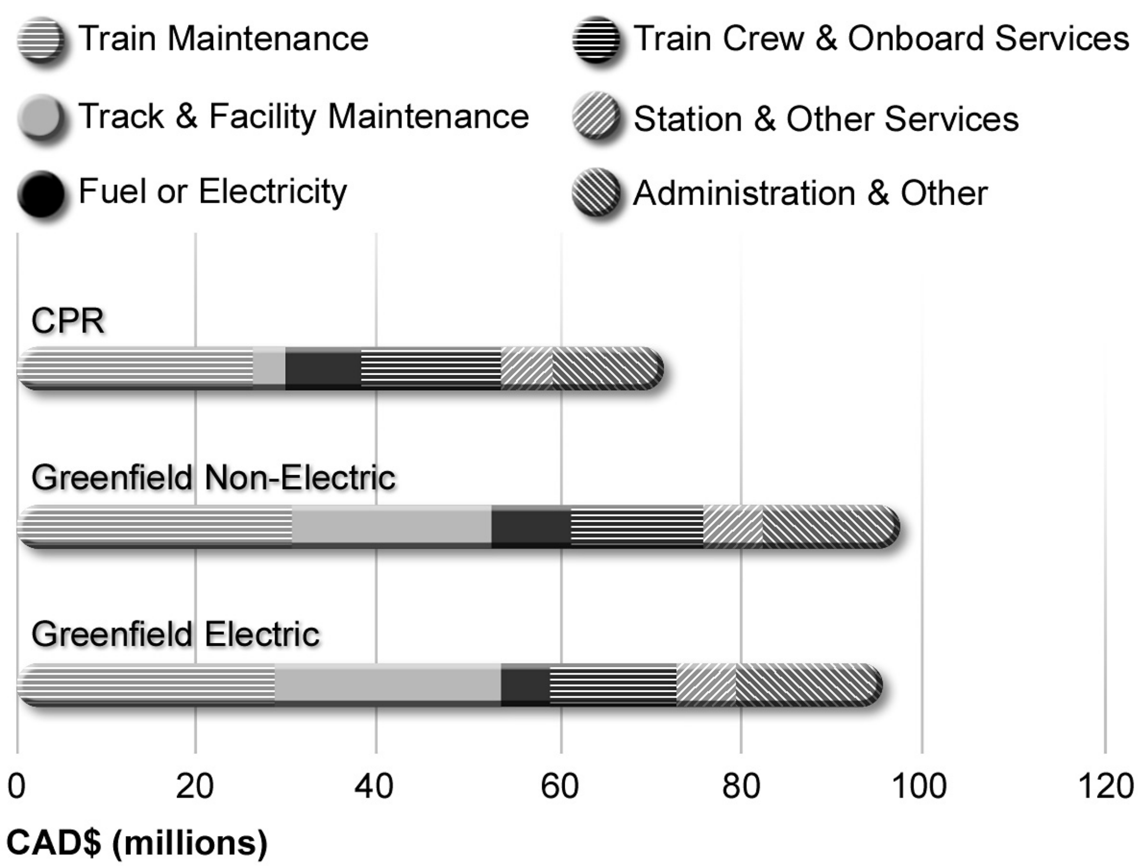
- The mid point between the low and average person trip rates derived from the market research was used;
- Of the two forecasting model results, the lower ridership forecast was chosen;
- Induced ridership[2] was ignored and excluded, even though it has significant potential;
- Ridership is projected to increase at the same rate as overall travel demand rather than accelerate as road congestion boosts rail's attractiveness;
- Ridership in years one and two of operation is discounted to 70 and 90 percent respectively to reflect the gradual conversion of travellers;
- Ridership growth is capped once it reaches 70 percent of train capacity rather than assuming the addition of rolling stock or fare increases;
- Other revenues, such as package and courier services and retail leases (e.g. bank machines, etc), have been excluded; and,
- An allowance included for food and beverage service is structured to be revenue neutral (i.e. revenue is equal to the cost of product and staff costs).

[2] New trips or trips that occur because high speed rail is available.

OPERATING COSTS

Annual operating costs for the CPR alternative are estimated to be $71 million in the first stable year of operation (year 3), $97 million for the Greenfield Non-Electric and $95 million for the Greenfield Electric, and are increased by the rate of inflation (2 percent per annum). The principal cost difference between the CPR and two Greenfield alternatives is track maintenance costs because CPR proposes to waive this charge for the CPR alternative for the first five years in recognition of the benefits to freight from track upgrades and thereafter this cost is much lower because it is shared between the high speed rail and freight services.

Technology differences are the primary factor explaining the cost difference between the two Greenfield alternatives. The Greenfield Electric alternative enjoys lower train maintenance and electricity costs, and lower crewing costs because the higher speed of the electric trains results in shorter trip times that allow staff hours to be optimized.



Operating costs were developed based on VIA Rail's current experience, labor work rules and labour rates, and thus represent a realistic but conservative cost estimate related to an established operator. A new private operator may be able to reduce costs through more favourable work rules, broader job classifications and lower wage rates.

FINANCIAL ANALYSIS

The financial analysis concludes that high speed rail is financially viable insofar as it is able to cover all its operating costs under any scenario plus repay all or most of the capital cost for the system depending on the route/technology alternative and financing option chosen.

The study examined two potential financing options, namely a traditional 100 percent publicly financed option and a shared public-private financed option. Under both options, it was assumed that funds advanced by one or more governments would be provided on a grant basis (i.e., no interest charged). With the shared public-private financed option, it was assumed that the private sector would pay for all rolling stock and miscellaneous equipment (e.g., communications, ticket vending, etc) and government(s) would pay the rest of the project's capital cost. As a result, the initial capital outlay by government would be reduced by 14 percent for the Greenfield Electric alternative and 24 percent for the CPR alternative compared to the publicly financed option. In addition, the private sector would partly share in the project's revenue risk.

Under the publicly financed option, the CPR alternative repays the upfront capital required from government on a "grant" basis over a 30-year period with a surplus of $669 million. The Greenfield Electric repays 73 percent of its capital costs over the 30-year period.

Under the shared public-private financed option, a portion of government capital costs are recouped over the 30 years, leaving an outstanding balance of $656 million for the CPR alternative and $2,530 million for the Greenfield Electric alternative.

SOCIO-ECONOMIC BENEFITS

High speed rail requires a large upfront capital investment of public funds for which there are undoubtedly many competing demands. For this reason, it is important not only to address the financial viability of the system but the social, economic and environmental benefits that high speed rail can bring to Alberta.

The study concludes that high speed rail would bring significant benefits to the Calgary-Edmonton corridor and Alberta as a whole. Depending on the route/technology alternative selected, the project is estimated to generate between $3.7 and $6.1 billion in quantifiable benefits over 30 years, including:

- $172 to $565 million in incremental tax revenues for Alberta and $378 to $1,185 million for the federal government;
- 25,500 to 52,000 person-years of construction employment and $1 to 2 billion in associated employment income;
- 2,700 to 4,050 direct, indirect and induced jobs related to rail operations and enhanced economic development and $1.1 to $1.8 billion in associated employment income;
- $1.2 to $1.9 billion in other public benefits, including travel time and cost savings for system users, accident reduction and environmental benefits.
- Reduce greenhouse gas emissions by 1.8 to 3.1 million metric tonnes.

The project would also result in significant qualitative and other benefits. By effectively shrinking the distance and time separation between Calgary, Edmonton and Red Deer, high speed rail could unify the region into a single economic unit, fundamentally changing how it is perceived and improving its competitive position among urban centres on the world stage. It also has the potential to reshape growth and development in support of Alberta's future economic development strategy promoting economic diversification and increasing knowledge-based, high value jobs. Furthermore, the high speed rail line would improve access to both Calgary and Edmonton International Airports and that in turn would create opportunities and make the region more attractive to firms requiring high quality air services.

CONCLUSIONS AND RECOMMENDATIONS

The study concludes that:

- High speed rail would bring significant benefits to the Calgary-Edmonton corridor and Alberta as a whole, ranging from $3.7 and $6.1 billion in benefits, depending on the route/technology alternative selected.
- The project would also result in significant qualitative and other benefits in reshaping growth, development and perception of the corridor.
- Sufficient demand exists <u>today</u> to support a high speed rail service which is significantly different from the previous studies.
- The two route/technology alternatives investigated are technically feasible to construct and are able to offer travel time of two hours or less required by prospective riders.
- Projected ridership and revenues are able to cover all operating costs and repay all of the CPR alternative's capital cost plus generate a surplus of $669 million and 73 percent of the Greenfield Electric's capital cost over 30 years, if the project is publicly funded on a grant basis.

Based on all of the above, the CPR alternative has significant advantages over the Greenfield alternatives and particularly the Greenfield Electric alternative. These advantages include:

- Significantly lower capital and operating costs
- Less property disruption and complexity to implement (i.e., reduced environmental requirements, property acquisition and engineering and design work)
- Less time required for construction
- Added benefits to Industry and freight operations
- Improved rail and road safety as a result of the rail upgrades.

However, these advantages must be balanced against slightly lower ridership and the associated benefits of the Greenfield alternative. In addition, choosing the CPR alternative is contingent on the CPR's agreement and cooperation and would require more extensive participation by CPR in implementation of the project that would have to be negotiated upfront.

The current study differs significantly from the previous studies as it was able to explore the option of shared high speed passenger and freight use of the existing CPR line as well as a Greenfield Non-Electric alternative, which would be less costly to build and operate than the Greenfield Electric alternative recommended by the previous 1980s studies as well as yielding other implementation advantages.

Based on the results of the pre-feasibility study, proceeding to the next step of firming up estimates and addressing various key project implementation issues appears justified, particularly considering that it will take five to six years to construct the system after these issues have been resolved. Therefore, a decision to move to the next step likely makes realization of high speed rail at least six to seven years away. Thus, to postpone proceeding to the next step could result in the loss of a window of opportunity to reshape growth and development effectively, as unfocused urbanization along the Highway 2 corridor in the absence of such a commitment will continue. Postponement could also rule out or make development of prime station locations prohibitively expensive, particularly in downtown Calgary.

Some important issues to address as the next steps include:

- While the pre-feasibility study developed a reasonable estimate of expected high speed rail use based on market research, ridership is always the largest project uncertainty. For this reason, an investment grade ridership analysis should be carried out.

- Additional engineering and technical work should be undertaken to firm up both capital and operating costs in areas of greatest uncertainty. This work would be more extensive if the Greenfield alternative is chosen.

- Discussions with CPR should be initiated on how to proceed with the project, possibly leading to the development of a project agreement.

- The Province of Alberta should explore the willingness of the federal and municipal governments to participate in the project.

- The advantages and disadvantages of different project organization and governance structures, including such options as an independent authority, should be explored, particularly in terms of accountability, debt financing capabilities, legal powers and other essential implementation requirements.

- Opportunities to develop partnerships with both airlines and the inter-city bus companies should be investigated.

- Linkages with both the Calgary and Edmonton light rail systems, including station linkages and expansion particularly of the Edmonton system to support high speed rail, should be studied.

- Opportunities and a program to involve private developers in developing and operating the stations should be explored.

INTRODUCTION

1.1 Background

Interest in developing a high speed rail link between Calgary and Edmonton dates back to the late 1970s. At the time, Alberta's economy was booming and the province was experiencing rapid population growth. Advocates for high speed rail development pointed to these factors, as well as the large travel volume between the two cities and examples of high speed rail development in Europe involving city pairs with a similar intervening distance.

Responding to this interest, the Alberta government conducted a series of detailed studies between 1980 and 1985 on the feasibility of high speed rail service in the Calgary-Edmonton corridor. The preferred option identified by these studies involved a frequent downtown-to-downtown service of two hours or less using a new, dedicated right-of-way parallel and west of Highway 2 with electrified TGV type technology. The studies concluded that this service would be technically feasible to construct and operate, and have sufficient demand to be financially viable by the late 1980s.

In 1985, the Alberta High Speed Rail Review Committee reviewed the study's findings. Citing both high project costs and risk associated with ridership/revenue assumptions, the Committee recommended that the project not proceed at that time but that the government monitor trends and continue to review the situation in the future.

In 1995, the Alberta Transportation and Utilities Policy Development Branch carried out a high level update of the project that the Alberta Economic Development Authority Transportation Committee then reviewed to determine if the project should be technically re-evaluated. The economy at this time was experiencing a downturn but, in addition, fundamental changes in the travel market since the early 1980s were also observed that resulted in declines in both air and bus travellers in favour of car travel.

Citing concerns over the shift away from two prime potential markets for high speed rail together with lower overall growth in travel than had been forecast in the 1980s study, the Committee recommended against a technical re-evaluation of high speed rail at that time, but again recommended the government monitor trends and high speed rail developments relevant to the corridor and carry out periodic updates.

1.2 Initiation of This Study

Within the last three years, renewed interest in high speed rail development between Calgary and Edmonton has emerged. In 2001, a discussion paper formulated as input to the Alberta Ministry of Economic Development's business plan recommended re-examination of high speed rail feasibility in light of population and economic growth and technological advances. The Alberta government also received private sector proposals to construct and operate a high speed rail link between Calgary and Edmonton provided that the government fund the infrastructure capital costs for this enterprise.

Stimulated by this renewed interest, the Van Horne Institute (VHI) was approached by the Alberta government to carry out a pre-feasibility study on high speed rail service for the Calgary-Edmonton corridor. VHI then solicited and successfully gained the support and participation of several of its members in this initiative. In January 2003, it commissioned Shirocca Consulting to review previous studies and develop a work plan for the pre-feasibility study that included:

- identifying the key questions and concerns to be addressed,
- developing a work plan to answer these key questions, updating and especially adding new information as necessary,
- identifying skills and resources available from stakeholders as in-kind contributions,
- identifying consulting resource requirements, and,
- establishing a budget and schedule for completion of the work program.

The product of this scoping exercise, which was jointly funded by Alberta Economic Development and Alberta Transportation, was used to apply for further government funding and also serves as the blueprint for the current study.

1.3 Study Purpose and Objectives

The purpose of this study was to investigate the feasibility of a high speed rail link between Calgary and Edmonton in light of Alberta's strong population and economic growth, new travel demand trends and technological advances in high speed rail since the mid-1980s. The approximately 300 kilometre rail line is to serve both downtowns and Red Deer (2003 population of 72,700) about halfway in-between. Consideration was also to be given to stops in suburban Calgary and Edmonton near their respective International Airports. The study's specific objective was to identify for governments and others the economic and other implications of implementing a high speed rail service in the Calgary/Edmonton corridor, and to suggest the next steps in determining its feasibility should governments and/or private sector parties choose to support and/or pursue the project further.

To accomplish this objective, the study set out to:

- determine if sufficient market demand and revenue potential exists to justify this service and, at minimum, cover its operating costs;
- identify the technology option that best meets technical and financial performance requirements, in particular a competitive travel time advantage;
- establish the alignment, stations and other facilities required to support the service and capital costs estimates associated with these elements;
- develop a service plan and estimate of operating costs;
- identify other economic development, investment deferral and societal benefits that could result from this investment; and,
- outline financial structure options for high speed rail implementation.

1.4 Study Approach

While the current study makes reference to and builds upon key elements of the previous 1980-85 work, it improves upon and differs from this past work in several significant ways. A key difference and improvement in the current study is the inclusion of primary market research on actual travel, traveller attitudes and travel attributes valued by travellers that can be projected to the population as a whole with statistical confidence. The 1980s study, on the other hand, relied on a sample of traveller intercept data, which in the case of car users represented a very small sample that was collected in three different years and locations, in one direction and for a period during the summer only.

The current study includes consideration of both technological advances to previously considered technologies as well as two new technologies, the 240 km/hr non-electric *JetTrain* and 500 km/hr maglev technology. Unlike the previous studies, the current study also benefits from the direct participation of Canadian Pacific Railway (CPR) in consideration of its corridor as an alignment option, as well as actual commercial and operational data and costs from VIA Rail, Bombardier Transportation and CPR.

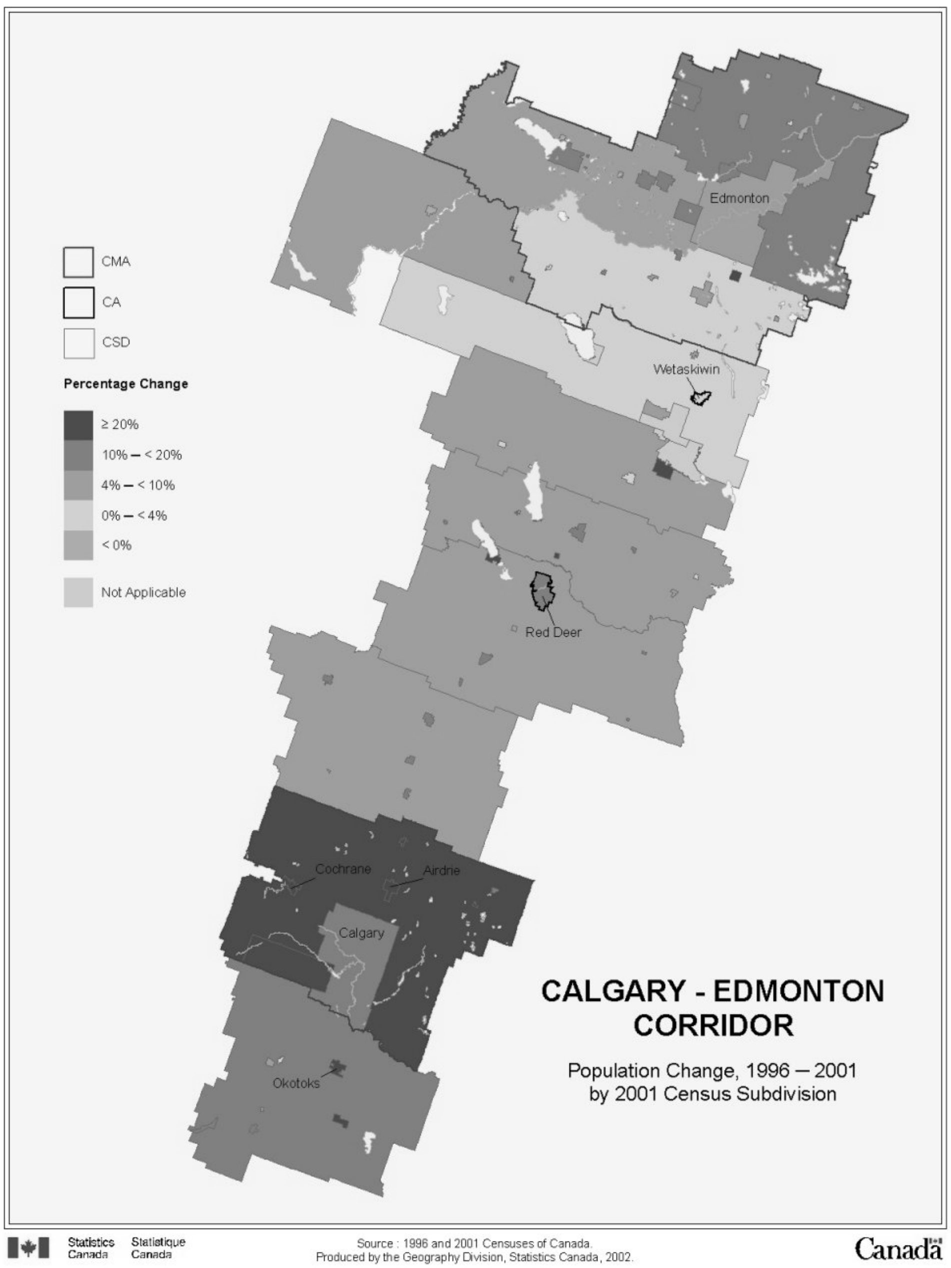
The study consists of a series of component studies and combines work carried out by the commercial participants in the study as well as consultants and experts commissioned by the Steering Committee. The scope of work and findings of all the component studies were reviewed and accepted by both the VHI's independent project manager and the Steering Committee. The Steering Committee comprised representatives from the following organizations:

- Alberta Economic Development
- Alberta Transportation
- Bombardier Transportation
- Canac Inc.
- Canadian Pacific Railway
- SNC Lavalin
- Transport Canada
- Van Horne Institute
- VIA Rail Canada
- Western Economic Diversification

CONTEXT FOR HIGH SPEED RAIL

2.1 Calgary-Edmonton Corridor Profile

The Calgary-Edmonton corridor stretches 300 kilometres from Calgary in the south to Edmonton in the north. It encompasses several million hectares of prime agricultural land, a dozen or more small communities as well as Red Deer, a city of 72,700 people situated approximately half way between the two major metropolises. The corridor housed 2.2 million inhabitants in 2001, representing 72 percent of Alberta's total population, and is the fourth largest and most rapidly growing urban region in Canada.



Over the past decade, the corridor has experienced explosive economic and population growth far exceeding that experienced in most other North American urban centres.[3] Calgary[4], which has a population of just over one million[5], is the fastest growing metropolitan area in Canada. From 1996 to 2003, its population grew by 24 percent, and accounted for almost half of Alberta's total population growth. By 2033, its population is projected to reach 1.6 million.

Edmonton, although slightly smaller and slower growing than Calgary, has a population of 990,500 in 2003 up 12 percent since 1996. It is the fourth fastest growing metropolitan area in Canada and is expected to reach over 1.2 million people by 2025. Red Deer, the corridor's third largest centre grew by more than 21 percent between 1996 and 2003.

Alberta's economy has grown at an average rate of 4.2 percent over the last ten years, the fastest growth rate of any province in Canada. The Calgary-Edmonton corridor is credited with $87 billion in annual real output and about 7 percent of Canada's real GDP. It is the only urban region in Canada to rival US metropolitan areas in terms of productivity and standard of living[6]. Per capita GDP is estimated to be $52,000 (US $40,000) putting the region 40 percent above the Canadian average and 10 percent above the US metropolitan average.

Export trade is critical to Alberta's economy, accounting for about 42 percent of the province's $150 billion economy. In terms of volume, rail carries approximately 42 percent of all exports, whereas 7 percent are transported by truck. Here, the corridor again plays a pivotal role. The Calgary-Edmonton corridor provides strategic road and rail access to the North American free trade market and is part of the broader CANAMEX Trade Corridor linking all of western North America and extending 6,000 km from Anchorage, Alaska to Mexico City. It also provides access to the main east-west rail link and Trans Canada Highway, which are important to Alberta's access to Asian markets and for inter-provincial trade. Alberta initiated CANAMEX in the early 1990s and plans to spend up to $1 billion on road improvements to enhance the north-south flow of goods and people. However, rail investment has been distinctly lacking.

2.2 Challenges for the Future

Alberta's economic strength mainly derives from its extensive energy reserves. Oil and gas production and exploration accounts for 19% of the provincial GDP and is the province's largest industry. While energy remains vital to Alberta's economy, its contribution to GDP has decreased from 36% to 22% between 1985 and 2002 as the economy became more diversified. Furthermore, Alberta is currently pursuing a 20-year development strategy aimed at increasing knowledge-based high value jobs and thus shrinking its reliance on oil and gas production. A formidable asset in this pursuit is the fact that Alberta is now debt free and looks forward to budget surpluses that can support investments in infrastructure and other measures to stimulate new economic growth.

The Calgary-Edmonton corridor is important to Alberta's future economic development strategy because, like elsewhere, economic growth in new knowledge-based economies occurs in urban

[3] TD Economics, *The Calgary-Edmonton Corridor,* Special Report, April 2003.
[4] Census Metropolitan Area
[5] Statistics Canada, 2003.
[6] TD Economics, *The Calgary-Edmonton Corridor,* Special Report, April 2003.

regions. While the corridor offers many assets and competitive advantages, economists have also identified traffic congestion and urban sprawl resulting from its rapid growth as problems that need to be addressed if the corridor is to reach its full potential. Furthermore, strong economic and population growth are expected to continue for the foreseeable future.

In order to respond to globalization, the cities within the corridor must build strong relationships with each other, thus improving the flow of trade and labour from one to another. Investments in transportation are key to addressing these challenges. However, economists agree that second to lack of investment, over-reliance on one mode of transportation creates constraints on economic growth and retards efficiency.

For all these reasons, high speed rail could be an important component of a transportation and development strategy in support of these goals. It would add the single element within the transportation system that is currently missing, namely inter-city passenger rail. It would increase transportation choice, promote price competitivity and also add inter-city capacity. Based on high speed rail experience elsewhere, it also has the potential to reshape growth and development and transform perceptions of the region from one with two cities of a million people to a unified economic unit of two to three million people.

This study and this report focuses on how a high speed rail service can be accomplished, whether it would be financially viable, and what benefits it may bring to the corridor and as a consequence to Alberta as a whole.

TECHNOLOGY REVIEW

3.1 Introduction

High speed rail operation is made possible by a combination of geometry of the rail corridor (horizontal curvature), track condition, protection and control, and train technology. High speed rail systems have been in operation for more than 25 years in Europe and Asia, but only recently have begun to be introduced into the North American market.

In Europe and Asia, trains are electrically-driven and either designed with tilting mechanisms that allow operation on existing track at moderately fast speeds (200-250 km/hr), or operate on dedicated alignments with geometry that allows trains to maintain high speed (300+ km/hr). These systems, while very safe, do not conform to some North American safety design standards and, therefore, must either operate only on dedicated track with special authorization or be adapted to North American standards.

Lack of rail electrification in North America, together with differences in design standards requiring dedicated track or significant design modifications, have impeded introduction of high speed rail largely because of cost. However, recent technological advances have broadened the rail technology options available for consideration.

For these reasons, the Steering Committee decided it would be appropriate to identify and review a wide range of proven inter-city passenger rail technology options for potential implementation in the Calgary-Edmonton corridor. The objective of this review was to:

- analyze each option based on a number of criteria, such as trip time, typical infrastructure and operating costs, technology readiness, etc; and,
- narrow down the options to two or three recommended for further consideration.

The selected rail technology options were then used to determine infrastructure requirements, capital and operating costs, expected trip times and ridership potential in the Calgary-Edmonton corridor. This Chapter presents the results of the technology review and the selection process.

3.2 Overview of Technologies Available

The range of rail technology options available to serve the inter-city passenger rail market is diverse. They include:

- self propelled passenger cars also referred to as diesel multiple units (DMU) or electric multiple units (EMU) capable of operating at speeds up to 200 km/hr in mixed traffic;
- conventional diesel locomotives hauling passenger cars capable of speeds up to 160 km/hr in mixed traffic,
- integrated trainsets (locomotives and passenger cars) capable of 200-240 km/hr;
- electric trainsets operating on dedicated tracks at speeds up to 330 km/hr ; as well as
- magnetic levitation (Maglev) trains capable of reaching speeds of up to 500km/hr on dedicated special structures.

To operate at high speed, various safety measures related to the rolling stock or supporting infrastructure are required. In the United States, all passenger rail cars ordered after September 2000 must incorporate safety-related structural requirements and industry standards into their design and manufacture consistent with the newly developed Federal Railroad Administration (FRA) regulations and APTA Passenger Rail Equipment Safety Standards (PRESS).

The new regulation, “Passenger Equipment Safety Standard 49 CFR Part 238”, establishes two sets of standards:

- Tier I for trains operating at speeds up to 200 km/hr; and,
- Tier II for those operating at speeds between 201 km/hr and 240 km/hr.

In addition, a set of rules also applies to track as per “Track Safety Standards Part 213”. The measures depend mainly on the speed at which the trains will operate.

In Canada, maximum passenger train speed is limited to 95 mph (153 km/hr)[7], with the exception of VIA Rail’s LRC service, which operates at a maximum speed of 100 mph (160 km/hr) with a waiver from Transport Canada. No regulations currently exist in Canada for speeds above 160 km/hr, but it is assumed that something similar to the FRA requirements would be required. Consequently, all typical costs cited in the Technology Review assume Canada will adopt standards similar to the FRA standards.

3.3 Review of Rail Technology Options

The range of rail technology options identified above have been grouped according to similar characteristics and purpose based on operating speed capability, power propulsion and ability to operate in mixed traffic, as follows:

- Non-electrified technologies for mixed traffic operation at speeds up to 160 km/hr;
- Diesel multiple unit technology for mixed traffic operation at speeds up to 200 km/hr;
- Non-electrified technologies for mixed traffic operation at speeds up to 200 km/hr;
- Non-electrified technologies for mixed traffic operation at speeds up to 240 km/hr;
- Electrified technologies for dedicated track operation at speeds up to 330 km/hr; and,
- Maglev technology for operation at speeds of up to 500 km/hr on dedicated special structure.

For each group, examples of technologies by manufacturer and implementation are described for illustrative purposes, along with typical trip times, design speed, typical consist and passenger capacity range, typical per kilometre initial investment cost and operations and maintenance cost, and other key considerations, such as FRA-compliance. Bombardier Transportation provided descriptions and characteristics for all technology groups except Maglev, which Siemens provided. However, typical investment and operating costs for all technologies were based on FRA reports, converted to Canadian dollars based on a publicly quoted rate of exchange ($1 US = $1.297 Cdn) on January 1, 2004.

[7] Railway operations and regulation in Canada are in the British system to conform with US practice).

Non-Electrified Technologies for Mixed Traffic Operation at Speeds up to 160 km/hr

This group represents the main technology historically used in North America for intercity passenger rail service, largely because of its wide availability and, as a result, relatively low cost. It consists of a diesel-electric locomotive that pulls a series of passenger cars. The diesel-electric locomotive uses a diesel engine to drive an alternator that generates an electric current, which in turn powers the locomotive's traction motors. The locomotives are based on proven conventional freight locomotives with large and heavy diesel engines.

The equipment is designed to operate on Class 4, Class 5, or Class 6 tracks according to the FRA Track Safety Standards, and is thereby limited to operating speeds of 80mph (129 kph), 90mph (145 kph) or 110mph (177 kph) respectively. Canada has similar track safety standards. However, trains tend to operate below their maximum speed capability because very little Class 5 or Class 6 track presently exists in North America. In fact, in the United States, outside of the Northeast Corridor, the maximum revenue speed achieved is 145 km/hr.

Locomotives - The two main manufacturers of such locomotives are General Motors – General Electric Transportation Systems (GETS) and Electro Motive Division (EMD). Both companies supply locomotives with similar capabilities.

The heavy weight of these locomotives limits their ability to operate at higher speeds, as track damage would exceed currently accepted levels in the industry. In part because of these limitations, these locomotives are better suited for commuter rail applications, where speed requirements are lower.

GETS Locomotive

EMD Locomotive

Passenger Cars - Numerous manufacturers have supplied intercity coaches over the past 20 years. Examples include Bombardier's Superliner and Horizon equipment in use by Amtrak and LRC used by VIA Rail, Talgo's TPU used on the US Northwest Corridor and Alstom's Surfliner used in California.

Passenger cars vary greatly in design, a key difference being the presence of a tilting system. The tilting system allows the train to operate at higher speeds in curves without affecting passenger comfort. The principle of the tilting system is to bank the cars in curves to lower lateral centrifugal forces, which cause passenger discomfort. The alternative is to reduce speed, which results in longer trip times, or to increase track super-elevation, which adds infrastructure cost and can be in conflict with freight train requirements. Therefore, combining a tilting system with a high cant deficiency[8] allows trains to operate safely at higher speeds in curves without needing to increase track super-elevation.


Bombardier Superliner (No tilting)


Bombardier Horizon (No tilting)


Bombardier LRC (No tilting)


Talgo TPU (Passive tilting)


Alstom Surfliner (No tilting)

Manufacturer and product	**Bombardier Superliner**	**Bombardier Horizon**	**Talgo TPU**	**Alstom Surfliner**
Design speed	143 km/hr	143 km/hr	169 km/hr	169 km/hr
Typical consist (# of locomotives – # of coaches – # of locomotives)	2-10-0	1-5-0	1-12-1	1-7-1
Trainset seated passenger capacity	388	265	236	419
Tilting system	No	No	Passive (2.5°)	No
Cant deficiency	10 cm (locomotive)	10 cm (locomotive)	10 cm (locomotive)	10 cm (locomotive)
FRA compliance	No	No	No	No
Where used	- Southwest Chief - Capitol Limited Autotrain	- Hiawatha - Illinois Zephyr - State House - Kansas City Mule	Northwest Corridor	San Diego California
System O&M cost per passenger-km[9]	C$0.09 – C$0.13			
Initial investment per route-km[10]	C$1.62 M – C$4.05 M			
Est. Calgary-Edmonton Trip Time	2 hours 40 minutes			

[8] Cant deficiency is a technical measure designed to set safety limitations on speed in curves given a degree of curvature and super-elevation. A higher cant deficiency allows a higher speed in curves.

[9] FRA, High speed Ground Transportation for America (1997), “Accelerail 110”, includes maintenance of way, maintenance of equipment, transportation, passenger traffic and services, general and administrative expenses.

[10] FRA, High speed Ground Transportation for America (1997), “Accelerail 110”, includes infrastructure, vehicles and ancillary systems. Infrastructure costs include sidings, turnouts, etc. needed to accommodate - without adverse impact - freight train frequencies one-fifth greater than those of today, along with projected high speed trains.

Diesel Multiple Unit (DMU) Technology for Mixed Traffic Operation at Speeds up to 200 km/hr

This technology group comprises self-propelled units (typically 2 or 3-car units) that can be assembled into consists of varying lengths (i.e. coupling two or more together), thereby allowing train size to be adjusted in response to fluctuations in ridership throughout the day. As a result, DMUs are also energy efficient, as fuel consumption is directly tied to utilization. Furthermore, as all units are motorized, DMUs are very responsive to acceleration and deceleration demands.

DMUs are designed and configured to operate in either commuter or inter-city applications in mixed traffic with freight trains (i.e. compliant to FRA/PRESS standards) at speeds up to 200 km/hr. Their capabilities make them particularly well suited for:

- services sensitive to acceleration and deceleration rates, ride quality, fuel consumption, and overall noise level;
- low density or feeder services or services with highly variable ridership patterns and where lower operating costs are critical;
- where electrification cannot be justified; and,
- where lower axle loads are important, as they do not require a locomotive, which typically has a higher weight than self-propelled passenger cars.

At present, there are only two DMUs which meet North American standards and can be used in mixed traffic; Bombardier's DMU and Colorado Rail Car's AeroDMU. Although neither DMU has yet been put into revenue service, the Colorado Railcar recently started one-year demonstration runs. However, a recent joint procurement by North Carolina TTA and Portland, Oregon's Tri-Met has attracted a lot of potential supplier interest that may produce other competitors to introduce FRA-compliant DMU technology.

Bombardier DMU

Colorado Rail Car Aero DMU

Manufacturer and product	Bombardier DMU	Colorado Rail Car Aero DMU
Design speed limitation	200 km/hr	160 km/hr
Typical consist (# of locos – # of coaches – # of locos)	0-2-0 (married pairs)	0-3-0 (motor coach-coach-cab)
Trainset seated passenger capacity	150	214
Tilting system	No	No
Cant deficiency	Information not available	Information not available
FRA compliance	Not certified (Conceptual product based on certified LIRR car shell)	Tier I
Where used	None in North America	Started 1 yr demo. service for Florida Tri-Rail in Dec.2003
System O&M cost per passenger-km[11]	C$0.08 – C$0.14	C$0.09 – C$0.13
Initial investment per route-km[12]	C$2.43 M - C$4.46 M	C$1.62 M – C$4.05 M
Est. Calgary-Edmonton Trip Time	2 hours 10 minutes	2 hours 40 minutes

Non-Electrified Technologies for Mixed Traffic Operation at Speeds up to 200 km/hr

This technology group encompasses integrated locomotives and passenger car trainsets designed to operate on and requiring Class 7 track according to the FRA Track Safety Standards. The trainsets are capable of greater acceleration than conventional locomotives, and can be offered with or without tilting systems. Since they are designed for higher speeds than conventional locomotives, they are lighter to reduce track impact.

Many suppliers have trainsets in various stages of development, including Supersteel, Talgo, Siemens and Bombardier. An important consideration in this technology group is the availability of proven solutions. Only Supersteel and Bombardier have actually built products, since Tier I standards became effective in 2000.

[11] FRA, High speed Ground Transportation for America (1997), “Accelerail 110” for Colorado Railcar and “Accelerail 125” for Bombardier, includes maintenance of way, maintenance of equipment, transportation, passenger traffic and services, general and administrative expenses.

[12] FRA, High speed Ground Transportation for America (1997), “Accelerail110” for Colorado Railcar and “Accelerail 125F” for Bombardier, includes infrastructure, vehicles and ancillary systems. Infrastructure costs include sidings, turnouts, etc. needed to accommodate - without adverse impact - freight train frequencies one-fifth greater than those of today, along with projected high speed trains.

- Supersteel is re-building the RTL Turboliners used on the Empire Corridor in New York State to meet Tier I requirements. Some of the re-built Turboliners have recently entered revenue service. The Turboliner uses two small turbines to hydraulically transmit traction power;

- Talgo offers its European XXI trainset and state this product can be modified to meet the more stringent North American standards. For the North American market, the Talgo XXI is powered by a diesel-hydraulic locomotive designed by Krauss-Maffei (Siemens);

- Siemens' North American product is a diesel-electric integrated trainset called the ACE, a conceptual solution derived from the ICE family of trainsets developed for and operated by Germany's Deutsche Bahn;

- Bombardier offers its *JetTrain*[*] turbine electric powered technology in a Tier I configuration. The *JetTrain* trainset combines a newly developed turbine powered locomotive with coaches derived from the Acela, an electric trainset capable of 240 km/hr (150 mph), currently in revenue service in the US Northeast Corridor (Boston-New York-Washington). The Acela cars have accumulated over 8.5 million miles in service. In addition, the *JetTrain* locomotive has undergone extensive testing at the Transportation Technology Centre (TTC) test track in Pueblo, Colorado, but has not yet operated in revenue service.

SS RTL Turboliner

Talgo XXI

Siemens ACE

Bombardier *JetTrain*

[*] Trademark of Bombardier Inc.

Manufacturer and product	RTL Turboliner	Talgo XXI	Siemens ACE	Bombardier *JetTrain*
Design speed limitation	200 km/hr	200 km/hr	200 km/hr	200 km/hr (240 km/hr cap.)
Typical consist (# of locomotives – # of coaches – # of locomotives)	1-3-1	1-12-1	1-61 (estimate)	1-4-0
Trainset seated passenger capacity	264	396	286 (est)	250
Tilting system	No	Passive (2.5°)	Active (8°)	Active (6°)
Cant deficiency	14 cm	22.9 cm	21m	21.6m
FRA compliance	Tier I	Not certified (conceptual product)	Not certified (conceptual product)	Tier I[13]
Where used	Empire Corridor	None in North America	None in North America	Demonstration locomotive undergoing trail running.
System O&M cost per passenger-km[14]	C$0.08 - $C0.11			
Initial investment per route-km[15]	C$2.43 M – C$4.46 M			
Est. Calgary-Edmonton Trip Time	2 hours 10 minutes			

Non-Electrified Technologies for Mixed Traffic Operation at Speed up to 240 km/hr

This group currently includes only one product, the Bombardier *JetTrain*. The *JetTrain* is the result of a private-public-partnership between Bombardier and the US FRA.

Although high speed trains capable of 240 km/hr and higher have been in use in Europe and Japan for many years, the unique North American operating environment has made the cost of implementing high speed trains prohibitively expensive. Only a small portion of the North American

[13] In 1-4-0 configuration, trainset would be Tier I compliant, although *JetTrain* trainset is designed to meet all FRA Tier II/APTA PRESS standards.

[14] FRA, High speed Ground Transportation for America (1997), "Accelerail 125F", includes maintenance of way, maintenance of equipment, transportation, passenger traffic and services, general and administrative expenses.

[15] FRA, High speed Ground Transportation for America (1997), "Accelerail 125F", includes infrastructure, vehicles and ancillary systems. Infrastructure costs include sidings, turnouts, etc. needed to accommodate - without adverse impact - freight train frequencies one-fifth greater than those of today, along with projected high speed trains.

network is electrified. In addition, passenger trains must operate in mixed traffic with freight trains having permissible axle loads that are higher and different standards than Europe.[16]

The FRA identified this problem and launched the initiative "Next Generation High speed Rail". Bombardier was chosen to develop a technology that would:

- reduce trip times;
- minimise infrastructure improvement costs;
- address operational constraints;
- ensure safety in mixed traffic;
- address funding constraints;
- minimise environmental impacts.

JetTrain technology meets all FRA Tier II/ APTA PRESS standards for operation up to 240 km/hr. As such, it is the only trainset capable of operating in mixed traffic on track up to Class 8. It can also operate on lower classes of track, but at lower speed according to FRA speed standards.

The main advantages of the technology are that it combines a high top speed with fast acceleration and braking, thereby minimizing trip times. Furthermore, the advanced tilting system and high cant deficiency allow operations through curves at higher speeds without affecting passenger comfort. Despite the high speeds reached (240 km/hr), the *JetTrain* locomotive's low weight reduces track impact and its performance is similar to conventional passenger locomotives operating at 145 km/hr.

As previously mentioned, the *JetTrain* trainset is derived from the Acela, which is used in US Northeast Corridor (Boston-New York-Washington). As of April 2004, the Acela fleet had accumulated over 8.5 million miles in revenue service, whereas the *JetTrain* locomotive has undergone extensive testing at the TTC test track in Pueblo, Colorado, but has not yet operated in revenue service.

[16] e.g. truck attachment of 113,400 kilogram compared to 5g X truck weight in Europe (approximately 59,000 kilograms in the case of the high speed trainset HST350) and static strength of 800,000 lbs (362,800 kilograms) compared to 226,800 kilograms for Europe.

Manufacturer and product	**Bombardier *JetTrain***
Design speed limitation	240 km/hr
Typical consist (# of locomotives – # of coaches – # of locomotives)	1-6-1
Trainset seated passenger capacity	350
Tilting system	Active (6°)
Cant deficiency	21.6 cm
FRA compliance	Tier II
Where used	Demonstration locomotive undergoing trail running
System O&M cost per passenger-km[17]	C$0.08 – C$0.11
Initial investment per route-km[18]	C$3.65 M - C$5.67 M
Est. Calgary-Edmonton Trip Time	1 hour 45 minutes

Electrified Technologies for Dedicated Track Operation at Speeds up to 330 km/hr

Electric trainsets running at high speed on dedicated infrastructure have been in use in Europe and Asia for many years. The high speeds reached have made them very popular with travellers and, as a result, numerous examples can be found where ridership has significantly increased following their introduction. Over the years, many studies have investigated their applicability in North America.

A key disadvantage of this technology is that it relies on dedicated electrified infrastructure, which has historically made its total system cost prohibitively expensive in North America, where less than 1percent of the rail network is electrified. In contrast, the higher population density and traffic volume in Europe have made electrification justifiable over the years and an extensive electrified network has developed. In addition, none of the existing high speed electric trainsets in use meet North American safety and design standards, and would therefore need to receive special authorization/exemption to operate. However, it is more likely that design changes to meet North American standards in the equipment (structural or other) would be required.

Since the trainsets are designed to operate on dedicated tracks specifically built for high speed (minimal curves), they do not need tilting for passenger comfort. This results from the design philosophy adopted in Europe of building the high speed capabilities into the infrastructure (tangent

[17] FRA, High speed Ground Transportation for America (1997), "Accelerail 150F", includes maintenance of way, maintenance of equipment, transportation, passenger traffic and services, general and administrative expenses.
[18] FRA, High speed Ground Transportation for America (1997), "Accelerail 150F", includes infrastructure, vehicles and ancillary systems. Infrastructure costs include sidings, turnouts, etc. needed to accommodate - without adverse impact - freight train frequencies one-fifth greater than those of today, along with projected high speed trains.

track, large curve radii, etc.) rather than building high speed capabilities into the rolling stock (i.e. through high cant deficiency tilting, etc.). Where the high speed capability is built into the infrastructure, the track alignment must be planned accordingly to maximize the curve radii and allow trains to operate at high speed without constantly having to slow down in curves. This tends to require a larger footprint than if high speed capability is built into the rolling stock.

A number of electric high speed trainsets are in service in Europe, examples include:

- The TGV, operated by France's national carrier SNCF, was one of the first high speed trains introduced in the world. It is the result of many years of development, with the latest generation capable of speeds of up to 320 km/hr. The TGV is manufactured by Alstom and Bombardier;

- The ICE, operated by Germany's national carrier Deutsche Bahn, was first launched in the early 1990s and is now in its third generation reaching speeds up to 330 km/hr. The ICE is manufactured by Siemens and Bombardier;

- The AVE, operated by Spain's national carrier RENFE, is the latest example of high speed technology and as such benefits from some of the latest development in the field. The HST350 is capable of speeds of 330 km/hr and is manufactured by Talgo and Bombardier.

TGV in service in France

ICE in service in Germany

HST350 for Spain (AVE)

It should be noted that although not covered in detail in this review, a number of electric trainsets operating at speeds in the range of 200 km/hr also exist in Europe. One such example is the Swiss ICN, an electric multiple unit (EMU), developed by a consortium including Bombardier. These trains could also be used provided that they operate on dedicated electrified track. However, like the high speed trainsets described above, they would need special authorization/exemption to operate and/or significant re-design, since current products do not meet North American standards. Furthermore, the cost difference between these trainsets and those capable of higher speeds is relatively small.

Manufacturer and product	**Alstom/ Bombardier TGV**	**Siemens/ Bombardier TGV**	**Talgo/ Bombardier HST 350**
Design speed limitation	320 km/hr	330 km/hr	330 km/hr
Typical consist (# of locomotives – # of coaches – # of locomotives)	1-8-1	8 (EMU)	1-12-1 (max.)
Trainset seated passenger capacity	377	400	392
Tilting system	No	Available	None
Cant deficiency	11.4 cm	7 cm	18 cm
FRA compliance	Not certified	Not certified	Not certified
Where used	None in North America	None in North America	None in North America
System O&M cost per passenger-km[19]	C$0.07 –C$0.15		
Initial investment per route-km[20]	C$8.11 M – C$36.48 M		
Est. Calgary-Edmonton Trip Time	1 hour 20 minutes		

Maglev Technology for operation at speeds of up to 500 km/hr on dedicated special structure

Maglev is a technology that applies the principles of magnetic attraction and repulsion to lift, guide, and propel vehicles over a guideway. Maglev trains use electronically controlled magnets mounted along both sides of the vehicle that react to either ferromagnetic rails or electric coils on the guideway to levitate and guide the vehicle. Linear motors mounted along the guideway are used for propulsion and braking. Trains are electronically controlled using on-board as well as track-mounted systems for communication and control of vehicles, switches and other systems.

An advantage of maglev technology is low maintenance, as it relies on non-contact electronics instead of mechanical components, thus eliminating wear and tear from friction found with other rail technologies. Trains are also relatively lightweight and enjoy fast acceleration and deceleration capabilities as well as being able to travel at extremely high speed. The trains are quieter than other high speed technologies due to the absence of an engine and wheel/rail interface, but still emit noise due to wind resistance. They are also more energy efficient than conventional trains but only slightly so as most resistive force at high speed is due to air resistance.

A disadvantage of maglev technology, however, is its need for a specially designed and dedicated track, although proponents point out that maglev occupies less space in difficult terrain than conventional 320 km/hr rail technologies because of its ability to climb steeper grades (10% vs.

[19] FRA, High speed Ground Transportation for America (1997), "New HSR", includes maintenance of way, maintenance of equipment, transportation, passenger traffic and services, general and administrative expenses.
[20] FRA, High speed Ground Transportation for America (1997), "New HSR", includes infrastructure, vehicles and ancillary systems.

4%) and handle tighter curves (1950 m at 300 km/hr compared with 3,200 m for normal railroads). The guideway can be either mounted at-grade or elevated, but even an at-grade alignment requires a continuous guideway beam designed to meet strict tolerances. Unlike conventional 330 km/hr rail technologies that can use existing track, albeit at reduced speeds, maglev trains are restricted exclusively to their specially designed dedicated track.

At present, both Japan and Germany have developed maglev trains. The Japanese have a prototype vehicle and test track on which they have carried out extensive trial runs. However, Germany's Siemens TransRapid technology is the first long distance commercial service to be put in operation with construction of the 30 km Shanghai Airport line. This line began construction in March 2001 and started trial running in December 2002. To the end of 2003, the line had carried 200,000 passengers in trial runs prior to commencing revenue service. The cost of the project was $1.6 billion ($1.2 billion USD) or $52 million per kilometre. Recently, it was reported in the China Daily that the Chinese government announced it had abandoned plans to extend this line in favour of pursuing less expensive conventional rail options[21].

Siemens TransRapid

MLX01

Manufacturer and product	Siemens TransRapid	MLX01
Design speed limitation	500 km/hr	500 km/hr
Typical consist	2 – 10 cars	2 – 5 cars
Trainset seated passenger capacity	184 to 1172	136 to 340
FRA compliance	Not certified	Not certified
Where used	None in North America; Only Shanghai China	Prototype only
Est. System O&M cost per passenger-km[22]	C$0.05 – C$0.11	
Est. Initial investment per route-km[23]	C$16.21 M – C$52.00 M[24]	
Est. Calgary-Edmonton Trip Time	1 hour	

[21] AP and China Daily, January 15 , 2004.

[22] FRA, High speed Ground Transportation for America (1997), "Maglev", includes maintenance of way, maintenance of equipment, transportation, passenger traffic and services, general and administrative expenses.

[23] FRA, High speed Ground Transportation for America (1997), "Maglev", includes infrastructure, vehicles and ancillary systems.

[24] High end cost reflects reported actual cost for Shanghai project rather than FRA 1997 estimate based on theoretical comparatives.

3.4 Technology Comparison and Selection

The following table summarizes the key characteristics of the range of technologies that were reviewed:

Technology Groups	**160 km/hr**	**DMU (160 & 200 km/hr)**	**200 km/hr**	**240 km/hr**	**330 km/hr**	**Maglev (500 km/hr)**
Design speed limitation	143 km/hr – 169 km/hr	160 km/hr – 200 km/hr	200 km/hr	240 km/hr	320 km/hr – 330 km/hr	500 km/hr
Trainset seated passenger capacity	236 – 419	150 – 214	250 – 396	350	377 – 400	184-1172
FRA Compliance	Yes	Yes/No	Yes	Yes	No	No
System O&M cost per passenger-km[25]	$0.1655	$0.1655 – 0.16275	$0.16275	$0.16128	$0.16378	$0.15982
Initial investment (C$M) for Calgary-Edmonton[26]	$486 – $1,215	160 km/hr = $486-$1,215 200 km/hr = $729-1,338	$729 - $1,338	$1,095 – $1,702	$2,433 - $10,944	$4,863 - $15,600[27]
Est. Calgary-Edmonton Trip Time	2 hours 40 minutes	2 hours 10 - 40 minutes	2 hours 10 minutes	1 hour 45 minutes	1 hour 20 minutes	1 hour

In order to select the technologies to be considered further in this study, the first and foremost criteria adopted by the Steering Committee was that the technology be capable of providing inter-city trip times that offer a clear competitive advantage over other transportation modes now serving the corridor and thereby be sufficiently appealing to the majority of potential travellers. Market research carried out for this study showed that growth in traveller interest peaked at a two-hour Calgary-Edmonton trip time with only a small additional gain in interest for a trip time of 1 ½ hours. Therefore, using approximately

[25] FRA, High speed Ground Transportation for America (1997), includes maintenance of way, maintenance of equipment, transportation, passenger traffic and services, general and administrative expenses.
[26] FRA, High speed Ground Transportation for America (1997) includes infrastructure, vehicles and ancillary systems.
[27] High end reflects reported actual cost for Shanghai rather than FRA 1997 estimate based on theoretical comparatives.

2 hours as the cut-off point, technologies capable of speeds up to 177 km/hr were eliminated, whereas those capable of speeds of 200 km/hr or higher were favoured.

The ability to both operate in mixed traffic and use existing rail lines was another important criteria so that the option of upgrading the existing CPR line could be examined as one of the alignment alternatives. On this basis, it was decided to include the Bombardier *JetTrain* as one technology option, as it met these operational criteria, could represent both the 200 km/hr and 240 km/hr groups and was capable of offering a travel time of two hours or less although it has not yet operated in revenue service[28].

The Steering Committee also supported examining a dedicated alignment alternative for two reasons. First, a dedicated alignment was the recommended option by the previous 1980s study. And, second, it would enable performance, cost and benefit comparisons with the upgraded existing CPR alignment alternative. Based on a dedicated alignment, either conventional electrified rail technologies capable of 330 km/hr operation or maglev technology capable of 500 km/hr operation were possible candidates.

In comparing these two technology candidates, several factors weighed against the selection of maglev technology. A major concern was the high probability that initial investment or capital cost could be significantly higher than for conventional 330 km/hr rail technologies. This conclusion was based in part on the FRA typical per kilometer cost estimate range and in part on actual Calgary-Edmonton corridor conditions. Specifically, maglev's design advantages in handling steep grades or sharp curves do not apply here, and the inability to use existing rail lines as an option to access both city centres would also likely add to costs.

Given current population and travel demand, the incremental ridership and associated revenue that could result from faster service also do not appear to warrant higher investment cost. In addition, data on actual operating and maintenance costs for this technology or its major component parts[29] is generally lacking as the only commercial service of its kind in Shanghai has only just begun revenue service operation.

For all these reasons, the Steering Committee decided to adopt the 330 km/hr conventional rail technologies as the second technology option for this study. However, it also determined that the dedicated alignment option should examine use of both the 240 km/hr *JetTrain* and 320 km/hr conventional rail technologies, while the mixed traffic CPR alignment assessment should be based on the 200 km/hr/240 km/hr *JetTrain*.

[28] While it has been suggested that maglev, if elevated on structures, could be accommodated in the median of Highway 2, thus saving right-of-way acquisition costs, the adequacy of the median and implications from accommodating these requirements raise concerns. Furthermore, the additional cost of structures, stations and access in this configuration do not appear to be offset by land acquisition savings based on current land values.

[29] The Steering Committee recognized that while turbine powered *JetTrain* locomotive does not have a proven record of commercial service, *Acela,* the electrified version does. Systems common to both locomotives include the rheostatic grids, fire suppression system, auxiliary transformer, propulsion, electronics and controls and trucks. Furthermore, jet turbine engines, which are the differentiating technical component of the train propulsion system enjoy an extensive record of commercial service.

ALIGNMENT OPTIONS AND INFRASTRUCTURE REQUIREMENTS

4.1 Introduction

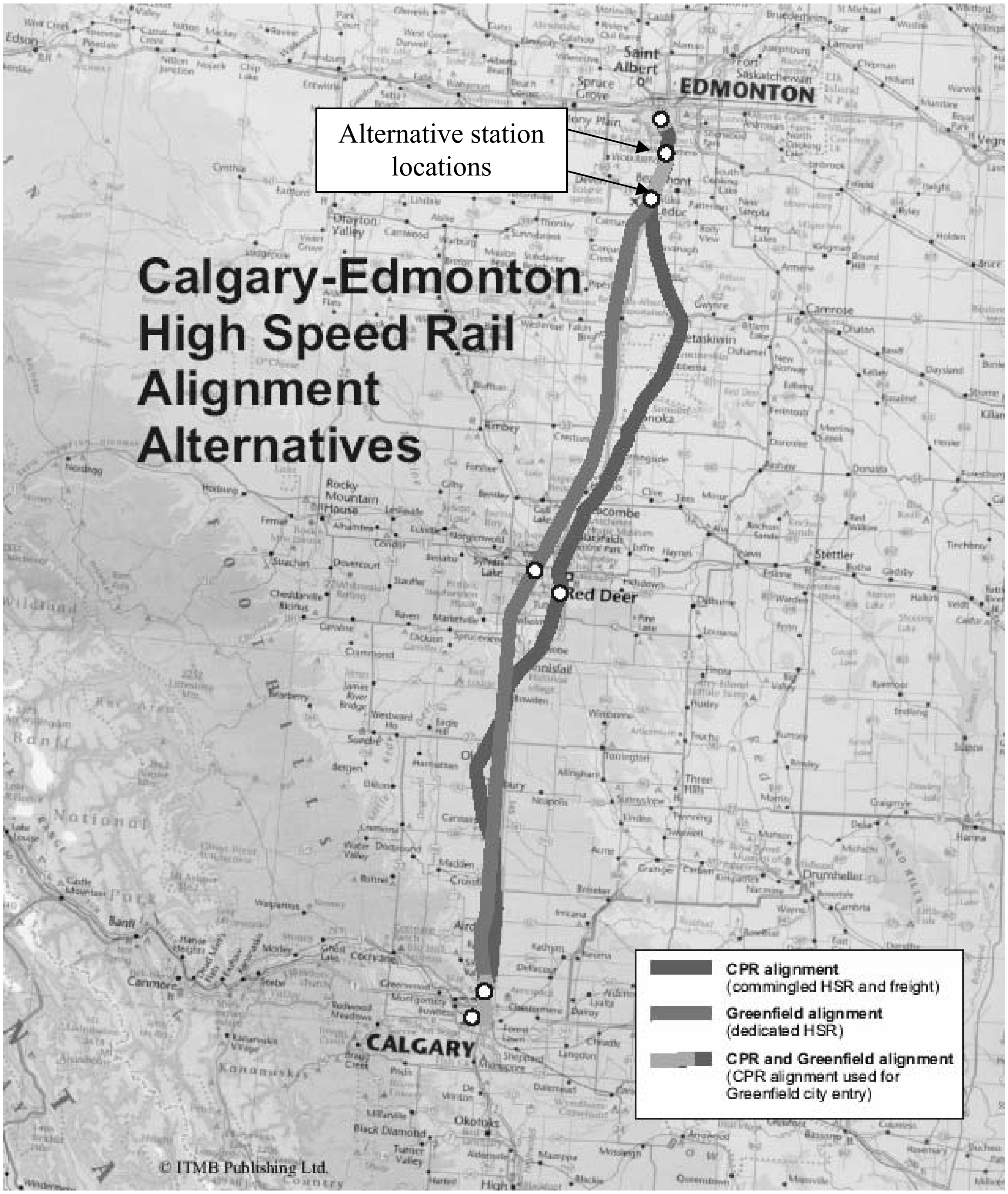
Two alignment alternatives were adopted by the Steering Committee for consideration in the current study. The first is the existing Canadian Pacific Railway (CPR) line with appropriate infrastructure upgrades to accommodate high speed rail service using Bombardier's *JetTrain* as the representative technology. The second is a new dedicated alignment (Greenfield option), as was recommended by the previous 1980s studies, using both Bombardier's *JetTrain* and electrified 330 km/hr high speed rail technology. With respect to the Greenfield option, it was determined that the most practical way to enter Calgary and Edmonton was along the existing CPR alignment. CPR developed the operational parameters, design and infrastructure requirements for the alternatives for the CPR alignment alternative as well as the city entry portions for the Greenfield alternative, and Canac these for the new dedicated portion of the Greenfield alternative.

The same city centre endpoints are applicable for both alignment alternatives because the Greenfield scenario uses the CPR corridor for city entry. The choice of endpoints, although based on practical considerations, including access, centrality and railway operating practicality, was arbitrary, recognizing that final selection of the precise terminal locations, weighing the pros and cons of each option, can occur at a later date. Any necessary alignment adjustments to address variations from the chosen endpoints are likely to be minor, and should not affect the overall study results.

For Calgary, the assumed endpoint is the intersection of 3rd Street SE and 9th Avenue, with a passenger terminal presumed to be located on now vacant land between the CPR tracks and 9th Avenue. This site is about milepost 175.4 on CPR's Brooks Subdivision, the east/west mainline and is located approximately above the LRT tunnel, in proximity to City Hall. Having the terminal situated north of the existing tracks and east of Centre Street minimizes conflicts with freight trains. Other sites at or west of Centre Street could be considered in the future, but would require adjustments to infrastructure that supports CPR's mainline and Alyth Yard freight operations that have not been factored into this study.

For Edmonton, the assumed endpoint is immediately south of 99th Avenue, adjacent to the Government Centre (Grandin) LRT station. This location is about milepost 98.8 of what was formerly CPR's Leduc Subdivision, 2.7 km north of CPR's currently owned right-of-way and the northerly limit of freight operations at milepost 97.1. The site is also 0.5 km south of the historic terminus of CPR's passenger train operations at milepost 99.1. Urban development has made extension of the alignment north of Grandin either very disruptive or costly.

This Chapter describes the alignment alternatives and infrastructure requirements associated with each alternative, as well as the design standards and other assumptions used in determining these requirements.



Calgary-Edmonton High Speed Rail Alignment Alternatives
Alternative station locations
EDMONTON
Red Deer
CALGARY
CPR alignment
(commingled HSR and freight)
Greenfield alignment
(dedicated HSR)
CPR and Greenfield alignment
(CPR alignment used for Greenfield city entry)
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4.2 CPR Alignment

Based on the selected endpoints, the CPR alignment is approximately 310 km (192.5 miles; CPR's infrastructure and operations are recorded in the British system) long, comprised of the following segments working north from Calgary to Edmonton:

CALGARY-EDMONTON CPR ROUTE DEFINITION (KM)			
Subdivision	**From milepost**	**To milepost**	**Kilometres**
Brooks – Calgary downtown station to junction with Red Deer Subdivision	175.4	174.5	1.4
Red Deer – Calgary to Red Deer	0.0	95.6	153.9
Leduc – Red Deer to Strathcona	2.8	97.1	151.8
Owned by CPR			**307.1**
Leduc – Strathcona to Edmonton	97.1	98.8	2.7
Owned by Province of Alberta			**2.7**
Total Kilometres			**309.8**

The CPR line between Calgary and Strathcona (South Edmonton) was opened for service in 1891, and the extension of the route to downtown Edmonton via the High Level Bridge was completed in 1913. Except for line relocations in the City of Red Deer and at Ellerslie made in recent times and possibly a few other very minor adjustments made many decades ago, the original alignment has remained unchanged.

This means that the starting point for a 21st century high speed passenger operation is a latter 19th century alignment created with shovels and horse-drawn plows, which presents a number of challenges, including alignment and suitability of the sub-grade, that directly affect infrastructure requirements for the new service.

A second but very important factor is the line's existing freight operation. Ensuring compatibility between the new high speed passenger service and existing freight operations, as well as maintaining these operations during track upgrading and construction, are critical. Together these two factors drive decisions about design standards, infrastructure requirements and the approach to construction.

4.2.1 Current Conditions

Track Alignment

Train speed in Calgary and Edmonton, where substantial urban development exists adjacent to the track, will be limited by factors other than alignment. However, in the middle portion of the route between the Bow River crossing in Calgary and approximately Ellerslie Road (9th Avenue) in South Edmonton, track alignment, specifically curvature, will be a primary determinant of train speed.

Within this 293 km middle section, some 228.5 km or 78 percent of the alignment is straight or tangent track. For railways, this is a fairly high percentage, the fortunate result of easy grading conditions of the prairie. In fact, no curvature exceeds five degrees in this section, and most are two degrees or less.

TRACK CURVATURE – BOW RIVER CROSSING TO ELLERSLIE ROAD				
Curvature	**# of Segments**	**Section Kilometres**	**% of Section**	**Cumulative % of Section**
= 0 (tangent)	151	227.27	77.6	77.6
> 0, < 1	84	37.22	12.7	90.3
> 1, < 2	45	16.93	5.8	96.0
> 2, < 3	18	9.11	3.1	99.2
> 3, < 4	3	1.24	0.4	99.6
> 4, < 5	3	1.22	0.4	100.0
Sum of curves	153	64.44	22.0	
Total	**304**	**293**	**100**	

Freight Operation

The Calgary-Edmonton corridor is very important to Alberta's economy. The continuation of this corridor to border crossings at Coutts, Alberta and Kingsgate, British Columbia is the only rail route directly south to US markets. The corridor's connection at Calgary to the transcontinental mainline is the route to eastern markets, and exports to the Pacific through the Port of Vancouver. In addition, Calgary-Edmonton is one of the most rapidly growing corridors in the CPR system.

Freight operations on the line include both road and local trains. Road trains usually transit the route without performing switching service for customers en route. If they do pick-up or set-off traffic, this only occurs at designated yards, such as Red Deer. Road trains are generally large, and are scheduled to make connections with other trains at Calgary for furtherance of freight. Maintaining these connections is fundamental to the freight service. It is common to have 14 road trains per day, and on busier days, 18 or more.

Local trains perform switching for customers situated along the route, and are generally much smaller than road trains. While performing pick-ups or drop-offs, the trains often leave the mainline entirely, thus imposing no demand on mainline capacity during these periods. However, they must re-enter the mainline to travel to the next customer. Although these trains have a schedule in the sense of hours of operation and portions of the route to be switched, the exact daily duty cycle varies considerably to meet local customer requirements. Presently, seven local train assignments operate during the hours proposed for the passenger rail service, covering approximately 60 percent of the route kilometres with some portions covered by two different assignments.

4.2.2 Design Standards

Maximum Design Speed

The first requirement in establishing the upgrades necessary to accommodate higher speed operation was to decide on the maximum passenger train speed. CPR selected 125 mph (about 200 km/hr) as the maximum for passenger trains operating on track shared with CPR freight trains. The choice of 125 mph (200 km/hr), or any other value, is arbitrary as there is no natural threshold of safety and/or practical considerations to determine maximum speed.

The main safety and practical issues associated with the choice of maximum passenger train speed in a mixed passenger/freight environment are:

- Safety
    - Collisions with motor vehicles at level crossings
    - Ensuring the safe separation and routing of trains to minimize risk from shifted freight loads and derailments

- Practical
    - Implications on capacity of widening speed differential
    - Maintaining track for higher passenger train speeds in an environment of wear from heavy freight trains

Operation at 125 mph (200 km/hr) is a concern for level crossings. Most, if not all crossings should be eliminated at these speeds. Under US railway safety regulations, 125 mph (200 km/hr) is the maximum speed at which level crossings are feasible, and only if they meet stringent tests. In Canada, new grade crossing regulations are expected soon, and indications are that few if any level crossings will be accepted where trains operate at 125 mph (200 km/hr).

125 mph (200 km/hr) is also the maximum authorized speed for Class 7 track, and therefore is a logical breakpoint beyond which costs increase to maintain the more strict geometry of a higher class track, although capital costs are the same. The next lower category, Class 6, peaks at 110 mph (177 km/hr), which is too low to achieve the desired trip time for this service. In addition, 125 mph (200 km/hr) is considered a feasible step-up from proven mixed passenger/freight service at 100 mph (160 km/hr) between Montreal and Toronto.

Super-elevation

In addition to track alignment, super-elevation or banking of the track through curves to help operating performance, affects maximum allowable train speed. Super-elevation counteracts the outward centrifugal force, providing for more even weighting of the equipment on the two rails. The greater the super-elevation, all other things being equal, the greater the possible speed in the curve. The speed that corresponds to an exact even weighting on each rail is called balance, or equilibrium speed. Speeds above this balance speed are authorized by railways, and are expressed as the amount of super-elevation deficiency.

On the CPR system, freight train over-speeds through curves are capped at 2-inches (5 cm) of deficiency (i.e. 5 more cm of super-elevation in the track would produce balance). Conventional passenger trains without tilting systems are capped at 3-inches (7.6 cm) of deficiency. Both thresholds are typical of North American industry practice. However, in some applications elsewhere, curve speeds that are the equivalent of 7-inches (17.8 cm) or more of super-elevation deficiency have been authorized for passenger trains with tilting systems.

The following table presents the maximum authorized passenger train speed for up to 4 ½ inches (11.4 cm) of super-elevation and 3-inches (7.6 cm) and 7-inches (17.8 cm) of deficiency.

RELATIONSHIP BETWEEN CURVATURE & SPEED (KM/HR) (conventional vs. tilt body equipment)				
Degree of Curve	**Super-elevation (cm)**	**Balance Speed**	**Max Speed 7.6 cm deficiency**	**Max Speed 17.8 cm deficiency**
0.75	3.2	79	145	200
1.0	10.2	122	160	200
1.5	11.4	106	137	167
2.0	11.4	92	117	145
2.5	11.4	82	106	130
3.0	11.4	74	97	119
3.5	11.4	69	88	109
4.0	11.4	64	84	103
4.5	11.4	61	79	97
5	11.4	58	74	92

For this study, CPR chose 4 ½ inches (11.4 cm) as the maximum super-elevation in the track. Accordingly, train speed will be limited to below 125 mph (200 km/hr) on curves of slightly more than one degree. While CPR occasionally uses slightly more elevation for its freight operations (on fairly tight mainline curves), accurate maintenance, which is critical for these high speed passenger train speeds, of this much elevation can be difficult.

The implication of using this standard is that a curve realignment plan to minimize curve related speed restrictions is needed to reduce as many existing curves over one degree to one degree or less as is practical. Trade-offs between additional construction costs for a 0.75 degree standard (the curvature at which most of the incompatibility is eliminated between the needs of CPR's freight trains and this passenger service) and the savings from prolonging rail life as a result can be explored at a later date.

4.2.3 Revised Alignment

As previously indicated, 37 km of track between the Bow River crossing in Calgary and Ellerslie Road in South Edmonton has a curvature of one degree or less. Added to the total km of tangent track, some 90 percent of this section of the route does not require any alignment modification to accommodate operation of 125 mph (200 km/hr) trains with tilting systems.

In an earlier study looking at 100 mph (160 km/hr) operation with conventional trains, each curve was reviewed for feasibility of realignment to one degree. This work constituted the starting point for this study. The CPR's line location plans, recent video recordings of the route and current maps were consulted to make judgments about the difficulties of realigning curves.

Factors considered were the size of shift in location of the track, nearby development, bridges and level crossings. The latter is important because for level crossings to remain open, the realignment should locate road crossings on tangents, not curves where large super-elevation could be a problem for vehicles. The final step was to use computer aided drafting (CAD) to locate the old and new alignments producing mileposts for the endpoints and the amount of land required for each realigned curve.

This process concluded that 45 of the 69 curves greater than one degree could be reasonably realigned to one degree, and two others could be realigned to one degree, 15 minutes. Of the remaining 22 curves greater than one degree, six pertain to a segment of the Leduc Subdivision just north of Red Deer between Labuma and Blackfalds. For these six, no specific realignment plan has been selected because:

- realignment to one degree would require too large shifts (up to 853 metres);
- maximum gradients climbing out of the valley of the Blindman River have to be limited for freight operations;
- a CN branch line passing overhead must be accommodated; and,
- possible realignment of Highway 2A and a corresponding shift in the railway location is currently under study.

For these reasons, it was decided that a design solution would be better achieved at a later date as part of a more detailed site specific study. However, for the purposes of this study, it was assumed that at least a 2 degree solution would prove feasible, which with 4 ½ inches (11.4 cm) super-elevation and 7 inches (17.8 cm) of deficiency, would allow 90 mph (145 km/hr) operation. Realignment of the remaining 18 curves greater than one degree was rejected either because cost was too high, or derived benefits too small (i.e. near a station stop).

In total, some 58 km of the existing alignment are affected by curve realignment. The realignment plan results not only in elimination of 22 curves but reductions in the sharpness of 47 others. While in some cases realignment can be achieved within the existing 100 foot (30.5 m) CPR right-of-way, others require widening of the right-of-way, and still others that a new right-of-way separate from the existing one be acquired resulting in surplus land in-between the two right-of-ways and from the old right-of-way itself.

For the purpose of this study and to be conservative, it was assumed that right-of-way equal to the amount of the shift in the track centre line would be required, even for slight realignments that in practice may be accommodated within the existing right-of-way. The actual amount of net land acquisition required to implement these changes will only be known through negotiation and, if necessary, expropriation. The worst case, where all land, including surplus land between the new and old right-of-ways, must be acquired, results in a requirement of 309 ha. If, however, acquisition of the surplus land in-between the new and old right-of-ways could be avoided or recovered, required land acquisition reduces to 108 ha.

The videos confirm that in nearly every case the impacted land is agricultural and without buildings. In no case is a developed community affected. Nevertheless, on-site surveys and detailed alignment designs will be required at a later date to finalize land requirements and determine actual impacts.

4.2.4 Infrastructure Requirements

Track Work

In the earlier study looking at 160 km/hr train operation, a formal simulation was used to understand the interplay between infrastructure, number of passenger and freight trains and delays to trains. Based on this earlier analysis and CPR's practical experience in gauging capacity requirements, it was concluded that a double track mainline was required. This decision was based on:

- the large capacity demand resulting from the enormous speed differential between 200 km/hr and much slower freight trains; and,
- the super-imposition of 22 passenger trains bunched within 16 hours on top of 14 or more freight trains, having absolute priority over freights.

In addition, the two mainline tracks need to be signaled for operation in either direction (Centralized Traffic Control or CTC), and have numerous crossovers to permit movement of trains from one track to the other. Ideally, and the practice assumed in this study, is that the freight train in most instances will switch tracks to make way for the faster passenger train to pass. In so doing, neither the freight nor the passenger train will need to slow down. For the purpose of this study, the maximum spacing between crossovers is 14.5 km, and in most cases, 10 to 13 km.

A further requirement is to provide sidings or third main track to temporarily remove a long freight train from the network that would otherwise block the route, and also signalize this track so that switching can be done mechanically from a central location. Today, CPR often temporarily holds freight trains on the mainline in North Calgary over the Bow River awaiting clearance to enter Alyth Yard or the east/west mainline. To avoid this in the future, the capacity analysis provides a 4.8 km third main track just north of the Bow River, which can handle two large freight trains. This track would also be used to hold northbound freight trains that must be cleared from Alyth Yard or the east/west mainline for congestion reasons but cannot proceed north to Red Deer until passenger traffic permits.

A similar section of third main track is provided between Edmonton and Nisku to buffer the Edmonton intermodal and classification yards. Other segments of third main track are provided near Crossfield and Olds, the 1/3 d and 2/3 d points between Calgary and Red Deer, and at Blackfalds and Wetaskiwin between Red Deer and Edmonton. Where possible these sections take advantage of curve revisions to use redundant existing track rather than constructing new track.

Within Calgary, a second bridge over the Bow River is required for the second main track. South of that, the northwest leg of the 12th Street interlocking must be upgraded to add a second main track to allow simultaneous passenger and freight rail operations through the northwest leg and Alyth Yard hump lead operation. In addition, a new track is required to serve passenger service north of the existing tracks on the Brooks Subdivision and over the Elbow River to the entrance of the assumed passenger terminal. This configuration in Calgary is relatively easy to construct and nicely separates existing freight and proposed passenger operations as far west as the assumed terminal. If, at a later date, another terminal location further to the west were chosen, additional infrastructure would be required.

Within Red Deer, the second track curves through the yard area along its eastern property limits. This track would be primarily for passenger trains, and certainly so during periods of passenger operations. While passenger trains would normally be restricted to this single track for some 3.2 km, this is not expected to cause any significant delay.

Within South Edmonton, the second main track is placed along the western edge of the existing right-of-way, and in places, possibly on a new strip of land. This single track would serve passenger operations in both directions, separated from the other main track by a fence. This arrangement permits higher speeds (60 mph or 97 km/hr is assumed) without endangering railway employees working on the ground on the adjacent main and yard tracks.

The passenger track connects to the existing mainline freight track near the present South Edmonton freight yard, thus allowing incidental routing of passenger trains over the freight track when the passenger track is being maintained, or occasional routing of freights over the passenger track when a freight track is blocked and no passenger trains are in the area for some time. This connection adds resilience to the operation and does not alter the main design goal of high speed, safe, delay-free passage of passenger trains through the yard area.

Near Whyte Avenue, the new main track joins the 2.7 km Provincially-owned, single track former CPR Leduc Subdivision for the balance of the route to Government Centre. Altogether, about 8 km of passenger train operations are single track in Edmonton, with trains able to meet each other at Government Centre. Scheduling would be set to avoid passenger train meets on the single track section or, if this is not possible, a small signaled pocket track meeting location could be added.

Based on the assumed terminal locations, the terminal track structure includes two signaled stub-end tracks in Edmonton, and in Calgary two stub-end tracks and one through-track to permit incidental train routings westward on the Brooks Subdivision. For Red Deer and the two suburban stations, the track configuration provides for loading/unloading from either or both of one of the main tracks and a third short station track, to allow for instances when two passenger trains are in the station at the same time.

The structure of the tracks on which passenger trains will regularly operate is assumed to be new concrete ties, new 136# rail and 12 inches (0.3 m) of ballast under the ties. Freight-only tracks are assumed to be constructed from materials made surplus from the existing main track, namely used wood ties and used 115# rail, with 12 inches (0.3 m) of new ballast under the ties.

Turnouts on passenger train tracks are assumed to be new. For turnouts that serve as a connection between main tracks, including those to the third main track, #20's are assumed. Turnouts at junctions with branch lines and to enter intermediate stations are #16's. Powered connections with major customers and in the Calgary and Edmonton termini are #13's. Non-powered turnouts to industry trackage are #11's.

Track Centres

CPR's standard track centre for existing main lines is 13 feet (4 m), and has been the typical industry practice for many years. Most older multiple track configurations were constructed to this standard, as the grade for the new track could generally be built next to the existing grade without requiring land beyond the existing 100 foot (30.5 m) right-of-way. More recently in North America, however, when additional main tracks have been constructed, wider track centres (25 foot/7.6 m) have been used to lessen disruption to existing operations during construction, ease the slowing of trains when adjacent tracks are maintained, provide increased clearance for oversized loads and improve safety.

As safety is of paramount importance in the proposal to mix high speed passenger trains operating at 125 mph (200 km/hr) with much slower freight traffic, a minimum of a 25 foot (7.6 m) track centre was judged necessary. However, if the new grade were built to one-side of the existing grade on a 7.6 m centre, a wider right-of-way would be required in many instances to accommodate the side slopes and drainage ditching. This would result in the finished track structure being asymmetric within the right-of-way. Furthermore, the two grades would not be the same, as the new grade would be engineered using modern knowledge of soil strengths, whereas the old would still be a pioneer grade with limitations that could impact the 125 mph (200 km/hr) service.

To avoid these problems, construction of two new grades, one on each side of the existing grade, is proposed. Although 12 ½ foot (3.8 m) centres to each side would result in a 25 foot (7.6 m) centre overall when completed, the separation from the existing track would be less than the 13 foot (4 m) required minimum during construction. Therefore, for the purpose of this study, a 14 foot (4.3 m) track centre has been adopted, which eases construction, ensures largely undisturbed freight operation during construction and is slightly more conservative for costing purposes. Once both new tracks are completed, the freight operation would be transferred to them and passenger operations could commence. The old track would be deactivated and track materials would be removed gradually using equipment operating on the two new adjacent tracks.

Wherever new track is constructed adjacent to the existing one, a 28 foot (8.5 m) track centre results between the two new track grades. However, for the 58 km of curve realignments where construction is removed from the existing main track with no clearance issues during construction, a new two-track grade with 25 foot (7.6 m) centres is assumed.

Subgrade

A concern about 125 mph (200 km/hr) passenger train operation commingled with freight is the ability to maintain the geometry of the tracks to Class 7 Standards. The subgrades of the existing line are the product of the pioneer technique of piling up whatever soils were present on site, creating ditches on either side of the resulting built-up grade. Today, there are localized areas where CPR has difficulty maintaining the surface for even the easier standard of Class 4 required for freight train speeds.

Clifton ND Lea was commissioned to address this issue, and provided a report specifying the minimum strength criterion for subgrade, types of existing soils and their inherent strengths along the corridor and the depth of granular materials required to underlay the ballast to meet the strength criterion. This amount varies between 24 and 54 inches (61 cm and 137 cm) depending on location. The specified depth was fulfilled with one foot (0.3 m) of sub-ballast and the remainder granular material.

Grading

Grading, which is the foundation for track structure, is required for the construction of new tracks, any ancillary tracks and relocation of the main tracks where curve alignments requires it.

To calculate the volume for the new grade, office records were used to summarize the vertical profile of the existing main track grade relative to the prevailing grade as surveyed. This profile was then assumed to apply to other tracks constructed adjacent to the existing main track. For curve alignments, video recordings of the route were reviewed and judgments made about grading requirements at the approximate location of the shifted alignment. Horizontal information for the volume calculations was set by the specification used for design of the top width, slopes and ditches of the new grade based on CPR standards.

The depth of stripping of existing soil was assumed to be one foot (0.3 m). It was also assumed that all other material excavated on the property, such as for cuts and ditches, would be suitable for reuse and not require offsite disposal. In addition, wherever the cut or fill requirement was less then 2 feet (0.6 m), it was assumed to be 2 feet (0.6 m) to be conservative.

Bridges

Many of the existing bridges are effectively abandoned in the infrastructure plan because construction of two new tracks on 28 foot (8.5 m) centres renders the existing structure out of line. However, this loss is not as great as might be expected. Many of the existing bridges have decks that would not be suitable for 125 mph (200 km/hr) service and would require substantial modifications. Also, the largest structures are fortunately located in areas where train speeds will be lower. Here, 14 foot (4.3 m) track-centres are all that is required, meaning that the existing structure is used and only one new single-track bridge is added. New single track spans are required for the Bow and Red Deer rivers, whereas a new deck is assumed for the High Level Bridge.

Level Crossings

There are presently some 200 vehicular level crossings along the route, of which 125 are public thoroughfares and 75 private (e.g. farm crossings). There are also five formalized pedestrian crossings.

Level crossing safety is governed by federal regulation, with new draft regulations currently under review but expected to come into force soon. The regulations are expected to prohibit creation of any new crossings where train speed is in excess of 80 mph (129 km/hr). However, as the CPR line is already in existence, technically no new crossings are created, although some of the curve realignments shift the existing road crossing to a new location making their status less clear. Nevertheless, Section 22(2) of the Railway Safeway Act also permits the Minister of Transportation to exempt a provision of the regulations (such as the 80 mph/129 km/hr limit on new crossings), as long as the measures proposed provide an equivalent level of safety and full details of the alternative and a risk assessment are submitted.

For the purpose of this study, it was assumed that all public crossings would be eliminated where train speeds are higher than 145 km/hr. To determine infrastructure requirements for railway crossings, the following steps were carried out:

- train performance simulations were conducted by CPR to establish the "natural" train speed based on equipment capabilities, curve limitations and acceleration/deceleration for station stops;
- CPR reviewed detailed maps of the road system and railway videos and developed initial assumptions on road closures and grade separations, including whether the road would go over or under the railway; and,
- the above information and assumptions were reviewed with representatives of Alberta Transportation and modified accordingly.

Based on this process, it is assumed that 72 public level crossings will be closed and 46 others grade separated. Any public level crossings that are assumed to remain (where speeds are lower) are designated to have four quadrant gates preventing motorists from driving around the gates, with constant warning time technology.

Private crossings will also need to be addressed on a case-by-case basis. From video tapes, it is clear that many crossings are seldom used and it may be possible to negotiate their permanent closure with the land owner. Others are in close proximity to a public road, where it may be possible to close the private crossing by providing a connection to the public road. Still others are in close proximity to other private crossings where consolidation may be possible. Given the range of potential solutions, a lump sum cost to deal with these private crossings has been assumed rather than specific infrastructure solutions.

Fencing

For the purpose of this study, a 1.8 m chain link fence is provided on both sides of the right-of-way where train speeds exceed 40 mph (64 km/hr) or community development is close to the right-of-way. Based on video tapes, some 119 km of new fencing were identified plus an allowance for another 42 km of additional fencing to allow for community growth or requirements not apparent from the tapes. This includes fencing between the new second main track and the existing main track in South Edmonton to ensure the safety of railway employees working adjacent to passing passenger trains but excludes fencing where it already exists on the assumption that it is adequate.

Replacement of Storage Track Capacity

Freight customers are located along the existing mainline on both sides of the right-of-way, with ancillary tracks off of the mainline associated with each customer. In addition, numerous sidetracks along the length of the route are used for freight car storage and other purposes, such as temporary storage of track maintenance equipment. Construction of the new main tracks on 14 foot (4.3 m) centres and some curve realignments will obliterate or isolate many of the storage tracks whose capacity must be replaced.

While some storage tracks will not be affected by the new infrastructure, these too are assumed to be relocated because the present practice of having many storage locations distributed along the route is not conducive to the interference-free mainline operation necessary for high quality passenger service. As a result, the current infrastructure plan provides for concentration of most storage track requirements into two new support yards as follows:

- Balzac Storage Yard – At a location to be determined in open country near Balzac, a new storage yard comprising 5 track-miles (8 track-km) and at least five separate tracks on 12 ha of land is assumed. This yard would replace capacity lost at Beddington (location of Calgary suburban station), Airdrie, Bowden, Tuttle and Innisfail totaling some 4.5 track-miles (7 track-km).

- New Wetaskiwin Yard - At a location to be determined in open country near Wetaskiwin, a new storage yard comprising 9 track-miles (14.5 track-km) and at least nine separate tracks on 14 ha of land is assumed. This yard would replace capacity lost at Wetaskiwin (curve realignment), Millet, Hobema, Ponoka and Morningside totaling some 9 track-miles (14.5 track-km).

4.3 Greenfield Alignment

Unlike the CPR alignment alternative, the Greenfield alternative is not burdened by the characteristics or condition of an existing line nor with its existing use and requirements to accommodate freight traffic. Instead, it has the happy circumstance of starting from scratch and developing an infrastructure plan solely focused on the requirements of the high speed passenger rail service.

The starting point in developing the current Greenfield alignment was to re-examine the New Corridor Option (“Greenfield”) as outlined by Reid-Crowther and Partners in November, 1984. The objective of this review was to determine whether this route was still viable, given the considerable residential/commercial development between Calgary and Edmonton since 1984. The Alberta Department of Economic Development provided numerous reports and drawings from the 1984 study. Geotechnical and route assessment drawings were digitized and examined to comprehend the various routing options considered in 1984.

Once a clear understanding of the primary route was attained, a field visit of the entire alignment from Calgary to Edmonton was undertaken on April 29, 2003 to identify any necessary modifications to achieve a feasible current alignment. The findings of the visit were discussed with the Steering Committee and a route was selected for the purpose of this study to represent the current Greenfield alignment option. Next, infrastructure requirements identified in the 1984 plan were reviewed, revised and updated.

4.3.1 Alignment Review and Selection

Access to downtown Calgary was considered in the 1984 Phase III Sub-Study B. The 1984 recommendation was to terminate the high speed rail line in the vicinity of the Zoo LRT station due to difficulties in accessing the downtown core. At the time, CPR had concerns about shared use of its right-of-way; acquisition of a new right-of-way into downtown Calgary was deemed too disruptive and expensive; and, a technical and engineering examination of using the LRT tracks raised serious concerns about its feasibility, leaving detailed assessment of this option to future studies. Today, the willingness on the part of the CPR to consider joint use of its tracks into downtown Calgary, coupled with the even higher cost of land in downtown Calgary and still questionable feasibility of sharing the LRT tracks, prompted the decision to recommend the CPR right-of-way as the preferred route into downtown Calgary for the purpose of this study.

As a result, the current Greenfield alignment departs the same downtown location as assumed for the CPR alignment option and follows the CPR right-of-way for approximately 17 km (about 10.6 miles to CPR milepost 9.7 of the Red Deer Subdivision) before veering west onto a new dedicated right-of-way. Continuing northward, the alignment crosses over the CPR (which turns westward just south of Carstairs) and Highway 2A. It then continues north for 35 km before again crossing over the CPR and Highway 2A, after which the alignment remains west of the CPR mainline and Highway 2 until the approach to Edmonton.

Within this section of the route, the April 29, 2003 field inspection showed that housing developments in Leduc and Airdrie had encroached on the 1984 proposed alignment. As a result, the routing was modified to avoid these conflicts by shifting the Greenfield right-of-way slightly to the west of the 1984 alignment onto what is now vacant agricultural land. However, this adjustment was done without knowledge of future residential development plans and may require more extensive modifications at a later date[30].

Once established on the dedicated Greenfield route between the outskirts of Calgary and Edmonton, there are two vertical profiles that can be followed while remaining on virtually the same alignment. The first profile – referred to as Scheme A – is the most level, with a maximum grade of 1 percent. This profile was engineered to provide maximum reduction in frost heave potential by using fills whenever possible. The second profile – referred to as Scheme B – reduces the net borrow requirement (when the amount of earth required for fills exceeds the amount of earth that is obtained from cuts). By following the contour of the land more closely in places and increasing the maximum allowable grade to 3.5 percent, the net borrow could be eliminated, resulting in some construction savings in earthworks.

[30] Detailed surveys and plans will be required to finalize the alignment and optimize its design from the perspective of cost, impact mitigation and land acquisition. Nevertheless, relatively few sections of the current Greenfield alignment are likely to be significantly affected.

In 1984, the only profile costed in detail was Scheme A, and so this profile was selected for the purpose of this study. Consideration at a later date can be given to whether economies can be realized by following Scheme B, providing that slightly higher maintenance associated with Scheme B is acceptable and rider comfort is not compromised at high speed.

Just south of Edmonton International Airport, four different alignment alternatives were offered in the 1984 report, with options to pass by the airport either on its west or east side. Once north of the airport, a second routing choice was also available – to enter Edmonton via 111 Street or via the CPR right-of-way.

Entering via 111 Street enables a possible terminal at the Southgate Shopping Centre (corner of Whitemud Drive and 111 Street). Alternatively, by continuing northward on 109 Street and tunneling under the University of Alberta to the LRT bridge over the Saskatchewan River, a terminal at the Grandin LRT station (corner of 98 Avenue and 110 Street) is possible. Entering via the CPR right-of-way enables a possible terminal in the vicinity of Whitemud Drive or, by continuing along the former CPR right-of-way to the High Level Bridge, a terminal at the Grandin LRT station is again possible.

The two sets of choices presented the following four alternatives in 1984:

- “Main” Alternative: East of the airport / 111 Street
- Alternative 1: East of airport / CPR right-of-way
- Alternative 2: West of airport / 111 street
- Alternative 3: West of airport / CPR right-of-way

Obstructions from new housing developments and the high cost of building along 111 Street versus the relatively unobstructed entrance via the CPR right-of-way eliminated the “Main” alternative and Alternative 2.

The decision, then, was to determine where best to join the CPR right-of-way. The CPR mainline alignment has changed since 1984 and, whereas the preferred high speed rail connection to the CPR had been from the east side (necessitating a crossing of the CPR mainline), it was now preferable to join the CPR mainline from the west side and remain on the west side to avoid conflicts with freights accessing future yards. The ideal location to do this is slightly south of the original Alternative 1 connection with slight modifications to reflect the different distance and grade separations required.

On this basis, the alignment option chosen - a modified version of Alternative 1 -- passes to the east of the airport then turns eastward at the northeast corner of the Airport, crosses Highway 2 and joins the CPR right-of-way from the west side at approximately CPR milepost 85.5 of the Leduc Subdivision. It then follows the same alignment as the CPR alternative for the remaining 21 km to the assumed Edmonton terminus at the Grandin LRT station.

The resulting Greenfield alignment is 294 km in total length, of which 38.5 km use CPR and provincially owned right-of-way. These sections are common to both the CPR and Greenfield alternatives. The remaining 255.5 km are unique to the Greenfield option and require acquisition of a new right-of-way. This new right-of-way varies in width from 30 to 150 m depending on location and requires acquisition of 1,430 hectares of land, which is a major difference to the CPR alternative, which only requires between 108 and 309 hectares of land.

4.3.2 Design Standards

With the Greenfield alternative, design standards, including maximum train speed, super-elevation and track alignment, directly reflect the capabilities and requirements of the high speed rail technologies selected for consideration. The exception is the sections of the alignment entering Calgary and Edmonton that are common to the CPR and Greenfield alternatives and therefore adopt the standards applied to and described for the CPR alternative.

For the middle section where the new alignment is dedicated to high speed passenger rail service, three maximum design speeds governed by the selected rail equipment capability apply (200 and 240 km/hr as represented by *JetTrain* technology and 300 km/hr for electrified TGV type technology). For each of these speed categories, slightly different standards in design and especially in maintenance are required, with increasing stringency at each progressive speed level; namely, Class 7, 8 and 9 track respectively. However, the differences from a design and construction perspective between each class are relatively minor when dealing with construction of all new track in relatively flat and unimpeded terrain.

As the 1984 plan was based on 300 km/hr TGV type technology, design standards incorporated in plan development were set accordingly and equally apply to the current Greenfield alternative. For the purpose of this study, a single design and infrastructure plan was developed assuming 300 km/hr as the maximum design speed and 15.2 cm as the maximum super-elevation in curves. To ensure as few speed restrictions as possible, the alignment plan seeks to maximize the amount of straight or tangent track and restricts any unavoidable curves to less than one degree and grades to less than one percent.

No attempt was made to relax these standards for the 200 and 240 km/hr technologies with the result that the design and infrastructure plan is somewhat more stringent for these options than is absolutely necessary. Consideration could be given at a later date to potential economies that might be realized by adopting a lesser standard in certain sections if the Greenfield alternative with one of the lower speed technologies is selected as the preferred option. However, for the purpose of this study, this decision ensures a conservative approach in identifying infrastructure requirements.

4.3.3 Infrastructure Requirements

As previously indicated, 38.5 km of the current Greenfield alternative follows the same route as the CPR alternative in entering both Calgary and Edmonton. In these sections, two approaches are possible.

One is commingling of passenger and freight trains on shared track assuming that, in the case of the 300 km/hr electrified technology, necessary approvals can be obtained[31] and electrified

[31] An issue to be addressed is compliance with Transport Canada rule, TC O-12.1, Railway Passenger Car Inspection and Safety Rules, revised June 28, 2001. It requires that equipment acquired or modified after that date meet the

equipment does not conflict with freight operations. With this shared track option, the infrastructure required is nearly identical to the CPR alignment alternative on the city side of the two junctions, as described in Section 4.2.4. Beyond the two junctions for a short distance, fewer improvements designed to handle the merging of freight trains with passenger trains, are required than with the CPR alignment alternative. CPR specified the infrastructure needs and costs for this shared portion of the Greenfield alternative.

If necessary approvals for the 300 km/hr electrified technology cannot be obtained or electrification proves to be incompatible with freight operations, the other approach would be to separate the passenger and freight operations and thus construct tracks solely for passenger train use. Under this situation, additional land would likely be required and track configuration would be different and more costly. For the purpose of this study, the separate track option has not been studied.

The remainder of this section deals solely with the new dedicated 255.5 km portion of the Greenfield alternative.

Track Work

Like the CPR alternative, the Greenfield alignment requires a double track mainline with Central Traffic Control (CTC) for its entire length to ensure the frequency and quality of service needed for the proposed high speed rail service. If appropriate, sections of single-track operation could be considered for the 200km/hr option in the next phase of project development to realize economies. For options with a higher maximum speed, it is not considered practical to use sections of single track, as reliability (on-time performance) cannot be maintained.

The infrastructure plan provides for regularly spaced crossovers every 20 km to enable trains to switch from one track to the other when track maintenance is occurring or in the event of a disabled train. However, unlike the CPR alternative, sections of third main track are not required for temporary storage of trains or equipment. In addition, the track work requires fewer turnouts as the dedicated line does not have third track, branch lines or customer sidings that need service.

The structure of the tracks is also basically the same as that of the CPR alternative and comprises concrete ties, 136# rail and 5,400 cubic metres ballast for every kilometer of double-track. All turnouts are specified as #20s.

Track Centres

Unlike the CPR alternative, the Greenfield alignment does not have to contend with concerns about shifting loads and clearance from passing freight trains, nor with safety considerations associated with constructing new track adjacent to an operating freight line. As a result, 4.3 m track centres,

American Public Transit Authority's (APTA) Manual of Standards and Recommended Practices for Rail Passenger Equipment. 300 km/hr electric technology does not meet these standards, requiring either that the equipment be modified for compliance, or that an exemption be granted. This applies to whether the operation is federally regulated, or provincially regulated since Alberta has adopted the federal regulations. The difficulty in obtaining an exemption, if one is possible at all, is expected to be greater for commingled service.

which are industry standard and also used in Europe on dedicated high speed rail lines, were deemed adequate and have been assumed in the infrastructure plan.

Subgrade

Subgrade requirements were based on the 1984 geotechnical assessment and quantities calculated in the 1984 report with revisions to reflect the alignment modifications. The amount of granular material to underlay ballast varies between 61 cm and 137 cm depending on location. The specified depth was fulfilled with 0.3 m of sub-ballast and the remainder granular material.

Grading

Grading was also based on 1984 quantities and again revised to reflect alignment modifications. Quantities for cuts, stripping, waste and reject topsoil were also obtained from the 1984 Phase III Sub-Study A report. Sub-cuts for purposes of estimating granular fill were derived from the 1984 profile drawings that indicated sub-cuts required as a percentage of cut/fill quantities over each segment (about 15km/drawing) of the proposed route. The cut/fill quantities came from Appendix C of the 1984 Phase III Sub-Study A report. Sub-ballast quantities of 6,000 cubic metres per km of double track were taken from the 1984 Phase II Sub-Study II report.

Bridges and Over/Under passes

The Greenfield alternative requires construction of 12 new bridges to cross rivers and various watercourses over its length. In addition, 47 grade separations with existing roads and railway tracks are provided for in the infrastructure plan. This number reflects the assumptions that:

- being both a high speed and new facility, no level crossings will be permitted;
- all public roads that are presently grade separated with Highway 2 will also be grade separated with Greenfield alignment; and,
- all roads that are not grade separated with Highway 2 and thus severed will also be severed by the Greenfield alignment.

These assumptions are the same as those for the 1984 plan. In addition to the bridge and overpass structures, the infrastructure plan includes an allowance for acquisition of 1,211 ha of land associated with road severances.

Fencing

Due to the high speed of the trains in operation and also because no fencing currently exists, the plan provides for fencing of both sides of the right-of-way for its entire length. A total of 256 km of 1.8 m fencing on two sides is therefore included in the plan.

Electrification

Electrification of the alignment is only required for 300 km/hr operation and not for the 200 or 240 km/hr options. It is assumed that the only material deviations from the 1984 plan would be changes in the amount of overhead catenary due to alignment modifications. All other fixed elements, including substations, switching stations, end stations and 230kV transmission links, remain basically the same as in the 1984 plan.

STATIONS AND MAINTENANCE FACILITIES

5.1 Introduction

While track and related works constitute the vast majority of infrastructure requirements for this project and also its principal cost, stations and maintenance facilities are nevertheless important and essential elements of the overall project that cannot be overlooked.

For the purpose of this study, five stations have been assumed for both alignment alternatives serving the same general markets:

- Downtown Calgary;
- Suburban Calgary in close proximity to Calgary International Airport[32];
- Red Deer;
- Suburban Edmonton either near the Edmonton Ring Road or in proximity to Edmonton International Airport[33]; and,
- Downtown Edmonton.

A maintenance facility for regular train maintenance, servicing and repairs, as well as a satellite facility to carry out cleaning activities, inspections and light repairs prior to train departures, is also included in the infrastructure plan for both alignment alternatives. Station and maintenance facility requirements were developed by a working group comprised of representatives from Bombardier Transportation, Canac, CPR and VIA Rail.

5.2 Stations

Four of the five stations (downtown Calgary, suburban Calgary/Airport, suburban Edmonton/Airport and downtown Edmonton) are located within the alignment sections that are common to both the CPR and Greenfield alternatives. Only Red Deer requires different station locations for each alternative.

Greater latitude is possible in selecting the Red Deer station on the Greenfield alternative where the alignment can be modified to a certain extent to serve a preferred site. However, this results in the station being farther from the centre of Red Deer. Site selection for the other stations is limited to a large extent by both the location of the alignment, its relationship to freight operations and, to a lesser extent, its curvature (tangent track is desirable). To avoid conflict with freight operations, the station in downtown Calgary must be on the north side of CPR's freight corridor, and in suburban Calgary and suburban Edmonton on the west side. In Red Deer, it is desirable to have the station on the east side of the existing CPR line with the CPR alternative. A secondary consideration is proximity to main crossroads to facilitate and maximize access to the station.

[32] The CPR line is located approximately 2.6 km away from Calgary International Airport as the crow flies or 4.7 km via existing access roads.
[33] The CPR line is located approximately 3 km away from Edmonton International Airport both as the crow flies and via existing access roads.

For the purpose of this study, the main objective was to ensure reasonable representation of the stations, primarily for costing purposes. Facility requirements do not change substantially between sites, the main variable in their cost is the site itself. However, detailed studies addressing such factors as maximum ridership potential, land values, station access requirements, implications to track infrastructure and alternative methods of facility delivery (i.e., leasehold arrangements with developer partners, sale of air rights), were well beyond the scope of a pre-feasibility assessment. Furthermore, any decisions on these choices represent a relatively small cost differential compared to other project costs, and thus will not affect the overall conclusion about project viability.

On this basis, the station locations assumed for this study were based on the professional judgment of the working group, leaving determination of the final locations to a later phase in project development. The rationale used in selecting the terminal station locations has already been described in Section 4.1 of this report. The remaining station locations were assumed as follows:

- Suburban Calgary - approximately milepost 8.5 of the Red Deer Subdivision near Country Hills Boulevard and the extension of Airport Road;
- Red Deer – near to the intersection of 32nd Street and CPR; and,
- Suburban Edmonton – either the crossing of the new Anthony Henday Drive and CPR or near the Edmonton International Airport.

All sites chosen are within a reasonable distance from necessary municipal services and infrastructure, including water, sewer, electric power and access roads. In addition, the proposed locations for the two downtown stations were specifically sited in proximity to the light rail system in each city, as linkage with these systems would greatly enhance use and convenience of the high speed rail system.

5.2.1 Facility Requirements

Facility requirements were developed by VIA Rail based on their experience elsewhere in Canada. The objective was to identify the minimum facility requirements given anticipated passenger volumes, again for costing purposes on the assumption that revenue justification for additional space would be addressed in later phases of project development.

For the two terminal stations, a 1,000 square metre building with a ticketing area, passenger waiting areas, washroom facilities and approximately 50 square metres for a basic ancillary service (i.e. coffee shop etc., leased to a third party) was deemed the minimum requirement. Space for a checked baggage operation was not included. Ancillary areas can be increased in increments of 50 square metres to offer additional services, if these additions prove profitable or at least financially self-supporting.

Both terminal stations also include a small storage area for parts and equipment needed to service trains between runs, as well as loading docks and a small holding area to support just-in-time delivery of on-board food and other supplies. They will also require a 480v electric power panel to allow trains to be plugged in when not running on their own power. A fuel storage tank could be built into these facilities, if deemed necessary or desirable. However, fuel could also be delivered by truck.

The downtown Calgary station is assumed to have a canopy-covered, single elevated platform approximately 305 metres in length located between the two station tracks. On the side of one of the two station tracks, a storage track of similar length is also assumed.

In downtown Edmonton, space constraints preclude two station tracks plus a storage track and therefore only two stub end station tracks are assumed. A canopy-covered centre platform, 305 m in length is assumed between the two station tracks.

The Red Deer and two suburban/Airport stations all require at minimum a station building of approximately 510 square metres, accommodating ticketing equipment, a small passenger waiting area, washroom facilities and kiosk for passenger information. Provision has been made at all stations for two trains to load and unload at one time. A single uncovered platform situated between the station track and one of the two mainline tracks is assumed for the CPR alignment alternative, and between the two mainline tracks on the Greenfield alignment alternative at Red Deer.

5.2.2 Land Requirements

Both land availability and property values for the two downtown station locations may preclude provision of more than the minimum requirement for a stand-alone station development. Similarly, no provision has been made to acquire land for parking in either case, due in part to cost but also because commercial facilities exist nearby that train passengers can use. Alternative arrangements whereby a developer might be enticed to construct the station as part of a larger development, and in so doing expand on the station amenities, have been left to a future project phase.

For this study, the terminus station in downtown Calgary is assumed to be at the intersection of 3rd Street SE and 9th Avenue, on what is now vacant land between the CPR tracks and 9th Avenue. This site was formerly owned by the CPR but sold to private interests. Property development plans and availability are unknown and therefore the location is meant to be illustrative rather than specific. The amount of land required is defined as the minimum legal parcel or land area needed to accommodate the platform length and approach tracks. Land between the station building and 9th Avenue would be developed for passenger drop off, taxi and bus layovers to the extent that these activities can be accommodated on the remaining site area.

Land availability for the downtown Edmonton station is even more constrained than downtown Calgary. Here, the station is assumed to be situated adjacent to the Grandin LRT station within the 30 metre former CPR right-of-way that is now owned by the Province. The minimum parcel for station development would be based on the proposed platform length and confined to the width of the publicly owned right-of-way. The station will require design ingenuity, very likely including vertical development, to accommodate the two station tracks, platform and station house within this limited space.

For the Red Deer and each of the suburban/Airport stations, land availability is less constrained and, therefore, the minimum site required is assumed to be approximately 2 ha, which is sufficient to accommodate the station building, up to 400 parking spaces and drop-off and circulation. The suburban Calgary/Airport station site is assumed to be located near the intersection of CPR and an extension of Airport Road. The land in question is owned by the City of Calgary and forms part of Nose Creek Park.

In the case of the Red Deer station on the CPR alignment alternative, the site assumed is situated near 32nd Street between the CPR tracks and Highway 2 on property owned in part by the CPR and in part by the Province. For the Greenfield alignment alternative, a site is assumed again near 32nd Street on what is now undeveloped agricultural land in private ownership. Two options were discussed for the suburban Edmonton/Airport station. One assumes a site in the vicinity of the intersection of the CPR alignment and Anthony Henday Drive, and the other, a site near Edmonton International Airport. Land ownership and availability are unknown. Other suitable locations also likely exist for this station.

5.3 Maintenance Facilities

Use of CPR's existing maintenance facilities at Alyth Yard or its former Ogden Shops, or CN or VIA's facilities in Edmonton was considered but rejected because none have excess capacity or are suitable facilities for the requirements of the new high speed rail service. In addition, access to all these facilities entails operating complexities with freight operations. As a result, the working group concluded that a purpose-built facility was required to accommodate regular maintenance, servicing and repairs. Assuming five trainsets in total and four in service at any one time, one trainset will be in maintenance or held in reserve as a spare at the maintenance facility.

Although some train storage is required at the maintenance facility, overnight storage of trains at the two terminal stations is preferred as this avoids deadhead movements of trains and reduces operating cost. As a result, the infrastructure plan has made provision for train storage at the two downtown stations.

Based on the availability of large industrial properties adjacent to the alignment alternatives, the most promising locations for the maintenance facility were north of Calgary, south of Red Deer and to a lesser extent south of Edmonton. The end point locations have the advantage of allowing train changes from the maintenance facility into service and vice versa during the day. If the facility is located at Red Deer, the service design is virtually committed to early morning revenue departures from Red Deer; otherwise substantial deadheading would be involved.

Like the stations, detailed studies of the pros and cons of various maintenance facility sites were judged to be well beyond the scope of the current pre-feasibility phase. Therefore, for the purpose of this study, the maintenance facility was assumed to be located just north of Calgary near Balzac for both alignment alternatives, and a small satellite facility is assumed as part of the Edmonton terminus.

5.3.1 Facility and Land Requirements

To accommodate train servicing and maintenance activities, the principal maintenance facility requires a servicing track with a pit and three maintenance tracks, one with a mezzanine for locomotive maintenance, one with a drop table and a service track for general repairs. The servicing tracks need to be 280 metres in length so as to accommodate either a 1-8-1 consist for the CPR alternative and 1-10-1 consist for the Greenfield Electric alternative. The Greenfield Non-Electric alternative, however, will require another 50m of track to accommodate a 1-10-1 consist *Jet Train*, as it is slightly longer than the 300 km/hr electric trains. In addition, the maintenance facility must include space for storage of parts and equipment, offices and employee facilities. The centre must also include a train wash facility. Due to the Alberta climate, all of these facilities must be enclosed.

The yard requires at least three through tracks for maintenance facility access, storage tracks and adequate track for switching and bypassing of trains. A total track length of approximately 2.7 kilometres is estimated for these purposes, but this amount could vary depending on the site configuration. The facility also requires signalized turnouts to the mainline at both ends. 480v wayside power is required at appropriate locations inside the maintenance facility as well as in the yard.

Based on similar facilities, VIA Rail estimates that a 6,500 square metre building on a 2.42 hectare site is required.

The satellite maintenance centre will be used for interior cleaning, servicing inspections that do not require a pit, train fueling and watering, light repairs and overnight storage, as well as an enclosed storage area of approximately 40 square metres in size for parts and equipment as well as employee facilities. The building will have two sets of 480v wayside power plug-ins. The land required for the satellite facility is included in the downtown Edmonton station site assumptions.

CAPITAL COSTS

6.1 Introduction

Major transportation projects are capital intensive, requiring large upfront investment in land acquisition, infrastructure, design and engineering and other so-called soft costs and, in some cases, vehicles and other equipment. Capital costs frequently are a chief determinant of project viability and therefore capital cost estimates require care and diligence to ensure they are complete and neither overly optimistic nor overly pessimistic.

The key to developing a realistic estimate is to use the best available information on both project scope and current costs. However, these estimates inevitably involve a number of assumptions and risk or potential areas where costs can vary.

CPR, Canac and VIA Rail developed the capital costs for land acquisition, infrastructure, design and engineering, and wayside equipment, and Bombardier Transportation provided the costs for vehicles. These estimates benefit from the extensive experience and practical knowledge of actual current costs by each of these firms, in many cases directly in Alberta. However, to ensure consistency in the estimates for the CPR and Greenfield alternatives, and that the overall project estimate was comprehensive and reasonable relative to other similar projects, the capital costs were reviewed by Anthony Steadman & Associates, an independent expert in rail project costing.

This Chapter describes the major areas of capital cost for each of the three alignment/technology options and presents an annual cash flow of expenditures over the project implementation period. It also identifies the major opportunities to reduce project costs and, conversely, the major areas of project risk. All costs are indicated in present day (2004) dollars.

No attempt has been made to inflate the total costs to some future date when project management and construction would commence or during the construction period, which is dealt with in the financial analysis in Chapter 9 in this report. Each element of capital cost contains a contingency amount deemed appropriate to the specific circumstances to account for uncertainties related to the early stage of design. Contingency should be assumed to be fully spent. There is no provision for force majeure events or other unusual circumstances.

6.2 Breakdown of Capital Costs

The following table provides a breakdown of the major items of capital cost for the three alignment/technology options. The subsequent subsections describe what is included within each cost item and key differences between the three options.

COMPARISON OF CAPITAL COSTS ($ MILLIONS)			
	CPR	Greenfield Non - Electric	Greenfield Electric
Property	22.8	47.8	47.8
Rail Infrastructure	717.7	1,386.5	1,386.5
Stations and Parking	26.0	26.0	26.0
Maintenance Facilities & Equipment	66.0	75.0	78.0
Road Work	264.0	116.2	116.2
Electrification	0	0	566.9
Total Construction Costs	**1,096.5**	**1,651.4**	**2,221.3**
Vehicles, TVMs & Communication Systems*	**338.2**	**383.7**	**389.7**
Engineering	92.3	168.7	231.0
Project Management	10.5	86.0	143.9
Testing and commissioning, Ops prep	8.0	8.0	8.0
Insurance & Bonding	10.2	53.4	71.5
Total Engineering & Management	**120.8**	**316.0**	**454.4**
Contingencies	156.4	257.9	347.7
TOTAL PROJECT COSTS	**1,711.9**	**2,610.3**	**3,413.1**

* TVM – Ticket Vending Machine

Property Acquisition

All three options include $21 million for the stations and maintenance facilities, with the remaining balance attributed to land required for the alignment. The estimated value for the station and maintenance facility sites was derived using two corroborating approaches - one applying a current average per square metre price paid for comparable properties and the second a direct estimate of value developed by CPR's property department.

For land required by the CPR alternative as well as common section of the Greenfield alternatives, CPR developed a property cost estimate using recent per square metre values paid according to different sections of the line. For the dedicated new portion of the Greenfield alternatives, land value estimates were based on average costs provided by Alberta Transportation. The difference in property acquisition costs between the CPR and Greenfield alternatives reflects the much larger land requirement and greater severance of properties involved in developing the new portion of the Greenfield alignment.

Rail Infrastructure

Rail infrastructure includes grading, sub-ballast, ballast, bridges, trackwork, turnouts, signaling, fencing, support yards to replace lost storage capacity, and an allowance of $500,000 for permanent way spares in all three options. This cost category also includes allowances for environmental mitigation projects.

In the case of environmental mitigation, detailed studies and/or design development to mitigate any unavoidable environmental impacts deemed necessary by environmental approving agencies were premature and beyond scope of this study. For the CPR alternative, it is assumed that any environmental mitigation required will be relatively minor, as it is an existing corridor and therefore changes will result in minimal impacts that can easily be accommodated in the rail infrastructure budget or, in a worst case, from contingency. However, as a large portion of the Greenfield alignment occupies a new corridor, an additional allowance was deemed appropriate. As a result, an allowance of $2 million is included for the Greenfield alternatives only.

In contrast, a higher allowance ($20 million) for workarounds and other measures to offset construction impacts on freight operations is included in the CPR alternative, as the CPR corridor is predominantly shared with existing freight operations whereas only a small portion of the Greenfield alternatives is affected by freight. Given that the shared portion with freight of the Greenfield alignment is much less, an allowance of $3 million for this purpose was deemed reasonable. However, again no detailed plans or specific studies were carried out to develop these cost allowances, as again such investigations were both premature and beyond the scope of the current study.

The CPR alternative and the common sections of the Greenfield alternatives benefit from the assumption that ballast will be supplied by CPR from its own source and charged at a preferentially low in-house rate. Ballast for the remainder of the Greenfield alignment, however, is market priced.

Given this precedent, the opportunity to reduce granular fill and sub-ballast costs through a similar supply process was discussed. At present, these costs differ considerably in three regional zones within the corridor and have been priced accordingly. However, the magnitude of demand for a project of this size would provide sufficient incentive to establish a new source of supply that could substantially reduce project cost. Similarly, the cost of concrete ties could be reduced if a plant was established or contracted to supply them in bulk. The feasibility and means to facilitate such cost reductions should be investigated in future project development.

The higher cost of the Greenfield alternatives reflects the greater volume of work required to construct the new dedicated portion of the alignment, as unit rates for materials and labour were harmonized for the CPR and Greenfield estimates with the exception of ballast. Estimated expenditure for grading and bridges are approximately three times those of the CPR alternative and also significantly higher for signaling and fencing. Exceptions are the cost of trackwork, which is only slightly more, and for turn-outs and support yards which are less because sections of third track for freight trains and access to customer sidings are not required on the dedicated portion of the Greenfield alignment.

Stations and Parking

This item covers the cost of the station buildings and parking development and is the same for all three options. The cost estimate includes design, engineering and construction management for these structures. The costs assume a fairly basic structure and finishing for the suburban stations, but a slightly higher upgraded standard for the two terminal stations to allow for architectural enhancement and a higher standard of finish in keeping with their downtown context and stature as focal points for the service.

Maintenance Facilities and Equipment

This item includes the buildings and equipment associated with the principal maintenance facility as well as the satellite facility. The higher cost for the two Greenfield alternatives results from the inclusion of trackwork equipment and, in the case of the electrified alternative, additional equipment to maintain overhead catenary and other electrical infrastructure and equipment.

Road Work

For safety reasons, elimination of level crossings is likely required, which in turn necessitates construction of road overpasses and underpasses, road re-routing to connect with existing overpasses or underpasses and, in the case of the CPR alternative, costs to deal with closure of private crossings (e.g. buy-outs). While improvement of some these crossings is already planned or anticipated, other crossings would likely remain “as is” for many years, if not forever. For the CPR alignment and the common portion of the Greenfield alignment, CPR conferred with Alberta Transportation on the treatment of each crossing on a case-by-case basis and applied current costs for similar works to develop the estimate for roadwork costs. These costs are assumed to be inclusive of design, engineering and construction management, as construction of these works for a project of this magnitude would most likely be carried out through design-build contracts.

The dedicated new portion of the Greenfield alternatives, on the other hand, used the 1984 roadwork construction costs, which were then adjusted to current dollars. Design, engineering and construction management were calculated separately and are included under these specific cost items identified in the soft cost section of the cost estimate.

The higher cost associated with the CPR alternative is partly explained by the all inclusive nature of the estimate, but may also reflect the fact that the CPR line passes through numerous communities and has a larger number of existing level crossings, including private crossings, which must be dealt with.

In contrast, the Greenfield alignment tends to be in open territory. It also assumes severance of public roads that are not now grade separated with Highway 2, which may result in a smaller number of grade separations than can actually be realized. Furthermore, it assumes that no private at grade crossing will be created to provide access to properties that are severed, which may add to property acquisition costs. Another explanation may be that roadwork costs have escalated in price more than the cost of inflation since 1984. All of these considerations would require detailed study in a later phase of project development.

Electrification

Electrification is only required by the Greenfield alternative where 300 km/hr technology, more commonly referred to as TGV type technology, is used. The costs incorporated in this estimate include the FRA standard cost of US $2 million per mile converted to current Canadian dollars per kilometer to electrify the rail line and maintenance centre, as well as corridor specific costing of overhead catenary.

A review of the resulting cost in comparison to a preliminary estimate without feeds to the power grid suggests that it may be high. However, without knowledge of the costs of connecting sub-stations to the main grid, including distances and obstacles involved, the estimate was not reduced. Detailed investigation would be required in a later phase of project development if this option was selected.

Vehicles and Operation Communications Systems

This cost category includes locomotives and passenger cars, Closed Circuit TV, dynamic signage, passenger address systems, fiber optic cables to serve this equipment, on-board radios, ticket vending machines, reservations systems and management systems for these activities. All of these items are typically tendered and manufacturer supplied and, if necessary, installed. As a result, their cost is all-inclusive incorporating design, engineering, contingency and technology risk. Furthermore, many of these sub-items are at the discretion of the operator as contracted services (e.g., ticket reservations) or manned operations could substitute for some of these capital costs and then be treated as operating expenses.

Capital investment in trains also involves discretionary judgment of the operator. For example, deciding whether to operate larger trains less frequently or purchase more locomotives and operate a more frequent service with shorter trains. Furthermore, unlike track work or engineering which are sunk costs, vehicles and most of the operations communication systems are not fixed assets and can be sold, moved and used elsewhere.

For these reasons, these assets are often targeted as investments to be carried by a private sector partner in public-private partnerships and have been grouped separately from both construction and engineering and management costs. In addition, for the purpose of this study, it is assumed they would be obtained through fixed price contracts against which only project management mark-ups are applied.

Based on the ridership demand forecast, the CPR alternative requires five train sets with a 1-8-1 train consist, whereas the Greenfield alternatives require five train sets with a 1-10-1 consist. The primary difference in cost between the CPR and the two Greenfield alternatives is the ten additional passenger cars required by the Greenfield alternatives.

Engineering, Design and Construction Management

Engineering includes design, engineering and construction management costs that are typically calculated as a percentage based on construction costs.

For the CPR alternative, an average of 12 percent was applied only to rail infrastructure costs to derive the engineering cost estimate. The actual percentage varies from 2.4 to 15 percent based on the degree of difficulty or uncertainty that was judged in particular aspects of the work and on CPR's past experience. This approach also applies to the common portion of the Greenfield alternatives.

For the dedicated new portion of the Greenfield alternatives, design, engineering and construction management costs are calculated using 11 percent but applied to rail infrastructure, environmental mitigation projects and roadwork, and in the case of the electrified option, to electrification.

In addition, a $500,000 allowance for survey work is included in this cost item for the CPR alignment and, as more survey work would be involved, $1,500,000 for the Greenfield options.

Engineering, design and construction management for the stations and maintenance facilities in all the options, and for grade crossings in the CPR alternative and common portion of the Greenfield alternatives, are incorporated into the construction estimates for these elements, and therefore does not form part of this cost item.

The difference in cost between the options primarily reflects the larger scope and value of work involved in developing the Greenfield alternatives and, to a lesser extent, the difference in reporting design, engineering and roadwork construction to eliminate level crossings.

Project Management

Like engineering, design and construction management, project management is typically estimated by applying a percentage to project costs. In the case of the CPR alternative, project management for rail infrastructure has already been covered in the calculation of engineering, design and construction management, and for roadwork in its construction cost. Nevertheless, coordination between these and various other project elements has not been taken into account in this provision. For this reason, an allowance of $10 million is added in the cost estimate to cover a coordinating project office, staff and related costs. In addition, a $500,000 allowance is added for community-relations projects and public consultation.

For the Greenfield alternatives, project management of rail infrastructure and roadwork in the common portion of the alignment with the CPR is again included within the provisions for engineering and roadwork construction respectively. However, for the dedicated portion of the Greenfield alignment, 7 percent is applied to all other construction costs as well as vehicles and operations communication systems. In addition, a $1.8 million allowance is added for costs related to environmental and Transport Canada approvals, community relations projects and public consultation.

Once again, the difference in costs between the three options primarily reflects the larger scope and value of work involved in developing the Greenfield alternatives and, to a lesser extent, the difference in approach to accounting for these costs.

Testing and Commissioning and Operations Preparation

This cost item includes testing and commissioning of trains assuming 100 round trips for this purpose, uniforms, training, advertising and setup costs, safety and security prior to opening. Similar to vehicles and operations communications systems, many of these costs are at the discretion of the operator and can either be treated as operating expenses or investments to be carried by a private sector partner in public-private partnerships.

In total, an allowance of $7,950,000 is included for all three options.

Insurance and Bonding

For the CPR alternative and common portion of the Greenfield alignment, provision for insurance and bonding was included for rail infrastructure and road work related to the elimination of level crossings either in the construction estimate or the provision for engineering, design and construction management. However, for all other elements, including stations, maintenance facilities, vehicles, operations communications systems, route survey, overall project management, testing and commissioning and operations preparation, an allowance of 2 percent of these costs was included for insurance and another 0.5 percent for bonding.

For the Greenfield alternatives, 2 percent for insurance and 0.5 percent for bonding was applied to all project costs other than those already budgeted for in common portion of the alignment for rail infrastructure and roadwork as described above.

Again, the difference in costs between the three options primarily reflects the larger scope and value of work involved in developing the Greenfield alternatives and, to a lesser extent, the different treatment of these costs for CPR alignment work.

Contingencies

Contingency is an allowance set aside to cover costs that are either unexpected or higher than estimated in the total project. Typically, it is calculated as a percentage of all project costs (other than those that contain their own contingency, such as supplier procured and installed components) with this percentage being set according to the level of project development and degree of risk or potential project scope and cost variance that is perceived.

In the case of this project, many costs and particularly those for rail infrastructure (i.e. track, ties, ballast, etc) are well known, as they represent costs that are regularly incurred by CPR in their day-to-day operation. Therefore, unlike other projects where estimates are developed without this degree of practical knowledge and experience, the potential for variance in costs is greatly reduced.

For the CPR alternative, the percentage applied for contingency was determined on a cost line item basis according to CPR's standard practice and experience on construction projects. The percentage varied from 5 to 20 percent, resulting in an overall average of 9.1 percent. This approach was also applied to the common portion of the Greenfield alternatives.

For the dedicated new portion of the Greenfield alternatives, 13 percent was applied to all project costs to be in line with the CPR alternative. The overall average that results is 10.1 and 12.2 percent respectively for the Greenfield Non-Electric and Electric alternatives.

GST

It was assumed that all GST would be eligible for reclaim as an input credit. GST will of course be charged as part of fares and revenues collected and paid to the federal government as part of the operations.

6.3 Projected Cash Flow

A very preliminary implementation schedule was developed for the CPR and Greenfield alternatives to allow development of a cash flow projection. Approximately five years was estimated as the time needed to complete the CPR alternative with years one and two devoted to final design and engineering, securing approvals, land acquisition and preparation of contractor tenders, and years three through five for construction with the latter 3 to 4 months focused on operations start-up. As the Greenfield alternative will require more upfront planning, consultation, engineering and design, approvals and land acquisition, six years was projected as being required for project completion with a similar distribution of activities.

Based on the above, the following is projected cash flow for each of the alternatives:

Annual Cash Flow ($millions)						
	1	**2**	**3**	**4**	**5**	**6**
CPR	$40	$102	$476	$736	$443	
	2%	6%	27%	41%	25%	
Greenfield Non - Electric	$55	$173	$508	$703	$788	$492
	2%	6%	19%	26%	29%	18%
Greenfield Electric	$68	$195	$705	$939	$1,054	$634
	2%	5%	20%	26%	29%	18%

6.4 Exclusions from Capital Cost Estimates

Every effort has been made to ensure that the capital cost estimate for project implementation is comprehensive, including detailed estimates of line items or, where this was impractical, a reasonable cost allowance. However, as both the decision to proceed further at this time and choice of options is still open, no attempt has been made to estimate the cost for various studies and processes that may be required between the conclusion of this study and commencement of project implementation.

These activities could include such things at the very least as an investment grade ridership analysis and various engineering studies referred to in this report and public consultation particularly regarding the elimination of level crossings for the CPR alternative. For the Greenfield alternatives, they could include a corridor location study, more detailed engineering, surveys and mapping, environmental assessments and approval process, an investment grade ridership analysis and extensive public consultation.

6.5 Overall Cost Review and Comparison

Construction costs make up about two-thirds of total project cost for all the alternatives, with the percentage of total costs being slightly higher for the Greenfield Electric alternative because of the added high cost of electrification and slightly lower for the Greenfield Non-Electric because of the added cost for the larger train sets.

Vehicle and operations communication costs in absolute terms are fairly comparable for all the alternatives, although slightly higher for the Greenfield alternatives because of the larger number of cars required to serve demand. However, their percentage of total costs is deceivingly different depending on the relative absolute amount of construction cost expenditures, which both comprise the majority of total construction costs and drive other costs. The percentage for vehicle and communication costs ranges from 11 percent in the case of the Greenfield Electric alternative to 20 percent in the case of the CPR alternative.

COMPARISON OF DISTRIBUTION OF COSTS

	CPR	Greenfield	Greenfield Electric
Construction Costs	64%	63%	65%
Vehicles & Ops Communications	20%	15%	11%
Engineering & Management	7%	12%	13%
Contingency	9%	10%	10%

Engineering, design, construction management and project management costs account for 7 percent of total project costs for the CPR alternative and 12 and 13 percent for the Greenfield alternatives. This difference is primarily explained by the greater scope and value of work involved in establishing a totally new Greenfield corridor but is also partly due to differences in allocating these costs (i.e., inclusion of some of these costs as part of construction cost in the CPR alternative).

Contingency, which is driven by total project cost, is not substantially different as a percentage of the total cost for all three alternatives.

Comparing total project cost on a per kilometre basis to the previously quoted FRA averages for initial investment for different technologies provides a frame of reference for the capital cost estimates. On a per kilometer basis, the project cost estimates are $5.5 million for the CPR, $8.9 million for the Greenfield Non-Electric and $11.6 million for the Greenfield Electric alternatives. The cost estimate for the CPR alternative is slightly higher than the FRA average of $2.4 to $4.5

million per kilometre for 200 km/hr technology. This difference can be explained by the fact the FRA figures are now six to seven years old, conservatism in the estimate or additional requirements to replace freight storage and/or co-exist with freight operations.

The Greenfield Non-Electric option, however, is 57 percent higher the FRA average for 240 km/hr systems. Although the same explanations apply as those for the CPR alternative, this difference may also reflect the stringent 300 km/hr design standards used in developing this option. Comparing both Greenfield options to the FRA investment cost for 300 km/hr technology, they fall well within the FRA's average range from $8.1 to $36.5 million per kilometre.

While these comparisons serve as ballpark measures only, they nevertheless support the reasonableness of the project cost estimates at this stage in project development.

6.6 Opportunities to Reduce Cost and Project Risks

Various potential opportunities to reduce costs have already been referred to in this and previous Chapters. In each case, the implications of the cost saving to service performance, operating cost and other trade-offs will require consideration in future project development. They include:

- sections of single track (Greenfield alternatives only),
- alignment or grade relaxation (mostly Greenfield alternatives),
- setting up project specific fabrication yards (i.e., concrete ties), and
- establishing bulk supply of materials similar to CPR's ballast supply (i.e., sub-ballast).

Other measures to potentially reduce costs include: optimization of the project schedule with cost and financing; potential savings from design-build contracts for particular aspects of the work; shared use of facilities with contributions from others; contracted facilities (i.e., passenger reservations); and, development of stations by retail/commercial developers on a shared use or lease contract basis.

At the same time, given the preliminary nature of the project's development, there are also various potential risks that could result in increased project cost. Some examples include:

- bad ground conditions requiring extensive preparatory work,
- unforeseen environmental issues,
- both project delays and higher roadwork costs to eliminate or replace more level crossings with overpasses or underpasses,
- higher costs of materials due to price escalation or insufficient supply and added transportation cost,
- changes in property values, financing rates or abnormal inflation,
- schedule extension and additional financing costs,
- price escalation for manufacturer supplied items (e.g., vehicles, communications systems) to cover additional costs to cover technology risk or contingency, and,
- in the case of the Greenfield alternative, changes in route availability and increased route length.

RIDERSHIP AND REVENUE FORECASTS

7.1 Background and Methodology

Ridership and revenue forecasts are critical elements in determining the viability of a high speed rail link; all the more so in this study, as these were the foremost concerns identified in previous study reviews. The quality of any forecast largely depends on having good information on both current travel and the receptiveness of travellers to use the proposed service. This information constitutes the basic inputs for predictive models on changes in travel behavior responding to the new service.

A review of current data revealed that only total estimates were available for air and bus travellers derived from seat capacities using average load factors, and for road users calculated from highway vehicle counts. Data collection on car traffic origin-destination, trip purpose for all travel modes and attitudinal factors had not been done since the early 1980s and was clearly out-dated. For these reasons, an important component of the current study was to carry out primary market research.

Commonly, traveller intercept surveys as well as broad market surveys are used to collect the necessary data. However, the cost, complexity of arrangements and time involved in carrying out intercept surveys was disproportionate to other work components and not justified at a pre-feasibility level of inquiry. Instead, a broad-based telephone survey in the three primary target markets (Calgary, Edmonton and Red Deer) was developed in conjunction with nationally acknowledged experts in market research, Ipsos-Reid, to carry out all data collection requirements. The information derived from this survey was then corroborated using the total estimates from other sources.

Data collected from market research was used as input to a travel diversion model jointly developed by VIA Rail and Mercer Management for high speed rail ridership forecasts in Quebec-Windsor corridor. The methodology and structure of this model had been thoroughly reviewed by an outside expert using an independent modeling approach. The model's elasticity factors associated with ridership demand are based on extensive market research. In addition, the model's travel forecasts were tested and found to be both consistent with results from an independent demand forecasting model[34] and actual experience in both the US Northeast and Europe. Ridership forecasts derived from the VIA-Mercer model for the Calgary-Edmonton corridor were also compared to forecasts derived from CPR's in-house ridership forecasting model.

This Chapter reports on the market research process, its findings on current travel and public receptiveness to high speed rail as well as the corroboration of key findings. This Chapter also reports on the diversion model results and estimates of high speed rail ridership and revenue.

[34] The forecasting model (developed by TEMS) applies demographic, economic and consumer-behaviour variables to forecast total travel demand, and « value of time » trade-off analyses to derive market shares for all modes based on improved rail service.

7.2 Existing Transportation Options

People wishing to travel between Calgary and Edmonton presently have three options; namely, to drive, take the bus or fly. Conventional passenger rail service did operate between the two cities until the mid 1980s but was discontinued because it was unattractive and, as a result, uneconomic. The rail service consisted of two trains daily that took three hours and 40 minutes between the cities, as compared to three hours and 15 minutes by bus or three hours by car. Not surprisingly, the train captured less than one percent of the total travel market.

Highway 2 is the primary and most direct link between Calgary and Edmonton, and also serves Red Deer and several other smaller communities and the agricultural region of Central Alberta. Highways 21 and 22 run parallel to Highway 2 and may serve as alternative routes but their share of Calgary-Edmonton traffic is most likely very small. Highway 2 provides a high level of service although congestion does regularly occur particularly during peak periods on the approaches to Calgary and Edmonton, and the highway is also occasionally closed due to severe winter weather conditions. Assuming average conditions, downtown-to-downtown travel time is approximately three hours. Using the Alberta Automobile Association's estimates of average driving costs, the cost of travel one-way is between $42 and $126 depending on whether it is based on operating costs only or total ownership costs[35].

Both Greyhound and Red Arrow offer daily limited stop and express bus services in the corridor. The companies provide 10 and 6 departures Monday through Thursday and 13 and 7 on Friday respectively from both Calgary and Edmonton at approximately two-hour intervals. Scheduled travel time varies from 3 to 6 hours depending on the number of stops, but most runs take 3 to 3 ¾ hours downtown-to-downtown. Both companies serve Red Deer and South Edmonton on the majority of their trips. Red Arrow offers a suburban Calgary stop on all its trips, and Greyhound offers three trips per day with additional stops at Calgary Airport and/or Leduc and two with multiple corridor stops. Excluding those departures that make several intermediate stops, the effective frequency for service among the three cities is 11 per day each way. Adult one-way fares are $46 and $53 respectively with discount fares offered for seniors, students and children as well as for advance purchase and other promotional offers.

Air Canada and WestJet are the main air carriers between Calgary and Edmonton International Airports, offering 14 and 6 flights from each city daily. In addition, Central Mountain Air and Canadian North operate one to two flights daily, while Air North offers another three flights per week between May and November. In-flight time is scheduled as 50-55 minutes. However, access and egress time at both airports, flight check-in and waiting time results in a downtown-to-downtown travel time of something closer to 3 ¼ to 3 ½ hours, assuming no major delays. Adult one-way fares range from just over $138 to $364 (including taxes and fees); depending on flight time, advance booking or other promotional offers.

QuikAir and other executive or chartered small plane (10 seats) services operate between Edmonton Municipal Airport and Calgary International. QuikAir operates 18 departures from each

[35] Canadian Automobile Association, *Driving Costs 2003*. Costs are based on Cavalier Z-24 based on 18,000 km driven annually. Costs for larger vehicles, such as Caravan SE with same annual use would be higher.

city daily with a scheduled in-flight time of 35 to 50 minutes. Again, access and egress time at the airports, flight check-in and waiting time results in downtown-to-downtown travel time of something closer to 2 hours. Adult one-way fares range from $170 to 200 (including taxes and fees). However, the Edmonton Airport Authority recently announced that regularly scheduled air service to Calgary from Edmonton Municipal Airport will be phased-out by July 31, 2005.

Mode of Transportation	# of Weekday Departures from Calgary & Edmonton	Downtown-to-Downtown Travel Time	One-Way Cost (Adult)
Car	N/A	3 hours	$42 to $126
Bus	16-20	3 to 3 ¾ hours	$46 to $53
Air[1]	21-22	3 ¼ to 3 ½ hours	$138 to $364

[1] Excludes Edmonton Municipal Airport departures.

7.3 Characteristics of Current Travel

The market research survey developed for this study set out to determine:

- the incidence of travel between Calgary and Edmonton and each of these cities and Red Deer;
- trip purpose;
- mode of transportation;
- factors affecting travel decisions;
- price and frequency sensitivity towards high speed rail service; and,
- preferred station locations in Calgary and Edmonton.

Ipsos-Reid carried out 1,600 telephone interviews between September 2 and 15, 2003 with Albertans aged 18 and older. The breakdown of interviews was as follows:

- 600 in Calgary CMA, including 378 past year travellers;
- 600 in Edmonton CMA, including 348 past year travellers; and,
- 400 in Red Deer, including 356 past year travellers.

The final data was weighted to reflect the actual gender and age proportions of the three markets, as well as their relative size and actual incidence of travel in the past year. The margin of error associated with the proportion of responses for the survey sub-groups are as follows:

Respondent Type	Margin of Error on Percentages *
Calgary Respondents (n = 600)	+/- 4.0%
Calgary Travellers to Edmonton (n = 320)	+/-5.5%
Calgary Travellers to Red Deer (n = 195)	+/- 7.0%
Edmonton Respondents (n = 600)	+/- 4.0%
Edmonton Travellers to Calgary (n = 336)	+/- 5.3%
Edmonton Travellers to Red Deer (n = 200)	+/- 6.9%
Red Deer Respondents (n = 400)	+/- 4.9%
Red Deer Travellers to Calgary (n = 318)	+/- 5.5%
Red Deer Travellers to Edmonton (n = 309)	+/- 5.6%

** At 95% confidence interval*

In addition to the above, a second margin of error is associated with the mean (average) number of trips taken between each city pair, due to the high degree of variance in the number of trips taken by individual travellers. In fact, the 80/20 rule applies for most city pairs, meaning that approximately 80 percent of the trips are taken by 20 percent of the public. The margin of error associated with each city pair is shown in the table below:

Trip Type	Average # of Annual One-way Trips per Person	Margin of Error *	Range of Average # of Annual One-way Trips per Person
Calgary to Edmonton	2.5	0.6	1.9 - 3.1
Calgary to Red Deer	2.0	0.8	1.2 – 2.8
Edmonton to Calgary	2.1	0.4	1.7 – 2.5
Edmonton to Red Deer	1.1	0.2	0.9 – 1.3
Red Deer to Calgary	8.2	1.4	6.8 – 9.6
Red Deer to Edmonton	7.4	1.6	5.8 – 9.0

** At 95% confidence interval.*

Taking the survey's margin of error into account and wishing to be conservative in the travel estimates, the Steering Committee decided to use the Average Trip Rate as the maximum and the Low Trip Rate as the lower bound for the study's travel estimate range.

7.3.1 Current Travel between Calgary and Edmonton

The survey indicated that between 5.2 and 6.6 million person trips occurred between Calgary and Edmonton[36] over the last year. Business was the reason for just under half of all trips (44%), totaling 2.2 to 2.8 million person trips. The vast majority of all trips (89%), particularly non-business trips (95%), were made by car. Air and bus/other together accounted for 10 percent of all travel. However, air has a significantly higher share of business trips (13%) and a much lower share of non-business trips (less than 1%).

ANNUAL ONE-WAY PERSON TRIPS – CALGARY & EDMONTON (MIDPOINT LOW/AVG)			
Mode of Travel	**Business**	**Non-Business**	**Total**
Car	2,102,000	3,166,000	5,268,000
Air	347,000	37,000	374,000
Bus & Other	115,000	138,000	253,000
Total	**2,564,000**	**3,331,000**	**5,895,000**

[36] Survey respondents were asked how many times they traveled to the other city, including day or overnight trips but not just passing through the city on the way to another destination.

7.3.2 Current Travel between Red Deer and Calgary / Edmonton

An estimated 2.4 to 3.7 person million trips were made between Red Deer and Calgary and another 1.9 to 2.3 million trips were made between Red Deer and Edmonton over the last year. Most of these trips (60%) were made for non-business purposes, with business accounting for 40 percent of all trips. Again, the vast majority of trips were made by car, with one percent of business trips and two percent of non-business trips carried out by bus/other.

ANNUAL ONE-WAY PERSON TRIPS –RED DEER & CALGARY / EDMONTON (midpoint low/avg)		
Mode of Travel	**Business**	**Non-Business**
Car	2,024,000	3,076,000
Bus & Other	24,000	58,000
Total	**2,048,000**	**5,183,000**

7.4 Comparison with Other Sources

While no travel surveys have been completed since the early 1980s, annual estimates of total air and bus passenger volumes are calculated by using scheduled seat capacity and assumptions on average load factors. These calculations offer reasonable crosschecks on the reliability of the figures derived from the market research.

7.4.1 Air Passenger Estimates

The Calgary Airport Authority estimates the number of Calgary-Edmonton passengers based on the following information and assumptions:

- Total scheduled seats in both directions for flights between Calgary and Edmonton by Air Canada, WestJet, Canadian North and Central Mountain Air;
- Transport Canada’s domestic/local load factor (52%);
- Airport Authority’s Quality Service Indicator model percentage of passengers traveling between Calgary and Edmonton only (50%); and,
- Calgary-Edmonton passenger estimates for QuikAir and other Tier 3 operators at Edmonton City Centre Airport.

Allowing for margin of error, this calculation results in an approximate estimate of 337,000 Calgary-Edmonton one-way air passengers in 2003, and supports the market survey’s estimate range of 327,000 to 422,000.

7.4.2 Bus Passenger Estimates

Using a similar approach, bus passenger volumes can be estimated based on:

- the total number of bus runs between Calgary and Edmonton operated by Greyhound and Red Arrow according to published schedules (excludes overloads, charters and cancellations);

- an assumed seat capacity of 54 for all Greyhound buses (actual capacity ranges from 46 to 62);
- a known seat capacity of 36 for all Red Arrow buses; and,
- an assumed average load factor of 50 percent.

This calculation results in an estimate of 290,000 one-way bus passenger trips annually in the Calgary-Edmonton corridor, including trips to and from Red Deer which is served on the majority of runs, as well as a small number of trips to and from intermediate destinations served on the three Greyhound trips per day with stops at Calgary Airport and/or Leduc, and two trips with multiple stops.

This seat-based total passenger calculation is very close to the market survey estimate's low end of 292,000 bus/other trips between Calgary, Edmonton and Red Deer, but much lower than the market survey's upper end of 372,000. Several factors individually or in combination explain the differences between the calculated total and market survey estimate range. These include the possibility of a higher average load factor and margin of error in the calculation and/or market survey estimate, but the most likely explanation is the combined reporting of bus and "other" trips (eg., motorcycles, commercial trucks) in the market survey data. Given these explanations, the calculated bus passenger total appears to support the market survey estimate, particularly at its low end.

7.4.3 Car User Estimates

Estimating car travellers is more difficult than for air and bus due to the multiple destinations and combination of local, intermediate and through trips served by the road system along with trips of specific interest to this study. The most recent travel surveys of corridor traffic are those completed in the early 1980s for Alberta Economic Development's Intercity Passenger Rail Study. Based on a blend of three separate surveys[37], 1.4 million car travellers were estimated to travel between the two cities in 1981, representing 56 percent of travellers by all modes.

INTERCITY PASSENGER RAIL STUDY – 1981 ANNUAL TRIPS BY MODE					
	Car	**Air**	**Bus**	**Rail**	**Total**
Annual One-Way Trips	1,372,000	664,000	404,000	18,000	2,458,000

Trying to reconcile the estimate of car travellers reported in 1981 with those derived from the 2003 market research survey presents a number of challenges. First, travel patterns have changed significantly since 1981. Rail service has been eliminated and both air and bus passenger volumes have declined. In contrast, car traffic on Highway 2 has increased dramatically, suggesting a shift in travel from these other modes to the car. In 2003, 89 percent of all Calgary-Edmonton trips were reported by car, compared with 56 percent in 1981.

[37] These surveys collected data on southbound vehicles from Edmonton in 1982; vehicles in both directions at Red Deer in 1982; and northbound vehicles from Calgary in 1981.

Second, the 1982 surveys and resultant estimate of car travellers defined the origin/destination zone as the Cities of Calgary and Edmonton, whereas the market survey encompasses the Census Metropolitan Area (CMA). This latter definition is appropriate in today's context given CMA population growth since 1982 and the fact that in addition to downtown stations, suburban stations, which were not included in the 1980s study, are part of the current study's scope.

It was decided to compare the percentage of Calgary-Edmonton trips relative to all trips recorded in 1982 and 2003 by Alberta Transportation's permanent count station at the lowest traffic volume link on Highway 2. The lowest volume link was selected because it is most likely to have the highest representation of Calgary-Edmonton trips, and also be the least influenced by other traffic factors. However, to offset differences due to mode shift and survey area in the 1981 and 2003 surveys, and to enable more of an "apples to apples" comparison, the following adjustments were made:

- The number of 1981 car trips was increased to represent 89 percent of total Calgary-Edmonton travel in 1981; and,
- 2003 car trips were calculated based on the population 18 and older in the Cities of Calgary and Edmonton only rather than the CMA as a whole.

COMPARISON OF ADJUSTED CALGARY-EDMONTON TRIPS: 1981 & 2003

Year	Total Annual Passenger Vehicles *	Total Annual Car Passengers based on Traffic Counts	Annual Cal-Ed Car Passengers (based on adjusted 1981 & 2003 survey counts)	% Annual Cal-Ed Car Passengers of Total Annual Car Passengers (Column 3/Column 2)
1981	3,309,000	5,626,000	2,188,000	39
2003 (low rate)	6,515,000	11,076,000	4,154,000	38
2003 (avg rate)	6,515,000	11,076,000	5,330,000	48

** Source: Alberta Transportation Traffic Counts*

With these adjustments, the percentage of Calgary-Edmonton trips in 2003 using the market survey's low end estimate is basically the same as that in 1981, and the upper end estimate is only 9 percent more than in 1981. This correlation confirms that the absolute increase in Calgary-Edmonton trips between 1981 and 2003 results from mode shift and population and economic growth, and also supports market survey estimates.

In summary, the three checks using secondary sources corroborate the travel volumes derived from the market survey.

7.5 Receptiveness to High Speed Rail Service

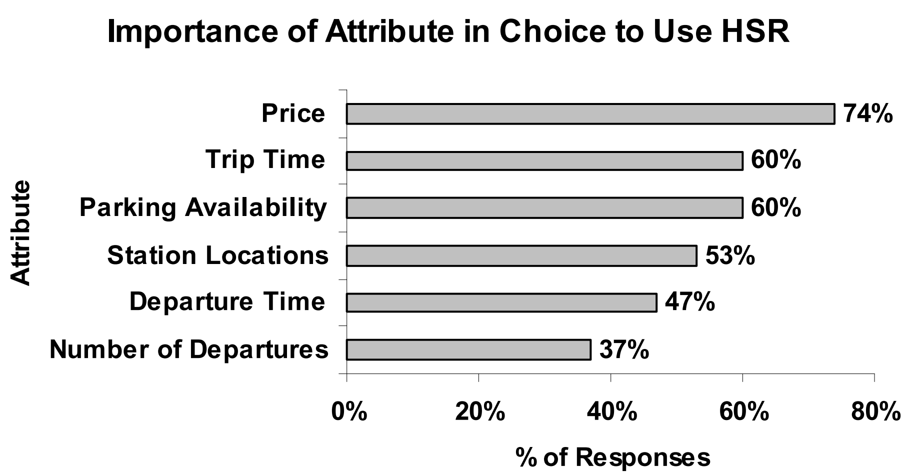
The market research survey also probed the receptiveness of all respondents to the proposed high speed rail service. The survey first asked respondents that if they had to travel, what would be their most important consideration in making a decision on whether to use or not use high speed rail. Price (59%) was mentioned most often, followed by speed/travel time (37%), scheduling

(20%) and station locations (17%). Business travellers mentioned scheduling and station locations more often than non-business travellers, but pricing received equal mention by both groups.

The survey then asked respondents to rate how important the following six considerations would be to their decision to use or not use high speed rail:

- Travel time;
- Number of train departures;
- Times of departures;
- Location of stations;
- Parking availability at stations;
- Price.

Based on this list, price (74% important) again ranked as the top consideration, followed by parking availability (60%), trip time (60%) and station locations (53%). Times of departure (47%) and number of departures (37%) were thought to be important by fewer respondents. Price was more important to non-business travellers, whereas departure time and number of departures were more important to business travellers. The importance of the other considerations was basically the same for both groups.



To focus the survey on service attributes of those respondents that would most likely use high speed rail, non-travellers were asked if they would have been more likely to travel in the past year if high speed rail service had been available. Those responding "no" were then excluded from detailed questioning on high speed rail service. The following table indicates the percentage of all interviewees in each of the three cities who had traveled to the other centres and those that said they would have been more likely to travel if high speed rail had been available.

CURRENT & POTENTIAL TRAVELLERS			
	Calgary	**Edmonton**	**Red Deer**
Calgarians		79%	48%
Edmontonians	81%		48%
Red Deerites	91%	84%	

The survey then probed current travellers and potential travellers[38] on how likely they would be to give seriously consideration to using high speed rail based on specified travel times, train frequency, prices and station locations.

7.5.1 Travel Time

Four one-way travel times were tested for trips between Calgary and Edmonton - 3 hours, 2 ½ hours, 2 hours and 1 ½ hours. At 3 hours, six-in-ten (61%) current and potential travellers indicated they would likely or very likely give serious consideration to using high speed rail. However, interest in using the service increased substantially at 2 ½ hours (74%) and again at 2 hours (89%), but made only minimal gains at 1 ½ hours (95%).

CURRENT & POTENTIAL TRAVELLERS - LIKELY/VERY LIKELY TO USE HSR

Travel Time	3 hrs	2.5	2	1.5
Calgary/ Edmonton	61%	74%	89%	95%

Travel times between Red Deer and either Calgary or Edmonton were given as 1 ½ hours, 1 ¼ hours, 1 hour and 45 minutes. Results for the two city pairs were slightly different. At 1 ½ hours, about half (48%) of respondents said they would seriously consider using high speed rail to/from Calgary, whereas six-in-ten (62%) would seriously consider using the service to/from Edmonton. Interest grew slightly for both markets at 1 ¼ hours, but showed the largest incremental gain when trip length was reduced to 1 hour, capturing 76 percent and 81 percent interest respectively. At 45 minutes, interest increased to 89 percent for both markets.

CURRENT & POTENTIAL TRAVELLERS - LIKELY/VERY LIKELY TO USE HSR

Travel Time	1.5 hrs	1.25	1	3/4
Red Deer/Calgary	48%	59%	76%	89%
Red Deer/Edmonton	62%	68%	81%	89%

7.5.2 Number of Departures

Five, eight, ten and twelve departures from Calgary, Edmonton and Red Deer were tested, but revealed relatively little impact on potential use. Roughly 90 percent of respondents stated they would likely or very likely use high speed rail under any of these scenarios. Therefore, for this measure, focus is placed only on those respondents who said they would very likely use high speed rail.

For trips between Calgary and Edmonton, the percentage of respondents saying they would very likely use high speed rail increased sharply between 5 and 10 daily departures, rising from 42

[38] Potential travellers comprise non-travellers who indicated they would have been more likely to travel in the past year had high speed rail been available.

percent to 68 percent. However, additional interest for 12 departures is minimal, attracting only another three percent of respondents (71%).

CURRENT & POTENTIAL TRAVELLERS - VERY LIKELY TO USE HSR				
# Departures	5	8	10	12
Calgary/ Edmonton	42%	59%	68%	71%

The pattern of increasing response is similar for the short haul market between Red Deer and Calgary or Edmonton, and once again slightly different for the two city pairs. Between Calgary and Red Deer, just over a third (38%) of respondents said they would very likely use high speed rail at 5 departures per day, increasing to 61 percent at 10 departures per day, with only a four percent gain with 12 departures (65%). Between Edmonton and Red Deer, take-up was slightly higher at 45 percent for 5 departures per day, increasing to 67 percent at 10 departures per day. Again, a very minimal gain in interest was observed with 12 departures per day.

CURRENT & POTENTIAL TRAVELLERS - VERY LIKELY TO USE HSR				
# Departures	5	8	10	12
Red Deer/Calgary	38%	51%	61%	65%
Red Deer/Edmonton	45%	59%	67%	70%

7.5.3 Price

Given the expected and survey-confirmed importance of price in the respondents' decision-making on whether or not to use high speed rail, the survey carried out three different approaches to explore price expectations and decision points. For all three approaches, respondents were asked to base their response on 8 to 12 departures daily and a trip time of 2 hours for Calgary/Edmonton trips and 1 hour for Red Deer to Calgary or Edmonton trips.

Approach 1: Respondents were asked the following series of open ended questions regarding the price of a round trip between cities to determine the range of acceptable prices.

- Price so cheap you would be concerned about service reliability
- Price considered to be a bargain
- Price that begins to seem expensive
- Price that is too expensive to consider

Based on this approach, the most acceptable round trip fares are $100 for business and $90 for non-business travellers between Calgary and Edmonton, and $47.50 for business and $42 for non-business travellers between Red Deer and Calgary/Edmonton.

Approach 2: Respondents were asked, on an open ended basis, what they would "expect" to pay for a round trip. The expected round trip fares are $115 for business and $100 for non-business travellers between Calgary and Edmonton, and $50 for business and $47.50 for non-business travellers between Red Deer and Calgary/Edmonton.

Approach 3: Respondents were asked how likely they would be to use high speed rail based on four specified round trip price levels of $200, $175, $140 and $115 between Calgary/Edmonton, and $120, $100, $85 and $70 between Red Deer and Calgary/Edmonton.

Past research by Ipsos-Reid and other market research firms shows that "weighting" respondents purchase intentions (i.e. likelihood of traveling at tested price points) results in a more accurate projection of how respondents will actually travel. Logically, not everyone who says that they would very likely use a product or service will actually do so. However, those who state they are "very likely" are much more prone to actually use the service than those who stated they were "somewhat likely" and so on.

The weighting of responses used is:

- 81% of those "very likely" to travel at a stated price
- 27% of those "somewhat likely" to travel at a stated price
- 3% of those "not very likely" to travel at a stated price
- 1% of those "not at all likely" to travel at a stated price

Based on the weighted response, four-in-ten (41%) current and potential travellers are predicted to use the service at a price of $115 per round trip. Usage drops to 26 percent at $140 and to 13 percent at $175. Less than one-in-ten (8%) would use the service if a round trip cost $200. Business travellers would more likely use the service than non-business travellers at all price points, with the widest margin occurring at the $115 level (50% business vs. 39% non-business).

PROJECTED HSR USE BY PRICE – CALGARY / EDMONTON

$ Round Trip	$200	$175	$140	$115
All Current/Potential	8%	13%	26%	41%
Business	12%	18%	36%	50%
Non-Business	7%	12%	25%	39%

For trips between Red Deer and Calgary/Edmonton, projected use of high speed rail service is three-in-ten (28%) respondents at $70, dropping to only 6 percent at $120. Business travellers again show greater willingness to use the service at all price points, with the widest difference to non-business travellers occurring at $70 (31% business vs. 25% non-business).

PROJECTED HSR USE BY PRICE – RED DEER – CALGARY/ EDMONTON

$ Round Trip	$120	$100	$85	$70
All Current/Potential	6%	10%	19%	28%
Business	6%	12%	21%	31%
Non-Business	5%	8%	17%	25%

7.5.4 Station Locations

The survey specified that stations in downtown Calgary and Edmonton's inner city were basic to the proposed plan and asked respondents if they would be more likely to use the service if the following additional stations were added:

- Adjacent to Deerfoot Trail near Calgary International Airport, and
- South of the Edmonton city limits off Highway 2 in vicinity of Edmonton International Airport

It also asked respondents their preference of location for the Edmonton inner city station between Grandin LRT Station near the legislature buildings or the south side of the Saskatchewan River in Strathcona.

Respondents showed strong interest in adding a station at Deerfoot Trail near Calgary International Airport, with six-in-ten (59%) stating they would be more likely use the service (29% much more likely and 30% somewhat more likely). Moderate interest was also shown in adding the station south of the Edmonton city limits near the airport. Half (50%) of Edmonton travellers said the additional station would increase their likeliness to use the service (21% much more likely and 29% somewhat more likely).

Preferences on the Edmonton inner city station location were divided but slightly favored the Grandin LRT site, with 48 percent of respondents preferring this location versus 42 percent favoring the Strathcona area location and 9 percent having no preference.

7.6 Calgary – Edmonton Ridership Forecast

The VIA-Mercer model forecasts ridership based on choices among competing transportation modes as a result of relative levels of service defined by frequency, trip time and price. The model was calibrated using input data on total trips for each of the competing modes derived from the market research study carried out in September 2003 by Ipsos-Reid. The model then calculated the impact of the high speed rail service on demand for alternate modes of transportation (air, bus and car) by business and non-business travellers.

Elasticity values measuring the impact of each rail service attribute on competing modes are derived from a 1994 IBI Group study of the Quebec-Windsor Corridor travel market for a "surrogate" city pair that are similar to Calgary and Edmonton in distance, and have the same car dominance of total travel, similar mode share for bus and similar, although not identical, travel characteristics (travel time, cost, frequency) for all non-rail modes.

A modeling approach based on trip diversion factors is an efficient means of forecasting the overall market responsiveness to high speed rail service, and the importance of frequency, price and trip time in attracting travellers from other modes. Among the demand forecasting studies that VIA consulted (1991 Ontario-Quebec, 1992 Air Canada-CP, 1995 TEMS), each of the modeling methodologies relied on estimates of elasticity for overall rail demand. Reconciling individual rail elasticity values among the studies, however, proved difficult as estimates differed widely. Given these shortcomings, VIA determined that the IBI modal elasticities would provide reasonable forecasts.

In order to establish a final high speed rail service plan, different combinations of schedule and trip times were identified as inputs to the demand forecasting model. By comparing changes in high speed rail market share associated with each combination, a preferred service plan was identified for the Calgary/Edmonton market, and the following assumptions were used as inputs to the ridership forecasting model.

HSR SERVICE PLAN - CALGARY/EDMONTON MARKETS			
	CPR	**Greenfield Non-Electric**	**Greenfield Electric**
Time	2 hr 10 min	1 hr 46 min	1 hr 37 min
Frequency (round trips)	10	10	10
Cost (round trip) - Business Non-Business	 $115 $97	 $115 $97	 $115 $97

Using both the low and average total number of trips from the 2003 market research and high speed rail service plan as inputs, ridership forecasts were developed for each of the three alignment/technology alternatives. The following table presents the midpoint in the range of ridership forecasts for the three alternatives assuming a stable or mature high speed rail operation in 2003.

RIDERSHIP FORECAST BASE YEAR (2003 – BASED ON MIDPOINT LOW/AVG)				
Person Trips ('000)	**Car**	**Air**	**Bus**	**HSR**
CPR	- 947	- 189	- 184	1,320
Greenfield Non-Electric	- 1,148	- 208	- 184	1,540
Greenfield Electric	- 1,250	- 225	- 193	1,668

The model predicts that high speed rail ridership would range between 1.3 and 1.6 million trips in 2003 depending on the alignment/technology alternative selected, which represents a 22-28 percent market share of all trips. Business trips comprise roughly half of the forecast high speed rail ridership (52%). Almost three-quarters of forecast high speed rail riders are currently car users. Still, this represents a relatively small proportion of car trips and leaves the car as the dominant travel mode with a 68-73 percent share of the total travel market. The rest of high speed rail riders are current air and bus travellers, in particular, those traveling for business, because of rail's high frequency of service and reduction in travel time relative to the other modes.

Faster travel time with the two Greenfield alternatives has the strongest effect on business travellers and trip diversion from air and car. However, bus diversion remains essentially the same for all alternatives. The fairly significant diversion of car travellers with the two Greenfield alternatives compared to the more modest figure with the CPR alternative reflects the fact that time savings with this option are now sufficient to outweigh the convenience factor for car users who are time-sensitive.

7.7 Corroboration of Results

To test the reasonableness of the ridership estimates, the VIA-Mercer model results were compared with forecasts derived from two other methodologies.

7.7.1 Comparison Using Market Research

The market research findings provide a further insight into potential usage of high speed rail service. Using stated travel intention rates reported by survey respondents and weighting the strength of these travel intentions (on a scale that declines with respondents decreasing likelihood of using high speed rail), Ipsos-Reid estimated that 41percent of current and potential travellers would use the service at a price of $115 (50 percent of business travellers and 39 percent of non-business travellers).

Although respondents were not asked to estimate how many of their total trips would be made using new HSR, VIA regularly polls its customers in the Quebec-Windsor corridor about their use of other modes during the previous year. Travellers using VIA service report that they typically make between 45–50 percent of all trips by rail. With a much more competitive high speed rail service between Calgary and Edmonton, these rates of rail usage are probably conservative. Nevertheless, applying this propensity to actually use rail service produces a 21 percent market share which is very comparable to the VIA model.

7.7.2 Comparison with CPR Model Results

In 1992, CPR/Air Canada performed a high speed rail market assessment for the Quebec-Windsor corridor. Extensive traveller intercept surveys were conducted, and a demand forecasting model was developed and calibrated for each segment of this corridor. It was decided to apply this model to the Calgary-Edmonton corridor to determine whether its forecast approximated the VIA-Mercer model forecast, and therefore the reasonableness of this forecast.

The first step was to use the travel time (including access/egress time) and cost characteristics for the existing travel modes in the Calgary-Edmonton corridor to calibrate the CPR model to replicate current travel demand for all modes (i.e. without high speed rail). In so doing, the model became customized to the Calgary-Edmonton market. Then, the model was re-run with high speed rail to develop ridership estimates for the service. For comparative purposes, this was done for the CPR alternative only. The following table compares the ridership forecasts for the CPR alternative using the VIA-Mercer model versus those derived from the CPR model.

COMPARISON OF CPR & VIA RIDERSHIP FORECASTS BASE YEAR (2003) – CPR ALTERNATIVE (BASED ON MIDPOINT LOW/AVG)				
Person Trips ('000)	**Car**	**Air**	**Bus**	**HSR**
VIA-Mercer Model	- 947	- 189	- 184	1,320
CPR Model	- 1,506	- 128	- 76	1,712

The primary differences between the two forecasts is the much higher diversion of car travellers with the CPR model coupled with a much lower attraction of bus travellers. The latter is partly explained by the assumption of a higher cost differential between bus and high speed rail in the CPR model compared with that in the VIA model. Although the CPR model's overall ridership estimate was higher than that produced by the VIA-Mercer model, it nevertheless supports the reasonableness of the ridership estimates. However, to maintain a conservative approach, the VIA-Mercer results were chosen for use in the study.

7.8 Red Deer Ridership Forecast

Unlike Calgary-Edmonton, there was no representative city-pair whose transportation mode characteristics and modal share data were documented in enough detail to apply the elasticity factors and therefore use the trip diversion model. Instead, estimates of high speed rail demand between Red Deer and Edmonton/Calgary were developed using a probabilistic approach based on the stated travel intention rates reported by Red Deer residents in the 2003 Ipsos-Reid market research survey, and applying VIA's propensity to use rail data from their customer surveys.

Recognizing that short distance markets provide a strong competitive edge for the car that grows more pronounced as trip time begins to approximate a car-commuting trip (1 hour), it was decided to adopt a more conservative estimate of demand for the local Red Deer market. After weighting the strength of respondents travel intentions, Ipsos-Reid estimated that 28 percent of current and potential Red Deer travellers would use the high speed rail service at a price of $70 per round trip (31% of business travellers and 25% of non-business travellers), but at higher prices, expected high speed rail use fell significantly.

Based on professional judgment and experience, the initial demand estimates were discounted by 50 percent (confidence factor) to reflect the higher potential variance associated with stated travel intentions reported by survey respondents. In addition, VIA's propensity to use rail percentages of 49 percent for business and 53 percent for non-business travellers were applied. Based on the mid point between the low and average number of total current trips between Red Deer and Calgary/Edmonton, high speed rail ridership is estimated to be 363,000, which represents a 7 percent share of total current trips. To be conservative, Red Deer ridership was assumed to be the same for all three alternatives despite the incremental incentive of improved travel time associated with the two Greenfield alternatives.

RED DEER RIDERSHIP ESTIMATE BASE YEAR (2003 – BASED ON MIDPOINT LOW/AVG)			
Person Trips ('000)	**Business**	**Non-Business**	**Total**
Current Total Annual Trips	2,058	3,125	5,605
Stated Intention to use HSR @ $70 round trip	31%	25%	
Confidence Factor	50%	50%	
Estimated Rail Share of Trips	49%	53%	
Est. HSR Market Share	**7.5%**	**6.6%**	**7.0%**
2003 HSR Ridership	**154**	**209**	**363**

7.9 Induced Travel

Trip generation rates have frequently been found to be higher following introduction of higher-speed rail service in both Europe and North America. The degree to which total demand for all modes shifts to a higher level (the induced demand effect) is cited in demand forecasting studies as an independent benefit of rail service improvements. However, estimating the impact of these shifts in demand requires information on changes in the overall cost of travel (value of time), since the impact of improvements in rail service are influenced by specific market conditions, including the degree of economic integration and historical attraction between the city-pairs, and by favourable economic trends such as income and population growth.

Since shifts in demand occur in response to long term trends, estimates of induced demand typically show significant variability depending on the study parameters. These typically range from 5 percent (for Quebec-Windsor Corridor studies) to more than 20 percent (for many European projects). However, induced demand is also one of the most controversial and highly criticized components of ridership forecasts due to their speculative nature.

Although the market research probed the receptiveness of potential travellers[39] to use high speed rail based on different frequency, travel time, price and station location assumptions to obtain the fullest understanding of how best to position the service, the demand forecasts were based on travel data that only represented actual trips made. Furthermore, to continue to be conservative in estimating ridership, induced demand has not been included in the ridership forecasts albeit that the market research survey clearly confirms that such potential exists. If, for example, one applied the previously discussed discount factors (stated intention and propensity to use rail) to only those potential Calgary-Edmonton travellers that stated they would be very likely to use high speed rail, and assumed each took one new round trip per year because of the presence of high speed rail (induced demand), the ridership estimate would increase by 4 to 5 percent.

[39] Potential travellers are those respondents who did not travel to Calgary/Edmonton last year, but stated they would have been more inclined to do so if HSR had been available.

ILLUSTRATION OF POTENTIAL INDUCED RIDERSHIP – BASE YEAR (2003 – BASED ON MIPOINT LOW/AVG)	
	Calgary – Edmonton
Potential Travellers – very likely to use HSR	214,000
Stated Intention to use HSR	28%
Estimated Rail Share of Trips	50%
Number of Person Trips (2 each)/Year	**60,000**
% Incremental Ridership	**4 – 5%**

7.10 Overview of Total Ridership

Had high speed rail been in stable operation in 2003, the forecasts predict it would have carried 1.7 to 2.0 million passenger trips (1.3 to 1.7 million Calgary-Edmonton trips plus 363,000 Red Deer-Calgary/Edmonton) depending on which alignment/technology alternative had been implemented. The following table summarizes the ridership estimates for the three alternatives.

COMPARISON OF RIDERSHIP BASE YEAR(2003 – BASED ON MIDPOINT LOW/AVG)			
Passengers ('000)	**CPR**	**Greenfield Non-Electric**	**Greenfield Electric**
Calgary-Edmonton	1,320	1,540	1,668
Red Deer-Calgary/Edmonton	363	363	363
Total	**1,683**	**1,903**	**2,031**

Care has been taken to adopt a conservative approach in developing the ridership estimates. The mid point between the low and average estimates of current travel was used. The lower VIA-Mercer model ridership forecast was chosen over the higher CPR model forecast. Furthermore, induced ridership has been ignored and excluded from the ridership forecast even though it has significant potential. All of these decisions were made to ensure that the ridership estimates are reasonable and would not unduly inflate equipment requirements and associated capital costs, revenue and operating cost projections. Nevertheless, these estimates are preliminary and, while sufficient for the purpose of the pre-feasibility study, will require more in-depth analysis in the form of an investment grade ridership forecast should the project proceed.

Ridership is also projected to increase by only the same rate as the overall growth of travel demand rather than to increase more sharply as road congestion affecting other competing modes boosts the competitive attractiveness of high speed rail. Historically, traffic on Highway 2 has grown by 3 percent per year. Based on current population and economic growth, there is no reason to think that this rate of travel demand growth will not continue. As car travel makes up the vast majority of travel demand, 3 percent growth per year is applied to the ridership projection. However, high speed rail's market share remains constant from year three of operation once the service reaches "steady state"[40]. In years one and two, ridership is discounted to 70 and 90 percent respectively to reflect the gradual traveller conversion process that occurs with the introduction of new service.

[40] Industry experience reveals that it typically takes three years after the introduction of new or improved rail service for ridership to reach its full potential.

Furthermore, ridership growth is capped once annual ridership reaches 70 percent of the effective capacity of the train service, as operating experience shows that, at this point, trains in peak hours are effectively full, and ridership will level off. In actuality, the service provider would likely make one of two choices; namely, to either purchase additional rolling stock, which may also trigger additional infrastructure requirements, or use differential pricing to shift demand during the day and even suppress ridership growth. The former approach while adding capital costs to the project would also result in added revenue with marginal increases in operating cost due to economies of scale. The latter would result in additional revenue and net operating income to service capital cost repayment. The decision to cap ridership growth at the 70 percent of train service capacity was made to both simplify the analysis and also to again be conservative.

7.11 Passenger Revenue Forecasts

Annual revenues were estimated using two pricing options:

- Market-tested fares from the Ipsos-Reid market research associated with the highest potential to use high speed rail for business/non-business users; and,
- A higher business-class fare, widening the price differential against regular fares, and corresponding to the business premium applied on VIA Rail's Corridor fares (no price resistance to these higher fare levels has been calculated, therefore, these figures represent a theoretical maximum).

The following table summarizes the revenue forecasts for all three alternatives for the base year (2003).

PASSENGER REVENUE FORECASTS BASE YEAR (2003 – BASED ON MIDPOINT LOW/AVG)

	Tested Fares		**Differential Fares**	
Annual Revenue ($000's)	Business $115	Non-Business $97	Business $145	Non-Business $97
CPR Alternative				
Calgary-Edmonton	$39,736	$29,849	$50,102	$29,848
Red Deer- Calgary/Edmonton	$5,385	$7,315	$5,385	$7,315
Total	**$82,285**		**$92,651**	
Greenfield Non-Electric				
Calgary-Edmonton	$45,713	36,108	$57,638	$36,108
Red Deer- Calgary/Edmonton	$5,385	$7,315	$5,385	$7,315
Total	**$94,521**		**$106,446**	
Greenfield Electric				
Calgary-Edmonton	$49,824	$38,873	$62,821	$38,873
Red Deer- Calgary/Edmonton	$5,385	$7,315	$5,385	$7,315
Total	**$101,397**		**$114,394**	

Revenue forecasts range from $82.3 to $101.4 million for the base year 2003 when market-tested fares are used. Under the alternative, differentiated fare plan, revenues could increase to $92.7 to $114.4 million depending on the alternative chosen. Once again to be conservative, the lower revenue scenario based on tested fares was selected for use in the financial analysis of the overall project.

7.12 Other Revenue

Other revenues, such as package and courier services and retail leases (e.g. bank machines, etc), have been excluded from consideration in this study. An allowance is included for food and beverage service to business class passengers but it is positioned to be revenue neutral (i.e. revenue is equal to the cost of product and staff costs to provide this service) so as not to influence the assessment of the project's viability. The decision to confine revenue solely to fares and exclude other revenues was again made in an effort to be conservative.

OPERATING COSTS

8.1 Introduction

Although capital costs are a primary consideration in determining project viability, operating costs, particularly for the proposed high speed rail service, are equally important as they determine the draw on revenues and hence the surplus available to service capital repayment. As a result, equal care and diligence are required to develop realistic estimates of these costs.

Operating costs are largely a function of service frequency and passenger demand. Based on the market research described in Chapter 7 of this report, service frequency of eleven weekday departures from Calgary and Edmonton respectively plus an additional morning commuter departure from Red Deer have been assumed. In addition, five weekend departures from Calgary and Edmonton respectively plus an additional departure from Red Deer have also been assumed. The range of expected passenger volumes based on this service plan was also described in Chapter 7. For the purpose of estimating operating costs and to be conservative, the midpoint within this range was selected as the basis for operating costs.

The first step in developing the operating cost estimates was to run train performance simulations. These simulations were used to calculate train travel time for the two route alternatives, enabling the schedule and service plan to be developed. These simulations also generated train route kilometres, fuel consumption and operational hours of service for operating cost calculations. CPR carried out train simulations for the CPR alternative and common portion of the Greenfield alternatives, whereas Canac carried these out for the dedicated portion of the Greenfield alternatives.

Based on this information and data on equipment maintenance requirements provided by VIA Rail, with input from Bombardier Transportation, VIA Rail then developed operating cost estimates to run and maintain trains. These estimates were based on VIA's current operating experience, labour work rules and wage rates. A new private operator may be able to reduce costs based on more favourable work rules, broader job classifications and different labour rates. As a result, the operating cost estimates developed for the purpose of this study are both realistic and potentially conservative as they reflect those of an established operator.

The second component of operating costs is track and wayside maintenance. In the case of the CPR alternative, CPR would take responsibility for these activities as the tracks serve both their freight business and the high speed rail service within the corridor they own. The same would be true for the common portion of the Greenfield alternatives. For the dedicated new portion of the Greenfield alignment, maintenance responsibilities could possibly be contracted to CPR or carried out independently.

For the CPR alternative, CPR provided an "access fee" estimate to cover train dispatch, track and wayside maintenance and other related services. For the dedicated new portions of the Greenfield alternatives, VIA estimated track maintenance costs assuming in-house provision of these services by the high speed rail operator.

This Chapter describes the major areas of maintenance expenditure and assumptions associated with each of these areas.

8.2 Train Maintenance

The following represent the assumptions used to develop the operating cost estimates:

COMPARISON OF OPERATING ASSUMPTIONS			
	CPR	**Greenfield Non-Electric**	**Greenfield Electric**
Route Km	310 km	294 km	294 km
Consist	1-8-1	1-10-1	1-10-1
Seats per Train	512 (224 busn; 288 econ)	640 (280 busn; 360 econ)	640 (280 busn; 360 econ)
No. of Trainsets	5 (4 operating and 1 spare)	5 (4 operating and 1 spare)	5 (4 operating and 1 spare)
Fleet Size	10 locomotives; 40 cars	10 locomotives; 50 cars	10 locomotives; 50 cars
Trip Time	2 hr 10 min	1 hr 46 min	1 hr 37 min
Frequency	10.5 round trips weekday; 5.5 weekends (including starting and ending in Red Deer)		
Weekday Timetable	7 am w/ departure interval of 1 ½ hrs.		
No. of Annual Passengers*	2.2 million	2.5 million	2.7 million
Annual Train Km	1.4 million	1.3 million	1.3 million

* At maturity (2012)

Train maintenance involves an integrated program of scheduled preventative and corrective activities, including servicing, inspection, repairs and overhauls. Servicing and inspection of trains, including cleaning and basic safety inspections, occurs prior to every trip at the terminal stations. If trains are not equipped with a brake indicator that is visible at track level and require a pit to carry out inspections, then trains would be taken daily to the maintenance centre for inspection.

On roughly a weekly basis, more extensive inspections are carried out at the maintenance centre and/or satellite maintenance centre, typically overnight. In addition, periodic preventive maintenance is also carried out at the maintenance centre with each train requiring quarterly, biannual and annual inspections and service programs varying in time from between 4 and 7 days.

Based on this schedule of activities and the five train sets, the maintenance centre is expected to need one daily shift and a staff of 90 to 100, including electricians, mechanics, general workers, front line supervisors and support personnel. The satellite centre is expected to require approximately 20 to 25 staff, including trades people and supervision.

Direct labour and material costs for servicing and maintenance of trains are estimated to be $11 million annually for the CPR alternative, $13.6 million for the Greenfield Non-Electric and $12.4 million for the Greenfield Electric. The difference in costs reflects the different fleet sizes, technology and associated maintenance practices. In addition, fixed and semi-variable overhead and support activities, including management, operational and financial control, planning and scheduling, quality assurance, technical support and engineering and systems, are estimated to be approximately $3.5 million per year for all three alternatives.

Given the high capital cost for a wheel-truing machine and the expected workload, it is assumed that this work will be contracted out at an estimated cost of $181,000 per year for the CPR alternative and $206,000 per year for the two Greenfield alternatives because of their larger fleet size. For reasons of economy, it is also assumed that overhauls will be contracted out. Based on expected fleet utilization, the following overhaul schedule is anticipated:

APPROXIMATE FREQUENCY OF MAJOR MAINTENANCE AND OVERHAULS		
	Major	**Intermediate**
Locomotives	4 Years	2 Years
Passenger Cars	5 Years	2.5 Years
Trucks	2 Years	2 Years
Brakes & Bearings	2 Years	

Based on these assumptions, the annualized cost for major maintenance and overhauls is estimated to be $11.0 million for the CPR alternative, $12.9 million for the Greenfield Non-Electric and $12.1 million for the Greenfield Electric. As the life of these assets is at least 30 years, no capital replacement is projected during the life of the project.

8.3 Facility Operations and Maintenance

Annual operating and maintenance cost for facilities includes utilities, cleaning and janitorial services, building and site maintenance, repairs, property taxes, equipment and supplies, security and plant administrative costs.

For the CPR alternative, annual operating and maintenance costs are estimated to be approximately $2.7 million for the maintenance facility and satellite centres. For the two Greenfield alternatives, these costs are higher due to the longer train lengths. In the case of the Greenfield Non-Electric and Electric alternatives, annual operating and maintenance costs for these facilities are estimated to be $3.4 and $3.2 million respectively. The reason for the lower cost for the Greenfield Electric alternative is that the satellite centres do not require individual 480kv power panels as the entire alignment is electrified and maintenance for the electric infrastructure is included in overall line maintenance costs.

As with the maintenance facilities, station maintenance costs are slightly higher for the two Greenfield alternatives because of the longer train lengths and higher passenger volumes. For the two terminal stations and three intermediate stations, maintenance costs range from $0.9 to $1.0 million for the three alternatives. In total, facility operations and maintenance are estimated to cost

$3.6 million for the CPR alternative, $4.3 million for the Greenfield Non-Electric and $4.2 million for the Greenfield Electric.

8.4 Train Operations and Passenger Services

Train operations and passenger services include train crewing and on-board service staff, fuel, station, commissary and call center staffing, provisions, training requirements, marketing and advertising.

On-Train Crewing and Service Staff

On–board trains, the minimum and mandatory crewing standard for VIA Rail is two locomotive engineers and one service manager, with other service personnel assigned according to service delivery requirements. For the CPR alternative, the same crewing requirements are assumed.

However, for the Greenfield Non-Electric alternative, it is assumed that given the predominantly dedicated and protected right-of-way, one locomotive engineer would be adequate to operate the *JetTrain*, which, although equipped with two seats, has been designed with one man application in mind, with all the controls on one side, as is typical for high speed intercity service. This operating assumption would, however, require Transport Canada approval and, for the common portions of the Greenfield alternatives, CPR's concurrence if the infrastructure is shared with freight trains (sharing is assumed in the capital estimates).

In the case of the Greenfield Electric alternative, the cab in electric high speed trains can only accommodate one person as it is specifically designed for one man operation (central driving cab). Operation of this type of train will require Transport Canada approval regardless of the crewing assumption, and would, therefore, presumably include this provision. Again, it would also require concurrence with CPR for the common portions of the right-of-way if the infrastructure were shared with freight trains.

One crewing location is assumed to be sufficient, with crews operating round trips and either being released at their home terminal or provided with overnight accommodation for all three alternatives. Costs are included to cover overnight stays and meals, grooming and other service related costs.

The total number of engineers needed to operate the proposed service would range from 36 to 38 at an annual cost of $4.4 million per year for the CPR alternative, 19 engineers at cost of $2.2 million for the Greenfield Non-Electric and 15 for the Greenfield Electric at a cost of $1.7 million. The latter cost reduction as compared to the Greenfield Non-Electric alternative reflects crew optimization in terms of legal maximum hours of operation based on the improved trip times with the electrified service. A more detailed analysis would be required to confirm actual costs for all three alternatives, once schedules are finalized and requirements for reporting and release times have been firmed up.

In addition to a service manager, other on-board service staffing is dependent on the level of service, which in part reflects the price offering that will be acceptable to customers. For the purpose of this study, business class, offering alcoholic beverages and appetizer snacks on a cash basis and complimentary non-alcoholic beverages as well as newspapers, headsets, etc., and economy class without any on-board service is assumed. To deliver the assumed business class service, one employee per business class car plus a "floater" is assumed for a total of six customer service employees per train based on the midpoint passenger volume forecast for the CPR alternative and seven for the two Greenfield alternatives.

As a result, the total on-board customer service staffing required would be 113 at a cost of $6.4 million per year for the CPR and Greenfield Electric alternatives and 122 for the Greenfield Non-Electric alternative at a cost of $7.0 million per year. Again, the difference in costs between the Greenfield alternatives is as a result of staffing optimization.

Product costs, which are driven by passenger volume, are estimated to range from $4.7 million for the CPR alternative to $5.9 million for the Greenfield Electric. It should be noted that for the purpose of this study, revenue for the food and beverage service is set so as to offset all costs except the service manager cost, thus eliminating the service option as an influencing factor.

Station, Commissary and Call Centre Staffing

Station employees to provide ticketing, boarding assistance, information and other customer services were assumed for the two terminal stations and Red Deer station. To provide seven days per week coverage for all shifts, a total of 44 station attendants were estimated to be required at a cost of $2.4 million per year for the CPR alternative and 56 station attendants at a cost of $3.1 million for the two Greenfield alternatives due to their higher passenger volume. These staffing numbers also assume that automated ticketing kiosks for ticket processing, reservations and revenue/ticket collection are implemented along with other automated systems, such as Internet bookings, voice response, etc.

To provide food and beverage service, a commissary is one option that, if chosen, would require single location stocking for round trips, with special equipment, supplies, ware-washing provisions and inventory storage. Based on midpoint passenger volumes, 12 employees for the CPR alternative and 15 for the two Greenfield alternatives together with supplies would be required. The annual staffing and supplies for the commissary is estimated to range from $1.4 million for the CPR alternative to $1.7 million Greenfield Electric alternative. However, a less costly option could be to out-source this activity.

A call centre providing modern "user friendly" call processing and reservations, including a voice response system, voice recognition and the ability to process a reservation is assumed, reducing the staffing function to a "help desk" type of service. Based on these assumptions, 12 call centre employees are estimated to be required for the CPR alternative and 15 for the two Greenfield alternatives. In addition, telecommunications costs for a call volume of approximately 50 percent of all passengers carried have been assumed. The total annual cost for call centre service ranges from $0.9 million for the CPR alternative to $1.2 million for the Greenfield Electric alternative.

Fuel/ Electricity

Based on the train simulations, fuel consumption of 21.1 million liters for the CPR alternative and 22.5 million liters for the Greenfield Non-Electric alternative is forecast. The total cost for fuel based on $0.40 per liter is $8.3 million annually for the CPR alternative and $8.9 million for the Greenfield Non-Electric option. For the Greenfield Electric alternative, 59.6 million kilowatt hours at $0.09 per kilowatt-hour are estimated to be required for a total annual cost of $5.2 million.

Training, Equipment and Other Employee Needs

Both start-up and annual training will be required for all staff. The duration of start-up training varies significantly from nine months to a year for locomotive engineers to one week for commissary staff. VIA Rail provides on average 5 days of annual refresher and promotional training per employee. The cost of start-up training is estimated to be $5.3 million for the CPR alternative, $3.1 for the Greenfield Non-Electric and $2.6 million for the Greenfield Electric with the difference in costs largely reflecting the number of locomotive engineers required by each alternative. Annual training costs of $300,000 are assumed for all three alternatives. In addition to training, uniforms, equipment, radios, supplies and other provisions are also required. These items are estimated to cost $0.4 million per year for the CPR alternative and $0.5 million per year for the two Greenfield alternatives.

Marketing and Advertising

While advertising expenditure is at the discretion of the operator, various costs including sales commissions, reservation systems, transaction fees, travel agent fees and credit card discounts are driven by passenger volume and sales. For both these expenditures, typical percentages of revenues have been used to estimate costs. In the case of advertising, three percent of forecast revenue is estimated on an on-going basis and another three percent for sales driven costs. In total, these costs range from $7.4 million annually for the CPR alternative to $9 million for the Greenfield Electric alternative. In addition to this annual expenditure, a start-up advertising cost of $250,000 has been allocated.

8.5 Track and Wayside Maintenance

CPR alternative

In the case of the CPR alternative, the proposed Calgary-Edmonton high speed rail service and the magnitude of associated infrastructure improvements described in this report are unlike any other relationship between CPR and other passenger service operators. Similarly, the effect on existing maintenance activities is complex.

On the one hand, some maintenance expenditures that CPR would ordinarily incur will be postponed for many years because of the lifecycle of new investments compared to the replaced, older infrastructure. On the other hand, additional maintenance will be required because the new service involves two tracks instead of one and some activities will require greater frequency because of the higher demands of passenger service as compared to freight. At the same time, freight traffic will be the primary cause of track wear and tear due to their heavier loads.

Implementation of actual service on CPR would require the negotiation of an access fee. For the purpose of this study, the CPR developed a conceptual access fee estimate recognizing that some benefits from rail upgrades will accrue to freight operations and, at the same time, the fee could have a material effect on cash flow of the operator, and hence the feasibility of the project. In addition, CPR recognized that the start-up years would be the most difficult. Accordingly, a conceptual access fee estimate was based on the following assumptions:

- No access fee for the first five years of operation, and,
- Beginning in year 6, an amount of revenue per service train–kilometre that is equivalent to $1.25 in 2004 inflated at two percent per year to the applicable year or, based on the proposed service plan, a charge of $2.6 million per year.

Common Portion of the Greenfield Alternatives

For the common portion of the Greenfield alternatives, CPR notes that these are the areas of maximum congestion and therefore the infrastructure improvements for the partial option are largely the same as for the CPR alternative. However, the addition of high speed rail service would forever limit CPR's freight operation in these areas, while CPR and its freight customers would not realize the full operating benefits that result from the CPR alternative. Accordingly, the conceptual access fee estimate assumes the following:

- At inception of service, an amount per revenue service train-kilometre that is the equivalent of $3.10 in 2004 inflated at two percent per year to the applicable year or, based on the proposed service plan, $775,000 per year.

In addition, the above conceptual estimates assume that all liabilities associated with passenger train operations will be borne by the operator or other guarantor, and that suitable indemnities will be provided to ensure that CPR's insurance costs are not affected.

Dedicated New Portion of the Greenfield Alternatives

For the dedicated portion of the Greenfield alternatives, VIA Rail estimated track maintenance costs based on work that they had completed for previous federal-provincial high speed rail studies. For the Greenfield Non-Electric alternative, $17.5 million per year is estimated, and for the Greenfield Electric, $20.8 million per year, with the main difference being the cost for maintaining the electric infrastructure.

8.6 Comparison of Total Operating Costs

Based on VIA Rail's experience, it typically takes three years for new services to reach their full ridership potential and establish stable operation. Accordingly, passenger volumes in years one and two, or the "ramp-up" period, have been discounted to 70 and 90 percent respectively of their full potential. As a result, all costs that are either passenger or revenue driven are also discounted. All other costs are kept fixed.

Although in reality on-board, station and other passenger service related staffing levels would be adjusted according to passenger demand, an overall average approach was taken for all three alternatives on the assumption that initially there would be higher demands by passengers unfamiliar with the service, whereas later on higher passenger volumes would entail lower service demands and staffing requirements would also be less due to improved productivity. As a result, these costs remain fixed throughout the life of the project.

The following table compares operating costs for the three alternatives in the first year of stable operation (2012). Cost categories that include variable costs are asterisked. Several factors explain the cost differences between the three alternatives in the various cost categories.

COMPARISON OF OPERATING COSTS (2012 – 1ST STABLE YEAR OF OPERATION)

	CPR	Greenfield Non-Electric	Greenfield Electric
Train Maintenance	25.7	30.2	28.2
Track Maintenance (1)	0	17.4	20.7
Facility Maintenance	3.6	4.3	4.2
Total Maintenance Costs	**29.4**	**52.0**	**53.1**
Fuel or Electricity	8.3	8.9	5.2
Train Crewing	4.4	2.2	1.7
On-Board Passenger Services & Product*	11.1	12.4	12.2
Station Services	2.4	3.1	3.1
Commissary, Call Centre *	2.3	2.6	2.9
Training	0.8	0.8	0.8
Insurance	3.0	4.0	4.0
Advertising & Commissions*	7.3	8.3	9.0
Total Operating Costs	**39.6**	**42.5**	**38.9**
Admin & Other	2.1	2.8	2.8
TOTAL PROJECT COSTS	**71.0**	**97.3**	**94.8**
(1) Note: Annual access fee after five years is $2.6 million per year.			
* Includes variable costs based on passenger volumes.			

The principal cost differences between the CPR and Greenfield Non-Electric alternatives are lower track maintenance and higher train crewing costs. The CPR alternative includes lower track maintenance because the access fee charged by CPR is waived for the first five years of operation and the fee thereafter is much lower than the cost to maintain the dedicated portion of the Greenfield alignment. Higher train crewing costs reflect the assumptions that one engineer would be permissible with the dedicated Greenfield alternatives and that two will be required for the CPR alternative. All other cost differences between these two alternatives stem from differences in passenger volumes and route length that then drive fleet size and utilization, staffing and passenger and revenue driven costs.

In the case of the two Greenfield alternatives, technology differences are the primary factor explaining cost differences. Lower train maintenance and electricity costs are offset by higher track maintenance needed to maintain electric infrastructure. In addition, the higher speed of the electric trains and resulting lower trip times that allow staffing hours to be optimized, explains lower train staffing costs. In all other categories, costs are fairly comparable with all other differences explained by variations in passenger and revenue volumes.

Comparing the project operating cost estimates to the previously quoted FRA operating cost averages for different technologies provides a "ballpark" measure of the reasonableness of the operating costs. On a passenger kilometer basis, the CPR alternative decreases from $0.1937 to $0.1621 over the project life, which compares very favourably to the FRA average of $0.1628. The two Greenfield alternatives, on the other hand, are both slightly higher that the FRA average. The Greenfield Non-Electric operating costs decrease from $0.2375 to $0.1816 compared to the FRA average of $0.1613, whereas the Greenfield Electric operating costs decrease from $0.2194 to $0.1769 compared to the FRA average of $0.1639. These differences can be explained by the fact the FRA figures are now six to seven years old and also represent an average figure, whereas the estimates make use of actual up-to-date VIA Rail costs and may also be conservative. Nevertheless, the comparison supports the reasonableness of the operating cost estimates at this stage in project development.

FINANCIAL STRUCTURE

9.1 Introduction

The previous three Chapters have outlined the capital cost, ridership and revenue forecasts and operating costs for the high speed rail alternatives. With this information, an analysis can be carried out to determine the financial viability of high speed rail service, or more specifically whether forecast revenues are sufficient to cover operating costs plus repay some or all of the system's initial capital costs. A key factor to be considered in this analysis is how the project may be structured financially. Specifically, should the capital costs and monetary and revenue risks of the high speed rail system be entirely government or publicly financed, or should its cost and monetary and revenue risks be shared partly by government and partly by the private sector.

SNC Lavalin Capital[41] carried out the financial analysis looking at both the CPR and Greenfield Electric alternatives in terms of both a totally publicly funded financial structure and a shared financial structure involving both public and private sector funding. The following general assumptions were applied to this analysis for both financing options:

- Ridership/revenue forecasts and capital and operating costs are derived from the analysis documented in Chapters 6, 7 and 8.
- All costs and revenues (i.e., tickets) are in constant 2004 dollars.
- Construction of the project and hence its first year is deemed to begin at the start of 2005.
- Although the assets will still be serviceable, the last year of the project is deemed to be the end of 2034 for modeling purposes.
- Inflation of 2 percent per year is applied on revenues, capital costs and operating expenses.
- The construction period for the CPR and Greenfield Electric alternatives is five and six years respectively.
- No replacement[42] or addition of rolling stock (i.e., locomotives and passenger cars) will be required during the 30-year "life of the project".

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[41] Disclaimer: The above analysis was performed based on the pre-feasibility study information supplied to SNC Lavalin Capital Inc. ("SL Capital"). No representation or warranty is made or implied, or will be made or implied, and no responsibility is accepted by SL Capital or any of their respective partners, parents, affiliates, related corporations, directors, officers, employees, shareholders, unit-holders, advisers, contractors, representatives and agents (collectively the "The Parties") as to the accuracy or completeness of the information contained in this report. Furthermore, no reports or documents at any time distributed, prepared or caused to be prepared by any of The Parties in connection with this project and nothing contained herein or therein is or should be relied upon as a promise or representation as to the future performance of this project.

None of The Parties accepts any liability, whether in contract, in tort (including negligence), at law or by statute or otherwise, to any Recipient, potential respondent or third party in relation to the information contained in this report. In particular, The Parties do not accept any liability whatsoever in relation to the accuracy of any estimates, forecasts, projections, conclusions or any other material contained or referred to in this report.

[42] The effective life of rail equipment is typically treated as 30 years, although 50-year old equipment is commonly in active use. In addition, sufficient money was included in the operating cost estimates to cover major refurbishment of the rolling stock at the 15 to 20 year mark, thus ensuring the maximum extension of useful life of this equipment.

This Chapter first looks at alternative ways to structure the high speed rail construction and operation, and then describes the outcomes of the financial analysis.

9.2 Alternative Project Structures

Traditionally, major public sector infrastructure projects, including road and rail projects, have been 100 percent publicly financed. However, this financing does not necessitate that construction and operations must also be carried out by government agencies. In fact, construction and construction management are almost exclusively tendered, and then carried out by private sector contractors, who carry the risk of construction implementation, including cost overruns and delay.

Private sector companies under contract to government entities also commonly carry out project design and engineering. Under these contracts, design risk is carried by the private sector. Furthermore, there are numerous examples of transportation maintenance and operations that are contracted to private sector companies, including school bus operations in most jurisdictions and the West Coast Express, Vancouver's commuter rail service operated and maintained under contract by CPR and VIA Rail respectively to name but two. Typically, these contracts specify expected operations and maintenance standards and performance often linked to financial incentives and/or penalties.

Increasingly in recent years, project design and engineering together with construction and procurement are also being assigned to the private sector through design-build contracts, thus transferring the risk associated with the interfaces between design, construction and procurement from government to the private sector. In addition, there are design-build-operate-maintain (DBOM) contracts that assign risk and responsibility for all four implementation functions from government to the private sector. One advantage of this packaged approach is the vested financial interest of the private sector to ensure not only cost effective design and construction but also efficient and cost effective operation and maintenance over the life of the project. Through fixed price contracts, government can transfer virtually all risk associated with design, construction and operational performance to the private sector. The sole exceptions are areas over which either government chooses to retain control or delegation of risk is impractical or impossible (i.e., legislative authority).

TYPICAL DIVISION OF RISKS BASED ON DBOM

	Private Sector	Public Sector
Design, build, completion	X	
Operations and maintenance	X	
Life cycle costs	X	X
Ridership/Revenue		X
Capital Costs and Financing		X
Approvals/legislation		X
Land acquisition/right of way		X
Competition		X
Change in law		X
Force majeure	X	X
Environmental	X	X

What is relatively new to North America (although extensive experience exists elsewhere in the world, especially in Great Britain and Australia) is the inclusion of private sector financing in major public infrastructure projects. The advantage of this arrangement is that the private sector pays part of the capital cost that is structured to be paid back in part or in full from revenues. With this arrangement, the private sector both reduces the project capital costs for government and shares in the revenue risk of the project. This option is particularly appealing where government is either financially constrained or unwilling to tie up the full amount of capital required, and private sector participation makes a publicly worthwhile project possible sooner than otherwise might be achievable.

The main challenge in attracting potential private sector investment and avoiding unnecessary cost premiums in so doing is to reduce uncertainty associated with forecast ridership and revenue risk particularly in the absence of historical data. Banks and financial institutions that support private sector investors typically seek to mitigate their lending risk by setting both their equity-to-loan ratio and interest rates according to perceived revenue risk. The rate of return on equity is also set according to revenue risk. Thus, the greater the revenue risk, the higher cost bid by the private sector investor.

9.3 Publicly Financed Option

This option is the traditional model that has been applied to the majority of major public infrastructure projects in North America. Under this option, all capital costs for high speed rail would be financed by non-taxable public sector entities, which could include local, provincial or federal government ministries or crown corporations, a special authority (e.g., like airport or port authorities) or a combination thereof[43].

Governments do not have a standard approach to funding capital projects. In some jurisdictions, capital funding is treated as a grant, which is advanced from the Treasury on a cash flow basis as needed. The cost of this capital (i.e., either its borrowing cost or opportunity cost, depending on the financial situation of government) is then absorbed as part of general government operating expenditures. Examples of this practice include all US federal transit and highway funding and Canadian federal infrastructure grants (e.g., the Richmond-Airport-Vancouver Rapid Transit project).

In other jurisdictions, the cost of capital is passed onto the project and included in its publicly stated budget. In such cases, interest is applied to funds advanced during construction (IDC) typically at short-term borrowing rates. Once construction is complete, the accumulated capital advanced during construction and applicable interest is “termed” or consolidated, and converted to long-term debt against which then prevailing long-term borrowing rates are applied. Debt service (interest and principal repayment) is then charged to the operation to recover these funds.

This latter approach has frequently been criticized for several reasons. First, it ignores tax revenues that government receives into general revenue from construction and operations

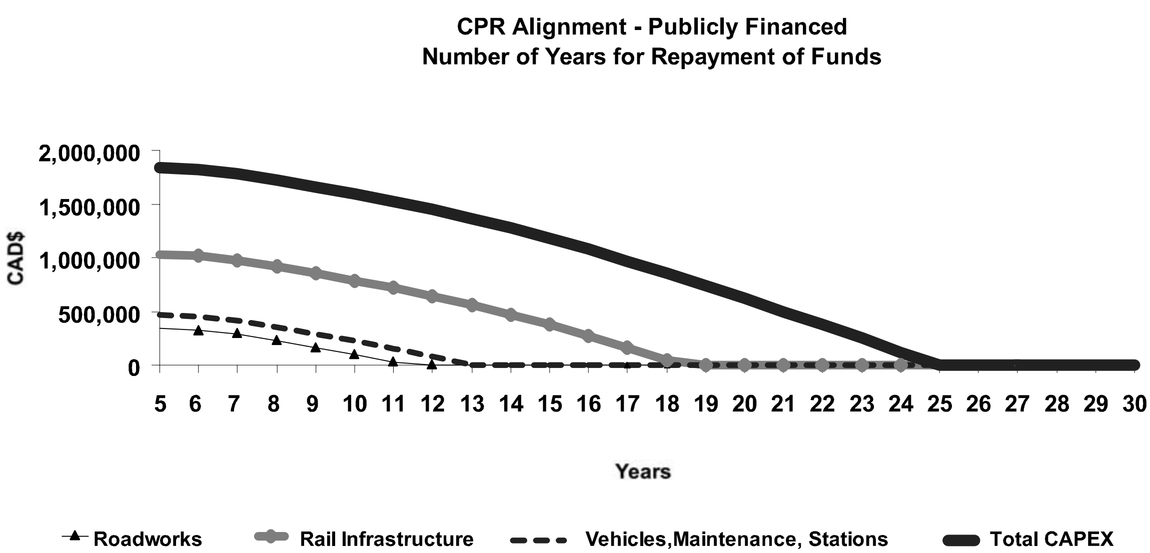
[43] There are many different options for the organizational and governance structure to oversee the construction and operation of high speed rail. The choice of the most appropriate structure, however, will depend on many factors, including the financing option that is ultimately selected.

employment and expenditures that reduce or offset their capital outlay. It also ignores the value of social, environmental and economic development benefits that are derived from the project. Second, if interest rates go up during construction, it can result in reductions in project scope or quality to absorb these increases and maintain budget that can negatively affect ridership/revenue and/or operating costs over the life of the project. Third, debt service can overburden the operation of the system, forcing a portion or all of the debt to be "forgiven" by government (e.g., post-operation provincial "grants" for Vancouver's SkyTrain system) or reduced operating expenditures, which, again, can negatively affect ridership/revenue and/or operating costs over the life of the project.

For the purpose of this study, it has been assumed that government funding would be advanced on a grant basis as necessary based on project cash flow requirements conceptually outlined in Section 6.3 of this report. As a consequence, no interest charges are applied to any funding advanced during construction or on debt.

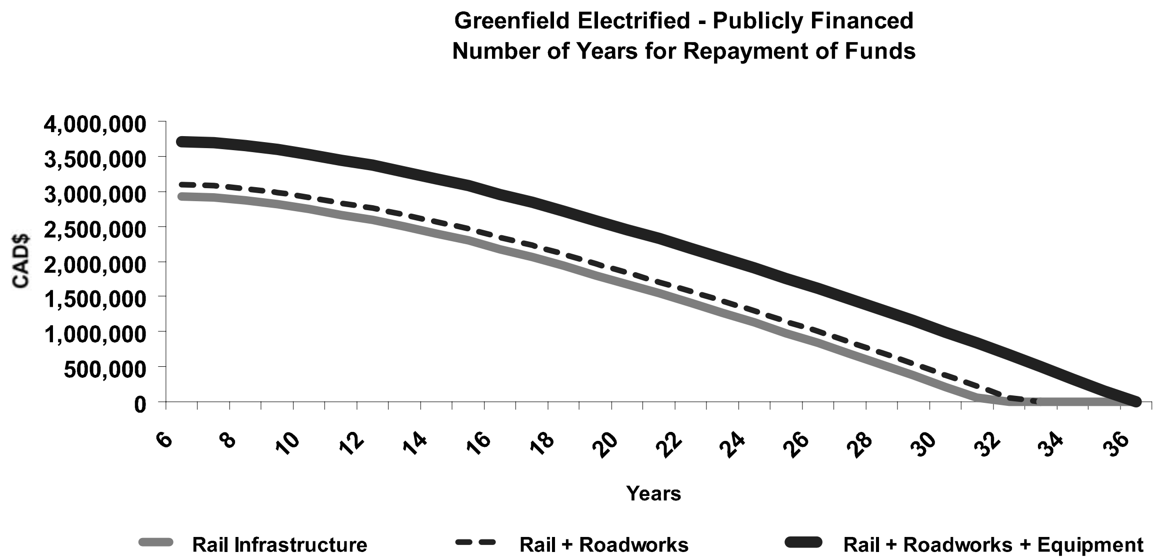
Based on these assumptions, all income after expenses (earnings before interest, taxes, depreciation and amortization) would be available for repayment of the initial capital invested in the system and returned to the public funding entities. On this basis, the analysis of the project concludes that the system is able to generate sufficient revenues to cover all operating costs from first year of operation in the case of both alternatives (2010 for the CPR alternative and 2011 for the Greenfield Electric). In addition, residual income after expenses is available to repay the initial capital cost of the system.

This residual income results in total repayment of all capital costs ($1,835 million)[44] by year 2031 for the CPR alternative as illustrated in the figure below. Furthermore, the system generates an additional $669 million over its 30-year life that could be either be considered as a dividend to the public funding agencies or applied toward future capital replacement and upgrades.



[44] Chapter 6 cites the capital cost for the CPR alternative as $1,711 million. The difference between that figure and $1,835 million quoted above is due to inflation during construction.

In the case of the Greenfield Electric alternative, 73 percent or $2,712 million of the system's initial $3,708 million[45] capital cost is repaid over the 30-year "project life". Complete repayment would require another six years approximately based on no change in the assumptions applied for the 30-year analysis period.



9.4 Shared Public-Private Financing Option

For this option, it was assumed that the private sector would pay for all rolling stock and other miscellaneous costs, such as for ticket vending machines, communications equipment, etc., and government would pay for all infrastructure costs, including rail infrastructure, roadworks, stations and maintenance facilities. For the purpose of this study, capital costs provided by the private sector would be financed through a combination of debt and equity contributions, whereas the government portion of capital costs would be treated as a "grant" for consistency with the 100 percent publicly financed option.

On this basis, the private sector would fund $447 million of the $1,918 million[46] total cost for the CPR alternative and $526 million of the $3,808 million[47] total cost for the Greenfield Electric alternative. The private sector would also share risk and responsibility for any negative cash flow in the initial years of operation as a result of unforeseen increases in operating costs or decreases in ridership.

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[45] As above, the difference between capital cost for the Greenfield Electric alternative quoted in Chapter 6 of $3,413 million and the figure quoted above of $3,708 million is due to inflation during construction.
[46] The difference between the total project cost under the 100% publicly financed option of $1,835 million and $1,918 million under this option reflects interest and return on equity costs on the privately financed component of the project.
[47] The same reasons as above apply explaining the difference between the total project cost under the 100% publicly financed option of $3,708.

It was also assumed that ridership and revenue risk would be shared between the private and public sector such that the debt equity ratio, interest rates and return rate on equity for the private sector investor would be most favourable. The private sector would be able to take advantage of depreciation and capital cost allowances but would also be subject to corporate taxes on their equity return.

As a result, the following additional assumptions were applied to the analysis:

- A debt equity ratio of 60:40
- Interest rate of 7.2 percent over a 28-year term is applied to private sector debt.
- A target of 13 percent is set for internal rate of return on equity.
- Residual income after debt service and equity return is consigned as a rental payment to the public sector to repay the public sector's capital cost contribution.

Based on these assumptions, the financial analysis concluded that under the shared public-private financing option, in addition to the rolling stock, etc., approximately 21 percent or $315 million of the $1,471 publicly funded capital cost of the CPR alternative would be repaid through rental payments. However, if federal and provincial taxes paid by the private sector[48] are also considered "repayments" to government, this figure increases to 55 percent or $815 million of the publicly funded capital cost. For the Greenfield Electric alternative, approximately 5 percent or $167 million of the $3,282 million publicly funded capital cost would be repaid through rental payments, increasing to 23 percent or $752 million if federal and provincial taxes paid are considered "repayments" to government.

[48] Taxes paid here refers to taxable income generated at the private sector project company level. These do not include taxes paid on employment income or expenditures and sales revenues which are discussed in Chapter 10.

9.5 Overall Summary and Comparison of Results

The following table summarizes the results of the financial analysis.

Financial Modeling Summary for the Calgary Edmonton High Speed Rail Link (30-Years)

$M	**Publicly Financed**		**Shared Public -Private**	
	CPR Alignment	**Greenfield TGV Electrified**	**CPR Alignment**	**Greenfield TGV Electrified**
Revenues	5,306	6,202	5,306	6,202
Operating costs	-2,802	-3,490	-2,802	-3,490
Rental Payments	0	0	-315	-167
EBITDA	2,504	2,712	2,189	2,545
Interest expense*	0	0	-351	-397
Federal taxes	0	0	-329	-385
Provincial taxes	0	0	-171	-200
Cash flow from operations	2,504	2,712	1,338	1,563
Project Costs				
Capital costs	1,835	3,708	1,835	3,708
IDC & Financing costs*	0	0	83	100
Total project costs	**1,835**	**3,708**	**1,918**	**3,808**
Private sector funding	0	0	447	526
Public sector funding	1,835	3,708	1,471	3,282
% of public funding repaid:				
- without including taxes	100%	73%	21%	5%
- including taxes	100%	73%	55%	23%

*Only calculated on Private Sector Debt

The main reasons for the difference in the amounts repaid to the public sector between the publicly-financed and shared public-private financing options are the cost of interest, financing costs and the return on equity applied to the latter option. As a result, $656 million of publicly funded capital costs would remain un-repaid for the CPR alternative at the end of the project under the shared financing option, as compared to complete repayment plus a $669 million dividend to the public investor under the publicly financed option assuming funds are advanced on a “grant” basis. For the Greenfield Electric alternative, $2,530 million would remain un-repaid under the shared financing option as compared to $996 million left outstanding under the publicly financed option. However, the advantage of this option for the public sector is the shared risk on revenue and a reduced upfront capital requirement.

Based on this analysis, it would appear that high speed rail system is financially viable as it is able to cover all its operating costs under any scenario. With the publicly financed option, the CPR alternative also repays the upfront capital required from government on a "grant" basis over a 30-year period with a considerable margin to spare as it yields a dividend or surplus of $669 million. The Greenfield Non-Electric comes close to repaying all of its capital costs over the 30-year period based on a publicly funded option but falls slightly short of this goal. In all other scenarios, the 23 to 55 percent of publicly funded capital costs are recouped if both rental payments and taxes paid are considered over 30 years. While these results have not factored in the cost of capital on government funding, neither have they taken into account tax revenues which government will receive from construction and operations employment and expenditures that will be dealt with in Chapter 10.

SOCIO-ECONOMIC BENEFITS

10.1 Introduction

The report to this point has focused on developing the high speed rail system concept and analysing the fundamentals of the system, including capital cost, ridership and revenue projections and operating costs. Chapter 9 brought all these elements together and analysed the financial viability of the system, confirming that projected revenues can cover all operating costs and completely or partly repay the system's capital cost depending on which high speed rail alternative and financing option are chosen.

Regardless of these choices, implementation of high speed rail requires a very large upfront capital investment of public funds for which there are undoubtedly many competing demands. For this reason, it is important not only to address the financial viability of the system but the social, economic and environmental benefits that high speed rail can bring to Alberta; more specifically, how high speed rail could change the social and economic environment of the corridor as it exists today and, especially, how it could reshape social and development patterns and the economy in the future to Alberta's betterment.

This Chapter draws on three sources – a socio-economic assessment carried out by Colledge Transportation Consulting, Economic Development Research Group and DRE Transportation Solutions; additional information supplementing and corroborating this work based on socio-economic quantification measures developed by the Canadian Institute for Tourism Research and EarthTech for VIA Rail; and, commentary and analysis by Dr. Alain Verbeke, holder of the McCaig Chair in Management at the Haskayne School of Business at the University of Calgary.

This Chapter describes the social, economic and environmental benefits associated with the high speed rail alternatives, including ridership, capital cost and operating costs described previously in this report. Wherever possible, these benefits have been quantified but, in some instances, data or information is lacking to permit quantification and benefits are addressed in qualitative terms.

10.2 User Benefits

User benefits are fundamental to justifying any transportation investment and intuitively underlie the decisions that consumers make to use the service. The two primary quantifiable user benefits associated with high speed rail are travel time and cost savings relative to existing transportation modes. Other benefits, including less stress for car drivers, more space and comfort, more productive use of time and improved travel reliability, particularly in winter, have not been quantified as specific research on these factors is needed, which can only be meaningfully carried out after the service is in operation. Nevertheless, these concerns factor into customer decisions to use the service and result in positive benefits to system users that should not be overlooked.

10.2.1 Travel Time Savings

Given the multitude of origins and destinations associated with both current travellers and forecast riders, travel time savings can only be approximated at this stage of analysis without either very complex transportation modeling or post-operation before-and-after surveys of users, both of which were beyond the scope of this study. For the purpose of this study, a simplified approach was taken to calculate travel time savings.

Travel time savings were calculated based on the following categories:

- Calgary-Edmonton[49] and Red Deer-Calgary/Edmonton riders;
- Business and Non-Business riders; and,
- Time savings relative to use of car, air and bus by diverted passengers.

Travel time savings were estimated looking at door-to-door travel time based on assumptions about average access and egress time for all modes and in-terminal and waiting time for air, bus and high speed rail in addition to en-route travel time. For example, car travel time between Calgary and Edmonton was estimated to be on average 180 minutes of driving time (assuming a speed of 100 km per hour) plus 15 minutes of total access/egress time allowing for the driver to get to their vehicle, find parking and walk to their destination or both. While some drivers may travel faster and make this trip in less time, others may have to stop for gas, be delayed by traffic or simply travel more slowly. Regardless, the key issue is the comparative difference between car and high speed rail travel time that has been calculated with the same kind of logic and assumptions. The following table outlines the average door-to-door travel times estimated for each mode.

ESTIMATED DOOR-TO-DOOR TRAVEL TIMES (MINUTES)					
Calgary-Edmonton	**Car**	**Air[1]**	**Bus**	**CPR HSR**	**Greenfield Electric HSR**
In-Vehicle	180	55	200	130	97
Access/Egress	15	75	30	30	30
In-Terminal	0	65	15	15	15
Total	**195**	**195**	**245**	**175**	**142**
Red Deer					
In-Vehicle	90	N/A	90	65	48
Access/Egress	15	N/A	15	15	15
In-Terminal	0	N/A	15	15	15
Total	**105**	**N/A**	**120**	**95**	**78**

[1] Assumes flights between Calgary International and Edmonton International Airports.

[49] Time savings for travellers using the two suburban stations in Calgary and Edmonton were assumed to equal those using the downtown stations.

Based on the above, the CPR alternative offers a 20 minute or 10 percent travel time saving relative to both car and air travel and 70-minute or 29 percent travel time saving compared with bus travel between Calgary and Edmonton. With the Greenfield Electric alternative, travel time savings increase to 53 minutes or 27 percent compared with car and air travel, and 103 minutes or 42 percent compared to bus travel. These estimates, however, are most likely conservative as high speed rail users are more likely to comprise individuals whose origin and/or destination are close to the stations, issues that are factored into the ridership modeling from the market research but generalized in the above estimate. Furthermore, they are based on current estimates of comparative door-to-door travel time, whereas future in-vehicle travel time required for both car and bus are likely to increase due to growing congestion while high speed rail will remain the same.

The value of time for business travellers is based on the June 2004 average wage for adults age 25 to 54 in Alberta of $20.58[50] plus 25 percent for benefits to reflect the total cost to employers. The value of time for non-business travellers used is approximately 50 percent of the June 2004 average wage without benefits.[51]

Based on these assumptions, the net present value[52] (NPV) of travel time savings associated with the CPR alternative are $317 million, and with the Greenfield Electric are $332 million over the 30-year life of the project. While some might discount the monetary value of non-business travel as being theoretical, business traveller time savings are very tangible and make up more than three-quarters of this benefit.

10.3 Travel Cost Savings

Unlike travel time savings, cost savings resulting from using high speed rail instead of other existing modes are relatively straightforward to calculate. Whether for business or non-business travel, cost savings represent the net difference between the current cost of travel by other modes and the cost of high speed rail. However, while air and bus fares are published, car costs again require estimation.

Albertans spend $8,828 per year (2001) or 13 percent of their total household budget on transportation.[53] Some 90 percent of this is spending on private vehicles (based on national estimates). The average number of vehicles per family is 1.66 and the average distance traveled is 18,900 km per year, resulting in an average vehicle operating cost of 25 cents per km. By comparison, the Canadian Automobile Association reports the 2003 average operating cost to be 14 cents per km based solely on variable operating costs, and 42 cents per km based on total ownership costs, with these costs varying according to type of vehicle. The latter figure of 42 cents per km also reflects the mileage cost commonly accepted by government and many businesses for reimbursement of their employees.

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[50] Statistics Canada, *Labour Survey*, June 2004.

[51] 50% represents a blended rate to reflect a mix of drivers and passengers for which the US Federal Highway Administration requirements specify 60% of average wage without benefits for drivers and 45% for passengers. Transportation Research Board, *Guidebook for Assessing Social and Economic Effects of Transportation Projects*, 2001.

[52] All Net present value calculations are based on a 6 percent discount rate.

[53] Statistics Canada, *Market Research Handbook,* 2003 Edition.

Perceived vehicle operating cost and its effect on travel choice tends to differ for business and non-business travel. For non-business travel, the choice of car or rail is strongly influenced by out-of-pocket or variable costs made up principally of fuel cost. As a result, the low end cost of 14 cents per km was adopted for non-business travellers, and the high end cost of 42 cents per km was used for business travellers.

ONE-WAY TRAVEL COSTS (including access/egress cost)[1]

Calgary-Edmonton	Car	Air[2]	Bus[3]	CPR HSR	Greenfield Electric HSR
Business	$126	$210	$63	$67.50	$67.50
Non-Business	$42	$172.50	$47	$48.50	$48.50
Red Deer – Calgary/Edmonton					
Business	$63	N/A	$47	$45	$45
Non-Business	$21	N/A	$31	$35	$35

1 Access/egress cost for business travel by air is assumed to be $75 by bus and HSR $10. For non-business travel, access/egress cost are assumed to be zero for bus and rail and half the cost of business for air on the premise that travellers will for the most part be dropped off or picked up by friends or family, or share costs with other travel companions and they will be negligible.
2 Assumes flights between Calgary International and Edmonton International Airports.
3 Business bus fare is based on Red Arrow's business-oriented service fare and non-business is based on Greyhound's fare.

Based on these assumptions, the net present value of travel cost savings associated with the CPR alternative is between $603 million and $1,128 million depending on assumed car occupancy[54]. With the Greenfield Electric alternative, the net present value of travel cost savings is between $756 million and $1,258 million over the 30-year life of the project.

10.4 Economic Development

Judging from high speed rail experience elsewhere in the world, its introduction to the Calgary–Edmonton corridor has the potential to fundamentally change the level and types of economic activities that occur within the region. By reducing travel time and cost, high speed rail would effectively shrink the distance between Calgary, Red Deer and Edmonton, thus integrating distinct markets and helping to create a more unified economic region[55]. It would also add transportation choice and promote competitive pricing for travel in the region, while improving the efficiency of the overall transportation network. In turn, these changes would lead to shifts in business and residential location, development patterns and improvements to quality of life.

Reduced travel time for existing businesses increases their access to labor, customer and supplier markets. This can both reduce business costs and enhance business efficiency by providing

[54] The low end assumes average car occupancy of 1.25 persons per vehicle. However, high speed rail users are more likely to otherwise be single car occupants. As a result, cost savings would tend to be at the high end.
[55] Studies on the recently opened high speed rail line in Korea that this change in perception was profound and has had a strong impact on businesses.

access to larger numbers of workers as well as better access to suppliers of materials and services. By enhancing access and interchange with the region's international airports, high speed rail offers opportunities to rationalize air services and develop partnerships with airlines that could lead to lower air operating costs[56] and expansion of the overall range of flight destinations from the region as well as improved access for international visitors. Reduced travel time for residents would also increase access to job opportunities as well as choices of where to live and lifestyle and expand options for shopping, services and tourism.

More importantly, these fundamental changes can re-shape the region's future development and, either by themselves or in concert with economic development strategies and marketing, elevate the region's attractiveness to more people and new types and scales of businesses in the future. These changes would allow Alberta to build on its existing competitive advantages, and could catapult it to the "next level" where the region is, or is seen to be fundamentally different and move it up a level in terms of its attractiveness to both people and business.

HIGH SPEED RAIL'S POTENTIAL ROLE IN CREATING A MORE INTEGRATED, DYNAMIC ECONOMIC REGION

STAGE 1 – SHORT TO MEDIUM TERM CHANGES

- **Reduce travel times** and the costs of economic interactions in the region.
- **Shift business location patterns**, area economic specialization and demands on infrastructure.
- **Change perceived quality of life** for those who work and reside in the region and offer an attractive location for firms considering investments in the region.

STAGE 2 – FUNDAMENTAL STRUCTURAL CHANGES

- **Reshape development patterns**.
- **Attract more people and new types and scales of businesses**

10.4.1 Short to Medium Term Business Attraction

Investment in a high speed rail system in Alberta in both the short and long term is likely to have two primary consequences:

- External attraction - business growth and attraction to Alberta, relative to the rest of Canada, may be enhanced with the result that high speed rail draws business activity to the region that might have otherwise located outside Alberta.

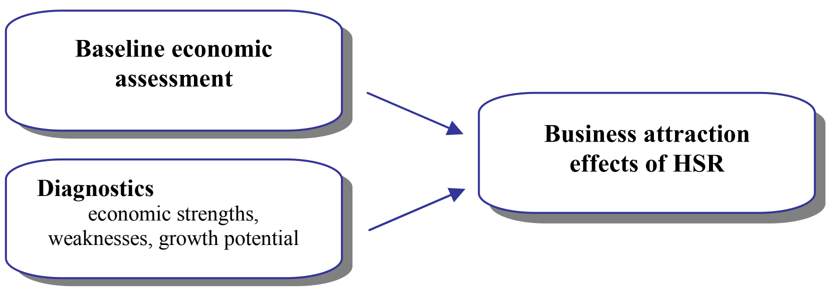
[56] This has been the case in France with the Paris-Lyon-Marseilles TGV line where airlines such as Continental now other joint travel packages with SCNF rail operator. Similarly, Virgin Airlines are a proposed operating partner in the Florida high speed rail project.

- Intra-provincial (distributional) - the specific location of business growth and attraction within the high speed rail corridor (e.g., affects the location of new businesses in Red Deer, Calgary or Edmonton) may change as a result of the new service.

The short to medium term economic growth effects of high speed rail were modeled using a business attraction model. The model captures the effects of changes in travel times and travel costs on current businesses, and assesses corresponding effects on business attraction. The model contains economic profiles, trends and growth projections for more than 80 industries, and evaluates each industry for economic performance gaps and thus potential for local business attraction by rating local area advantages and disadvantages.

Advantages and disadvantages are defined in terms of 1) costs of labour, materials, utilities, transportation and taxes; 2) size and characteristics of the local workforce; and, access time and costs for highway, air and rail transport, as well as the sensitivity of each industry to these factors. In addition, the model evaluates the effects of high speed rail on the size of the labour, product and final markets that can be accessed from local sites and then calculates the likely business attraction effects of high speed rail.

HSR Business Attraction Model



However, the model does not address long term structural changes to the region, including changes to development patterns, resident and business behaviour and business cost base, as well as efficiencies and rationalization in transportation and their effects on business attraction. Nor does it address other effects such as enhanced competitive image or changed perceptions about the province. These long term or secondary effects are dealt with separately later in this Chapter.

External Business Attraction Effects

The business attraction model estimates that an additional 1,600 jobs would be drawn to the region in the short to medium term based on the CPR alternative, and up to 2,600 jobs with the Greenfield Electric alternative. The corresponding growth in employment income is estimated to be $49 million per year for the CPR alternative, and $73 million per year for the Greenfield Electric alternative.

Assuming that some lag may occur before business reacts to high speed rail implementation, a ramp-up period comparable to that for system ridership was assumed. On this basis, the net present value of incremental employment over the 30-year life of the project is estimated to be $619 million with the CPR alternative and $922 million with the Greenfield Electric alternative. Please note that these jobs do not include direct, indirect or induced employment resulting from construction or operation of high speed rail, which are identified separately later in this Chapter under Financial Benefits.

Intra-provincial Business Attraction Effects

In the short to medium term, high speed rail is likely to result in strong business attraction to Red Deer, as firms wishing to serve the Calgary and/or Edmonton markets or take advantage of their skilled labour pools will be able to do so more easily from Red Deer. As the smallest of the affected cities, Red Deer will have better linkages to two cities with populations about seven times larger than its own. For Calgary and Edmonton, however, the linkage with Red Deer would increase their effective market sizes by 15 percent at present. Thus, Red Deer also experiences a far larger increase in access to new markets, an advantage magnified by its strong cost advantage in two important input factors, labour and land. Furthermore, Red Deer would also benefit from the introduction of a non-highway linkage as it does not currently have an international airport. Its linkage to both Calgary and Edmonton International Airports would be substantially improved with high speed rail.

The modeling results suggest that the introduction of high speed rail would initially shift about 1,500 jobs to Red Deer based on the CPR alternative, and about 2,600 jobs based on the Greenfield Electric alternative. In both cases, about half of these jobs would be re-distributed from Calgary and Edmonton. However, the intra-provincial shift in immediate new business attraction towards Red Deer could be larger if labour market interactions between Red Deer and Calgary and Edmonton are high, either through high levels of actual commuting between those cities, or through improved access by Red Deer firms to skilled labour in Edmonton and Calgary and vice versa.

NET EXTERNAL & INTRA-PROVINCIAL BUSINESS ATTRACTION SUMMARY

	Calgary	**Red Deer**	**Edmonton**
Estimated 10-yr employment growth **without HSR**	203,700	26,500	173,000
▸ External business attraction effect:			
- CPR alternative	835	109	709
- Greenfield Electric alternative	1,307	170	1,109
▸ Intra-provincial attraction shift:			
- CPR alternative	-589	1,508	- 919
- Greenfield Electric alternative	-779	2,025	-1,246
Annual employment growth			
- without HSR	2.70%	2.70%	2.70%
- **CPR alternative**	**2.70%**	**2.85%**	**2.70%**
- **Greenfield Electric alternative**	**2.71%**	**2.90%**	**2.70%**

However, this attraction to Red Deer is not expected to result in net employment loss to Calgary or Edmonton. Based on current trends in employment growth, the combined increase in jobs in Red Deer, Calgary, and Edmonton is expected to be about 400,000 within the next ten years. With the CPR alternative, Red Deer's annual employment growth rate increases by 0.2% (from 2.70% to 2.90%) while it stays the same for Calgary and Edmonton (2.70%).

In other words, Red Deer will tend to attract businesses seeking to take advantage of its lower cost base and improved accessibility, while Calgary and Edmonton continue to attract new business that require city amenities and proximity to other like businesses. The result would be tempered demand in Edmonton and Calgary for industrial and commercial real estate, municipal infrastructure, and workers. By slowing price pressures in land and labour in Calgary and Edmonton, the overall attractiveness of the cities for business investment and expansion will be increased, in turn encouraging other businesses to expand or locate there.

10.4.2 "Second Stage" Effects of High Speed Rail

The short to medium term shifts in business attraction would also set in motion longer term effects, including economic complementarity and changed perception of Alberta in the international business community that could influence the future economic growth trajectories of Calgary, Edmonton and Red Deer.

Calgary-Edmonton Complementarity

Historically, Calgary and Edmonton have been highly complementary cities. In the oil and gas sector, for example, they developed different complementary roles with Calgary as the location of corporate headquarters and Edmonton as the operations centre. In the 1980s, the corresponding rate of travel between the two cities was believed to be as high as any city pair in North America[57].

Over the years, the relationship between Edmonton and Calgary has evolved as the business community has grown and become more sophisticated. In the 1970s and early 1980s business was heavily focused on development opportunities within the province. This resulted in significant regional travel and contributed to Pacific Western Airline's highly successful Airbus service between Edmonton and Calgary.

Throughout the late 1980s and into the present, global trade in products and services increased in importance to the Alberta business community. The emerging focus on export markets outside of the corridor made regional travel relatively less important than long-haul inter-regional travel. At the same time, policy decisions decreased Edmonton's share of provincial government employment and new communication technologies emerged. As a consequence of these changes, the demand for transportation between Edmonton and Calgary may have diminished relative to the level of business activity in the province.

Calgary and Edmonton will continue to depend on each other because of shared interests in the future development of the energy sector. The future importance of northern energy also implies greater interaction between Edmonton and northern cities such as Fort McMurray. The TD Bank

[57] Alberta Transportation.

Economics group recently observed that cities in general are responding to global forces by building strong relationships with each other and suggested that communities in the Calgary-Edmonton corridor are becoming more "economically intertwined as flows of trade and labour move freely within the region."[58]

Another important consideration is the size of the cities. When Calgary and Edmonton were smaller, neither could fully support all of the functions of industry. This produced a certain degree of specialization as each city shared/traded services and resources. As the cities grew, they were able to support a wider range of activities and reach internal economies of scale. As a result, they became less specialized and less dependent on the other. High speed rail could catapult the region to the "next level" by transforming it from a region with two major centres of one million population each to a more cohesive regional economy possessing a greater critical mass that is seen as an integrated unit of 2 to 3 million population, and whether this will positively influence international companies seeking these attributes.

Competitive Image

Local economic development officials in the region emphasize that high speed rail could help Alberta achieve greater status and attention as a competitive, ultra-modern business region. This would act as a catalyst for economic growth and development, create new employment opportunities and help attract greater international investment to the province. It would also reshape development and growth.

By changing the perception of the region to a single integrated economic unit, economic development officials will be able to "sell" the region internationally as a unified metropolitan market of three million persons, instead of two separate cities of one million people, or in the case of Red Deer 72,700 people.

The second effect would be to change the economic development model used in the region from a competitive one in which Calgary, Edmonton, and Red Deer each separately recruit businesses, to a cooperative one, where the three cities jointly promote the whole region. Although local development officials report that such cooperation has already begun, implementation of high speed rail could accelerate and intensify the process, thereby maximizing the efficacy of economic development resources and making the region more attractive to outside firms and people.

Although it is not possible to translate these types of impacts into job estimates, these benefits could be significant future generators of employment in the corridor, perhaps meeting or exceeding the estimated employment impacts suggested previously in Section 10.4.1.

10.5 Property Values

Changes in property values reflect shifts in demand for residential or commercial properties relative to their available supply. Generally, high speed rail does not lead to change in region-wide housing or commercial land/building demand and increased prices but rather to localized impacts, including

[58] TD Bank Economics, *The Calgary-Edmonton Corridor,* Special Report, April 2003.

new and higher density development around station locations, which in turn tends to increase property values in those areas. General evidence from Europe, Japan and the US suggests that:

- Where high speed rail stations are located at existing intercity rail stations in the built-up downtown areas, they tend to stimulate little or no new development and hence have no significant impact on land/building values. However, if a new rail station is developed, land/building values around the site will benefit from the increased traffic flow.

- Where new high speed rail stations are constructed at urban fringe locations, providing major improvement in access to downtown or airport areas, new commercial and mixed-use development (and hence change in land/building values) is often stimulated in surrounding areas.

- Where a new high speed rail station is constructed at a medium-size community located along the route between larger cities, there can also be significant new commercial office development and hence increases in land values. This depends largely on the relative magnitude of changes in access times, volumes of additional riders passing through the area, and the nature of surrounding land use and buildings at that location.

- Increased attraction of business and population to a medium-size community located along the route between larger cities as a result of its improved accessibility can also lead to increased demand for commercial, retail and residential development with corresponding increases in land values. Initially, much of this will depend on the value of property in the mid-sized city being lower than similar properties in the large cities so as to offset transportation costs. However, once the economy of the mid-sized centre grows and becomes increasingly self-sustaining rather than a commuter shed this differential value becomes less important.

In this context, we would expect to see relatively small increases in land development and property values at the downtown Edmonton and Calgary stations, but larger potential for increases at the South Edmonton and Calgary airport locations, as well as in Red Deer, although that will depend on the specific location for that station and surrounding land availability. Red Deer should also benefit from higher demand for business locations and housing.

Unfortunately, quantifying land value increases is not possible at this stage of investigation in part because detailed station location studies have not been undertaken to determine the precise station locations, and in part due to lack of precise information on additional demand for residential, commercial and industrial land.

10.6 Transportation Network Optimization

The introduction of high speed rail into the Calgary-Edmonton corridor would add another transportation option for travellers, thus diversifying the transportation network and creating more competition within this market. The benefits to high speed rail users have already been addressed. However, the effects of introducing high speed rail on other elements of the transportation system also require attention. Potential benefits include easing of road congestion and the possible deferral of highway infrastructure investment, improved inter-modal connectivity, and improved reliability and efficiency for rail freight operations as a result of track upgrades, particularly in the case of the CPR alternative.

10.6.1 Road Congestion and Highway Infrastructure

By diverting some travellers from cars, including those now driving to the airports, and shifting future growth towards Red Deer, high speed rail would reduce the demand on existing roads. As a result, it may ease congestion, particularly on some of the main access routes to Calgary and Edmonton. In so doing, it may improve traffic flow and delay the need for infrastructure expansion and investment. All three cities are expected to experience high employment and population growth in the future, which means that any relief provided by high speed rail will increase in value over time.

Unfortunately, it is impossible to quantify the longer term effect of high speed rail's role in shifting growth and development patterns on traffic congestion due to the many other parameters and resulting dynamic changes that affect travel. Similarly, the immediate effect of diverting car trips to high speed rail cannot be quantified without complex and detailed traffic modeling, which was beyond the scope of this study. However, a rough assessment of potential immediate benefits can be provided, although these are likely to be relatively small compared to the longer term effect.

Based on the ridership estimates, an estimated 0.9 to 1.2 million Calgary-Edmonton passenger-trips, depending on the high speed rail alternative, would have been diverted from cars if it had been in operation in 2003. This represents about 18 to 21percent of the origin-destination car passenger trips between Calgary and Edmonton.[59] To this figure, another 0.3 million Red Deer to Calgary/Edmonton car passenger-trips and 0.2 million car passenger-trips to the airports by diverted air passengers can be added, bringing the total to 1.3 to 1.5 million[60] fewer car passenger-trips on the approaches to Calgary and Edmonton last year, and 1.1 to 1.3 million fewer car passenger-trips in the mid-section of Highway 2 (i.e. beyond the airports).

HSR VEHICLE REDUCTION ON APPROACHES TO CALGARY/EDMONTON (2003)

	CPR Alternative	Greenfield Electric
HSR Annual Passengers:		
Calg-Edm – from cars	934,000	1,251,000
Calg-Edm – from air	186,000	224,000
Red Deer to Calg/Edm – from cars[1]	164,000	164,000
Total Passengers Diverted from approaches to Calgary & Edmonton	1,284,000	1,639,000
Annual Vehicle Reduction @ Avg. 1.25 persons/vehicle	1,027,000	1,311,000
Weekday Vehicle Reduction (divided by 300 days) rounded	3,500 VPD	4,000 VPD

[1] One-half of total diverted car passengers.

[59] Source: Ipsos-Reid Market Research Survey, *HSR Pre-Feasibility Study*.
[60] 50% of Red Deer trips to each city is assumed.

Based on an assumed vehicle occupancy of 1.25 persons per vehicle[61], the reduction in road traffic would be about 1.0 to 1.2 million vehicle-trips a year, or 2,800 to 3,200 vehicles/day (VPD) near Calgary and Edmonton (2,400 to 2,800 vehicles/day in the mid section). By comparison, the Highway 2 traffic volume ranges from a low of about 18,000 VPD at Morningside (just north of Red Deer) to about 50,000 VPD near the Calgary and Edmonton city boundaries.[62] Therefore, the VPD reduction due to the introduction of high speed rail represents about 6 to 16 percent of the average total daily traffic on Highway 2, depending on location. Assuming that high speed rail use is skewed to weekdays, the trip reduction could be about 3,500 to 4,000 VPD (1.0 -1.2 million/300 days per year), or 7 to 24 percent of the average weekday traffic volume again depending on location.

The benefit of this reduction in terms of congestion relief and the degree to which this relief is felt depends on several location-specific factors, including road configuration, current congestion (level of service), local traffic patterns, time of travel and the concentration of diverted high speed traffic. Benefits will be felt most at choke points in the road system or where traffic flow is poor, and where all of the high speed rail traffic reductions combine. Conversely, where traffic is free flowing, and traffic diverted to high speed rail is dispersed through the city streets and mixed with local traffic, the effect of the diverted traffic will be minimal.

A recent review of the Highway 2 corridor between Calgary and Edmonton for the Alberta Ministry of Transportation assessed the corridor as follows:

"High traffic volumes and related congestion (level of service C and D) are currently prevalent during peak periods in the Deerfoot Trail section of the corridor. Over the longer term, with continued growth forecast and no new alternate routes planned for implementation in the foreseeable future (within 10 years), the level of service provided on this facility will continue to degrade.

The suburban sections of the corridor (e.g. Airdrie to Calgary and Leduc to Edmonton, Anthony Henday Drive) currently experience limited congestion in peak hours. This congestion is likely to increase over the longer term as volumes continue to increase. The majority of the Highway 2 corridor is rural in nature and carries relatively light traffic volumes. Congestion is not prevalent during peak hours." [63]

On this basis, the primary area of benefit from high speed rail would be during peak hours in the Deerfoot Trail section of the corridor and choke points on access routes to Highway 2 in Calgary and Edmonton, and to a lesser extent, the suburban sections between Airdrie and Calgary, and between Leduc and Edmonton. Assuming 60% of the 3,500 to 4,000 diverted trips are in the predominant direction and 20% of these trips occur in the peak hour, some 500 vehicles/hour

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[61] Average vehicle occupancy in Alberta ranges from 1.25 to 1.75 persons/vehicle.[61] However, as those passengers diverted to rail would likely be from lower occupancy vehicles.

[62] Source: Alberta Transportation vehicle classification, travel and statistics report, 2003.

[63] Delcan Corporation, ATIS and ATMS Blueprint for Highway 2 between Edmonton and Calgary, Alberta Transportation, October 2003.

would be removed from the system during the peak[64]. While seemingly a small number relative to the overall traffic volume, this reduction would have a noticeable effect by improving those sections of the highway and urban access roads and choke points operating with unstable flows (level D through F) to stable flows (level C).

The following table summarizes the current peak hour traffic levels on these key congested links on the Deerfoot Trail section of Highway 2 and impact that a 500 vehicle reduction would have on traffic flow in the peak hour.

IMPACT OF HSR ON DEERFOOT TRAIL CONGESTION

	Pk Hr Vehicles	**Adj. Pk Hr Vehicles[1]**	**Current Level of Service[65]**	**% reduction by 500 vehicles**	**Impact of 500 vehicle reduction on Level of Service**
Hwy 2					
N of Memorial	7088	7592	D	7%	C
N of 16th	6779	7288	D	7%	C
N of 32nd	5761	6216	C	9%	B
N of McKnight	5381	5785	C	9%	B
N of 64th	5215	5600	C	10%	C
N of Beddington	2994	3281	B	17%	A
N of Country Hills	2609	2846	B	20%	B

[1] Trucks are counted as two passenger vehicles.

Within the main access corridors to Highway 2 in both Calgary and Edmonton, peak hour congestion is also a problem, particularly at choke points such as the Langevin Bridge over the Bow River and Memorial Drive in Calgary, and the High Level, Low Level and Walterdale Bridges over the North Saskatchewan River and Gateway Boulevard in Edmonton. The practical effective capacity of each of these bridges is governed by the downstream limitation of signals and number of arterial lanes. Nevertheless, removal of 500 vehicles represents a 10 percent reduction of current traffic on the Langevin Bridge and 18 to 21 percent reduction on the three Edmonton bridges.

Furthermore, this benefit would be expected to increase over time as traffic demand and congestion grows. In 2012, the third year of operation (i.e., the first stable year of high speed rail operation), diverted traffic from the approaches to both cities is estimated to represent 1.7 to 2.1 million car passenger-trips[66] per year. By 2021, diverted traffic would represent 2.2 to 2.8 million car passenger-trips per year. As there are no immediate plans to expand capacity of the section Deerfoot Trail from Memorial to Country Hills Drive, or the key choke points on access routes to

[64] Train seated capacity is 512 to 640 passengers and, therefore, this is roughly equivalent to one fully loaded train arriving in the peak hour, whereas two trains one from Red Deer and the other from Calgary/Edmonton would likely arrive at each terminus in the peak hour.

[65] Level of Service A = free flow; B = stable flow upper speed range; C = stable flow; D = approaching unstable flow; E = unstable flow; F = forced flow.

[66] Using same assumptions as those for the 2003 estimate.

Highway 2 in both Calgary and Edmonton, the potential reduction of traffic demand by high speed rail becomes all the more significant in future.

Naturally, latent traffic demand would most likely lessen perceptible congestion relief as vehicles from the shoulders of the peak period or suppressed demand take advantage of the capacity relief. Nevertheless, the ability of the overall transportation network to accommodate travel demand will be expanded.

A further consideration is the extent to which traffic reduction by high speed rail could affect expansion and investment in road infrastructure. As previously indicated, Highway 2, although well traveled, is far from reaching its capacity in much of the corridor. The current plan for the next twenty years is to spend $80 million on rehabilitation work related to weather, ageing and some use-related defects. An additional $200 million is planned for capital upgrades to expand the road from four to six lanes beginning sometime towards the end of this timeframe.

The following table presents the average annual growth of daily vehicle volumes on Highway 2 and critical points on the main access routes to Highway 2 that are the most likely to benefit from traffic diverted by high speed rail. As the table illustrates, a reduction of 4,000 vehicles per day represents between 3.5 and 6 years average annual daily traffic (AADT) growth over the past several years depending on location.

AADT GROWTH & NO. YRS OF GROWTH = 4,000 VPD

Calgary	1999	2000	2001	2002	2003	Avg Growth	4,000 VPD = Yrs Growth
N of Memorial Drive AADT			138960	139690	141100		
Annual Growth				730	1410	713	5.6
S of 566E of Balzac AADT	44460	45490	47210	48120	50130		
Annual Growth		1030	1720	910	2010	1134	3.5
Edmonton							
5.9 km N of 2 & 19 AADT	48200	48560	52710	50630	51300		
		360	4150	-2080	670	620	6.5

Construction of the Calgary and Edmonton ring roads, which are intended to improve local traffic distribution around these cities, has been committed. As a consequence, it is unlikely to be affected by high speed rail. Although high speed rail is expected to have little or no impact on the need for Highway 2 improvements or their costs, it could serve to delay some of these expenditures for a period of time. If, for example, one assumed that the $200 million in capital upgrades were spread equally between 2032 and 2037, and that they were postponed by two years, a net present value of the deferral would be $62 million.[67]

10.6.2 Inter-modal Connectivity and Competition

The potential relationship between high speed rail and other public transportation carriers in the corridor is likely to be both competitive and complementary. On the one hand, the ridership forecasts project that high speed rail will divert a significant portion of existing air and bus users. On the other hand, potential exists for high speed rail to provide improved connections to air service at the two international airports, and to contract or receive feeder services from the intercity bus companies.

Effect on Inter-City Bus Transportation

The corridor is served by two inter-city bus companies, Greyhound and Red Arrow. Greyhound Canada has about a two-thirds share of the market and Red Arrow about a one-third share.[68] Greyhound provides scheduled daily departures in the corridor and also operates a charter service and a parcel express service that accounts for about 50 percent of its Alberta revenues. The Calgary-Edmonton service is supported by an extensive feeder system drawing passengers from many rural communities, and links to Greyhound's national network. The company employs approximately 500 people in Alberta.

Red Arrow focuses almost exclusively on the business traveller segment and also has some courier and parcel operations. The company provides scheduled service between Calgary-Red Deer-Edmonton-Fort McMurray as well as non-stop runs between Calgary and Edmonton. Red Arrow's parent company, Pacific Western Transportation, also provides transportation for workers to oil sands projects and operations with a fleet of about 100 buses. Information on employment by Red Arrow was not provided.

Ridership forecasts for high speed rail predict that it could capture all business trips and more than half of all non-business trips currently made by bus. There could be employment losses, if bus services are reduced significantly. However, losses, if any, cannot be calculated at this stage as potential exists to offset these losses, if bus companies reallocated their resources to service other markets or began providing feeder services to high speed rail. Opportunities to contract services (e.g., reservation and ticket sales) or develop partnerships with the bus companies should be explored to mitigate these job losses, if high speed rail proceeds to the next stage.

Air Transportation

In 2003, the Calgary Airport Authority handled 8.1 million revenue passengers and Edmonton International Airport Authority, 3.9 million revenue passengers. The vast majority of this traffic is domestic travel between Alberta and other points in Canada.

[67] 6% used as discount rate.
[68] Interview with Greyhound Canada, March 2004.

Air travel in the Calgary-Edmonton corridor is estimated at about 540,000 passengers per year of which about one-half relates to connecting flights to destinations outside the region. As a result, the Calgary-Edmonton route does not depend on intra-Alberta air travel but rather on connecting flights at both Calgary and Edmonton International. Discussions with Calgary Airport Authority suggest little or no net impact on revenues (or jobs) as a result of high speed rail as airlines would likely reallocate their resources and add more flights from some other point. Similarly, no job losses would be expected at Edmonton International Airport.

With respect to airport infrastructure, Edmonton International Airport has the capacity to handle about 8 million passengers (vs. existing volume of about 4 million revenue passengers). Edmonton International Airport has completed a major expansion with the construction of a new terminal. Current plans are underway to upgrade and modernize the old section of the terminal to present day standards and décor. There is also a plan to expand the parking facilities at the airport.

Calgary has capacity for about 15 million passengers (vs. 8 million today). Total enplaned/ deplaned passenger activity is forecast to reach 14.6 million by 2022. Calgary International Airport has completed a parking expansion and the addition of a second terminal in the past five years. Current major expansion plans are to add a second runway to accommodate volume growth. Calgary is fast becoming a distribution centre for western Canada and significant growth will continue in the air freight segment.

In summary, high speed rail is unlikely to impact or delay the need for upgrades and improvements at Calgary or Edmonton airports because existing capacity and/or planned improvements are expected to be sufficient to meet forecasted growth.

10.6.3 Rail Freight Operations and Shipper Benefits

The infrastructure improvements required for a high speed passenger rail service, particularly for the CPR alternative, will benefit Alberta shippers through faster and more consistent freight services. This will result primarily from a significant reduction in freight train delays that arise today because of the speed limitations of the single track system and, for some trains, from somewhat higher speeds due to the more favourable alignment.

The upgraded infrastructure will also make a new type of freight service physically possible that is not today. In Central Canada, CPR operates a short haul, high performance intermodal service geared to providing trucking firms with an alternative to using the highway for moving their trailers. This type of service requires freight trains to operate at highway-like speeds with few delays from other trains. This type of service is impossible on the present infrastructure but would be straightforward on the improved infrastructure. Naturally, the economic feasibility of such a service would have to be assessed at the time, taking onto account market size, freight rates and the cost to operate the service. However, with Alberta's growth, it is quite likely that such a service is financially feasible or, if not, that it is just a matter of time before such a service could work. However, this new service could never be contemplated with the infrastructure that is in place today.

The trade route between Alberta producers and the US is very important to the province. The only direct route south is on CPR's system south of Calgary to connections to two western US Class 1 railways – BNSF at Coutts, Alberta and Union Pacific at Kingsgate, British Columbia. However, CPR's network south of Calgary is secondary mainline and has not had the level of investment of the east/west mainline, nor even of the Calgary/Edmonton corridor, which has a higher train density. Some track speeds, for example, are as low as 40 km/hr (25 mph), and the spacing between sidings is large by mainline standards.

If the high speed rail project proceeds, CPR states that it will at its expense re-deploy the existing Calgary/Edmonton main track materials made surplus by the project to upgrade the quality and capacity of the network south of Calgary to the US interchanges. This will complement the improved freight service that will be possible in the Edmonton to Calgary segment, completing a service improvement for the whole export corridor from Edmonton to the US border.

The resulting benefits to Alberta industries in terms of transportation cost savings, expanded business opportunities and new business potential cannot be quantified given the many players that could be involved. Nevertheless, the side benefit of improved rail infrastructure for high speed rail to freight operations and industry, particularly with the CPR alternative, is an important additional advantage that should not be overlooked.

10.7 Social Benefits

The primary social benefits offered by high speed rail include accident reduction due to the diversion of primarily car drivers and passengers to the service, accident reduction as a result of rail crossing eliminations and safety upgrades and the re-shaping of growth and development, provided, of course, that this growth and development is controlled and does not just result in urban sprawl.

10.7.1 Accident Reduction

Highway 2 between Calgary and Edmonton is a limited access four-lane divided highway. The accident rate in this corridor is significantly lower than the rate on other divided highways in Alberta. Each year, there is an average of 10 fatalities, 296 persons injured, 883 collisions and 697 property damage only claims in the corridor.[69]

High speed rail would improve road safety by reducing accident exposure (i.e., vehicle-km traveled) and lead to a corresponding reduction in the number of collisions. Assuming reduced auto travel of 247 million vehicle-km, a 5-year average accident rate in the Calgary-Edmonton corridor of 40.37 collisions per 100 million vehicle-km traveled, it is estimated that the number of collisions would be reduced by about 11 percent.

In addition, there have been 3.5 accidents at level crossings on the existing CPR line on average each year since 1994. Of these, two on average are fatalities and three involve serious injuries. With CPR alternative, 72 out of the 125 public road crossings are eliminated, another 46 are grade-

[69] Source: Alberta Transportation statistics for 1998-2002.

separated and the remainder are upgraded. As a result, level crossing accidents are expected to be virtually eliminated.

With the Greenfield alternatives, the benefit is far less as only 38.5 km of the existing CPR line would be subject to safety improvements. However, as the full length of dedicated portion of the Greenfield alternatives would be protected, no additional accidents would be anticipated, In addition, some benefit would result from the safety improvements in the section using the CPR right-of-way to access both Calgary and Edmonton, which are the most densely developed.

ROAD SAFETY BENEFITS DUE TO REDUCED TRAVEL ON HIGHWAY 2				
	Fatalities	**Persons Injured**	**Collisions**	**Property Damage**
Hwy 2 Avg # per year:				
- existing	10	296	883	698
- estimated with HSR	9	264	786	621
Net benefit	**-1**	**-38**	**-118**	**- 91**
Rail Crossing Avg # per year:				
- existing	2	3	3.5	
- estimated with CPR	0	0	0	
Net benefit	**-2**	**-3**	**-3.5**	

Using an average cost per accident[70] of $4.4 million per fatality, $30,000 per serious injury and $10,000 for collisions and property damage, the CPR alternative yields $215 million in net present savings over the 30-year life of the project. To be conservative, no accident reduction due to level crossing upgrades was assumed for the Greenfield alternatives, explaining why the benefits for this alternative are only $72 million over the 30-year life of the project.

10.7.2 Re-shaping of Growth and Development

High speed rail can potentially have a positive effect on growth and development but only if land use policies and plans properly control development to avoid unplanned sprawl. To the good, high speed rail would reshape development by improving access to the central part of the corridor (e.g., Red Deer). This area would benefit from improved convenience and accessibility that would draw increased residential, commercial and industrial demand, and expand the region's land base of properties attractive for development in a more focused and concentrated way than that currently associated with highway development alone.

This potential invites opportunities for planned communities and development. In addition, by increasing developable land with accessibility comparable to areas closer to both Calgary and Edmonton, pressures on suburban areas adjacent to the cities would be lessened.

[70] Source: Transport Canada.

However, given the potential for high speed rail to dramatically change access to Red Deer and the ensuing development in that area, it would require proper planning and controls so as to avoid urban sprawl. If left unchecked, some of these changes could have negative implications and put pressure on agricultural land and residential land values.

10.8 Environmental Benefits

The principal benefits of high speed rail are its potential to reduce air emissions and noise relative to existing transportation modes that are available for inter-city travel.

10.8.1 Air Emissions

Greenhouse gas (GHG) and other emissions are produced when fossil fuels are burned. However, with the introduction of high speed rail, automobile and air travel will be reduced. Furthermore, the *JetTrain* technology assumed for the CPR and Greenfield Non-Electric alternatives also offers benefits over existing transportation modes as its air emissions are relatively less. In theory, the Greenfield Electric alternative offers the most benefit since it does not directly produce GHG emissions. However, this ignores the fact that more than 60 percent of power generated today in Alberta is derived from burning coal.

GHG EMISSION COMPARISON

Auto	**Air**	**JetTrain 125 mph**	**300 km/hr Electric**
126 g of GHG/ passenger km	201 g of GHG/ passenger km	50% less than automobiles; 82% less than aircraft	Zero direct GHG emissions

Source: Transport Canada GHG data and Bombardier fuel consumption data, assumes a direct correlation between fuel and GHG.

Based on ridership projections for the high speed rail alternatives, the cumulative reduction in GHG emissions over the 30-year life of the project will be just less than 1.8 million metric tonnes. Based on a value of $72 per metric tonne[71], the net present value of this reduction is just over $56 million. For the Greenfield Electric alternative, this benefit is a 3.1 million metric tonne reduction, resulting in $98 million over 30 years less emissions resulting from additional power generation.

10.8.2 Noise

The Greenfield Electric alternative offers greater benefits than the other alternatives using *JetTrain* technology, as noise tends to be confined to wheel-to-rail friction as opposed to both wheel-to-rail friction and engine noise. Furthermore, the dedicated portions of Greenfield alternatives are away from populated areas, resulting in little or no noise impacts. As for the *JetTrain* technology, its noise impact must be looked at relative to existing transportation modes from which it is expected to divert passengers, as well as changes in location where the noise occurs.

[71] Source: EarthTech, 2003 Emissions Study for VIA Rail.

Noise pollution from automobiles and aircraft may be reduced by passenger diversion to high speed rail but this gain would be off-set by the noise introduced by the high speed rail equipment itself.[72] Automobile noise occurs near the highway, and is minor compared to that produced by truck traffic. Aircraft noise is a nuisance at or near airports and is generally confined to take-off and landing activities.

High speed rail would produce noise near the track. This may be an issue in the small towns and cities along the CPR alternative route. However, freight trains already produce noise at these locations and, as a result, the addition of twelve trains a day might not result in a measurable increase in daily average noise levels. Moreover, as the high speed rail service would be confined to waking hours, it might not result in discernible increases in average noise levels during these periods. In addition, should noise issues become a problem, noise impacts along this alignment could be mitigated with the installation of acoustic walls, as required.

NOISE LEVEL COMPARISON

Auto	Air	JetTrain 200 kph[1]	JetTrain 240 kph[1]	300 km/hr Electric[2]
65 dB	72-77 dB	86 dB	88 dB	92 dB

[1] Sound levels measures at 30 m while train was in motion.
[2] Sound levels measured at 25 m while train was in motion.
Source: European Research News Centre Transport, Bombardier and Calgary Airport Authority.

10.9 Financial Benefits

Construction and operation of high speed rail, along with incremental economic development that it would generate (which were discussed previously in this Chapter), would accrue financial benefits to residents and businesses in Alberta as well as the federal, provincial and local governments. This would take the form of employment income, sales of goods and services and taxes, including building permits, licenses and development charges. While some of these benefits, such as local revenues for development are difficult to quantify, employment income and expenditures for goods and services are relatively straightforward and are outlined in the following sections.

10.9.1 Capital Costs and Economic Benefits

The estimated capital cost of the CPR alternative is $1.7 billion ($2004) over a five-year construction period. This cost includes major capital items such as permanent trackwork, grading, signaling, grade crossings, rolling stock, property, station facilities and engineering costs. The capital project activity is expected to generate 25,500 person-years of employment and $983 million in employment income.[73]

[72] The decibel (dB) is a measure of sound intensity on a logarithmic scale. For example, an increase of 10 dB is ten times as loud.
[73] Includes direct, indirect and induced effects; multipliers used in this analysis are from *Alberta Economic Multipliers, 2000* (Government of Alberta, 2004).

The comparable capital cost of the Greenfield Electric alternative is $3.4 billion over a six-year construction period. This alternative would generate an estimated 52,000 person-years of employment and $1,950 million in employment income.

In addition to employment income a significant portion of the material and equipment costs to build the high speed rail system would also be sourced in Alberta. The key supply components for this project are rail, concrete ties, fastenings and tie plates, grading and ballast, rolling stock and signaling equipment. Alberta-based firms would have major opportunities to supply many of these items.

While specialized equipment, including the rolling stock, may require both foreign and extra-provincial supply and manufacture, contracts for these types of projects typically include requirements for specified amounts or percentages of expenditures to be directed to Alberta goods and service suppliers. Furthermore, a construction project of this magnitude can also act as a catalyst for new investment and either the establishment of new enterprises or expansion in the scale of existing businesses.

10.9.2 Operating Costs and Economic Benefits

The cost of operating high speed rail service in the first "steady state" year of operations (i.e. year three) is estimated to be $72 million per year for the CPR alternative, and $97 million for the Greenfield Electric alternative. About 500 to 550 direct employees would be employed with the CPR alternative, and an additional 160 direct employees would be required for the Greenfield Electric alternative. Most of these jobs are relatively high-paying positions. As a result, the net present value of direct employment income over the 30-year life of the project is estimated to be $181 million with the CPR alternative and $316 million with the Greenfield Electric alternative.

In addition, jobs would be created in industries supplying goods and services to the high speed rail operation (e.g. wheel truing) and through the wage spending associated with both direct and indirect employment. All of these additional jobs and wages would result in economic spin-offs for Alberta firms because of the infusion of money either to existing businesses, or as stimulus for new enterprises.

Total direct, indirect and induced employment from operations associated with the CPR alternative is estimated to be about 1,000 to 1,100 jobs and $491 million in employment income using standard Alberta multipliers. For the Greenfield Electric alternative, total direct, indirect and induced employment 1,350 to 1,450 jobs and $861 million in employment income[74].

The net employment effect will depend on potential offsetting job losses from inter-city bus operations. However, as previously indicated, these potential losses, in any, may be mitigated by changes in the business model for these companies and/or services under contract or providing feeder services to high speed rail and, therefore, cannot be calculated at this time.

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[74] However, if rail industry specific multipliers are used, these figures increase to 2,600 to 2,900 jobs for the CPR alternative ($2.0 billion NPV), and 3,400 to 3,800 jobs for the Greenfield Electric alternative ($2.6 billion NPV). (Source: Canadian Tourism Research Institute).

10.9.3 Revenues to Government

High speed rail would generate significant additional tax revenues for both the federal government and Alberta over the course of 30 years. These revenues would include income taxes on incremental employment in construction, operations and new non-rail related businesses attracted to the corridor as well as possibly corporate taxes, if a shared public-private financing arrangement is chosen to finance the project.

Excluding corporate taxes, which would only be paid if shared public-private financing was chosen, Alberta would benefit from an additional $172 million (NPV) with the CPR alternative, and $365 million (NPV) with the Greenfield Electric alternative. In addition, the federal government would receive an additional $378 million with the CPR alternative, and $800 million with the Greenfield Electric alternative.

INCREMENTAL GOVERNMENT REVENUES ($ MILLIONS)		
	CPR Alternative	**Greenfield Electric Alternative**
Provincial Revenue Gains	$172 – $343	$365 - $565
Federal Revenue Gains	$378 – $707	$800 - $1,185

If, however, shared public-private financing is chosen and corporate taxes on return on equity were paid, Alberta would receive an additional $343 million with the CPR alternative and $565 million with the Greenfield Electric alternative, whereas the federal government would receive an additional $707 million with the CPR alternative and $1,185 million with the Greenfield Electric alternative.

10.10 Summary of Social, Economic and Environmental Benefits

The following table summarizes the estimated range of benefits associated with implementation of high speed rail in the Calgary-Edmonton corridor.

SUMMARY OF QUANTIFIABLE BENEFITS		
	CPR Alternative	**Greenfield Electric**
User Benefits:		
Travel Time Savings ($M NPV)	$317	$332
Travel Cost Savings ($M NPV)	$603 – 1,319	$756 – 1,258
Economic Development:		
Employment Expansion (# jobs)	1,600 jobs	2,600 jobs
Employ. Exp. Income ($M NPV)	$619	$922

Social Benefits:		
Accident Reduction ($M NPV)	$215	$72
Environmental Benefits[1]:		
Reduction in GHG	1.8 million metric tonnes	3.1 million metric tonnes
Value ($M NPV)	$56	$98
Financial Benefits[2]:		
Construction Employment	25,500 person-years	52,000 person-years
Const. Employ. Income ($M NPV)	$983	$1,950
Operations Employment (# jobs)	1,000 -1,100 jobs	1,350 -1,450 jobs
Ops. Employ. Income ($M NPV)	$491	$861
Tax Revenues - Alberta	$172 - $343	$365 - $565
Tax Revenues - Canada	$378 - $707	$800 - $1,185
NON-QUANTIFIABLE BENEFITS		
Economic Development :		
Competitive Image	▪ Positive – catalyst for economic growth ▪ Potential for corridor to be perceived internationally as a single economic unit ▪ Opportunity for greater economic cooperation and development between communities in the corridor.	
Property Values	▪ Increases in Red Deer and near suburban stations	
Transportation Network Optimization:		
Road Congestion & Hwy Infrastructure	▪ Could eases congestion particularly at chokepoints; may result in deferral of infrastructure	
Inter-city Bus Transportation	▪ May result in reduced service and job losses unless mitigation applied.	
Air Transportation	▪ Likely to spur specialization, increased choice & better service; no deferral of infrastructure or job losses expected.	
Rail Freight Operations & Shippers	▪ Reduced freight delays and improved speeds; potential for new intermodal freight service; and, enables upgrading of line south of Calgary using surplus rail materials	

	▪ May result in shipping costs savings, expanded business opportunities and/or new business potential for Alberta industries.	
Social Benefits: Re-shaping of growth & Development	▪ Shifts and focuses development to central area of corridor and relieves pressure on land and prices in Calgary and Edmonton but requires planning and controls to avoid urban sprawl.	
Environmental Benefits: Noise	Some reduction in hwy noise but may increase noise along rail corridor	Some reduction in hwy noise and less noisy than CPR alternative due to electric propulsion and dedicated portion of corridor away from settlements.

[1] Greenfield Electric reduction is based on direct emissions only; adjustment for emissions from power generation would reduce this reduction and its associated value.
[2] Includes all direct, indirect and induced employment, employment income and taxes on this income.

CONCLUSIONS AND RECOMMENDATIONS

The study concludes that high speed rail would bring significant benefits to the Calgary-Edmonton corridor and Alberta as a whole. Depending on the route/technology alternative selected, the project is estimated to generate between $3.7 and $6.1 billion in quantifiable benefits, including:

- $172 to $565 million in incremental tax revenues for Alberta and $378 to $1,185 million for the federal government;
- 25,500 to 52,000 person-years of construction employment and $1 to 2 billion in associated employment income;
- 2,700 to 4,050 direct, indirect and induced jobs related to rail operations and enhanced economic development and $1.1 to $1.8 billion in associated employment income;
- $1.2 to $1.9 billion in other public benefits, including travel time and cost savings for system users, accident reduction and environmental benefits.

The project would also result in significant qualitative and other benefits. By effectively shrinking the distance and time separation between Calgary, Edmonton and Red Deer, high speed rail could unify the region into a single economic unit, fundamentally changing how it is perceived and improving its competitive position among urban centres on the world stage. It also has the potential to reshape growth and development in support of Alberta's future economic development strategy promoting economic diversification and increasing knowledge-based, high value jobs. Furthermore, the high speed rail line would improve access to both Calgary and Edmonton International Airports and that in turn would create opportunities and make the region more attractive to firms requiring high quality air services.

The study determined that sufficient demand exists today to support a high speed rail service that offers about two hours or less travel time between Calgary and Edmonton. This was based on a purposely conservative estimate of high speed rail ridership (e.g. induced ridership is excluded) that was developed using up-to-date market research and two proven demand forecasting models. This conclusion also differs significantly from the previous 1980s studies, which indicated that, while demand at that time was insufficient, projected ridership by the late 1990s would support high speed rail. The current study appears to corroborate these past predictions.

The study confirmed that two route/technology alternatives are technically feasible to construct and are able to offer travel time of two hours or less required by prospective riders, namely:

- upgrading the existing CPR line to permit mixed freight and high speed passenger rail service based on *JetTrain* technology, or
- constructing a largely new or Greenfield line dedicated to high speed rail service with shared access via the CPR corridor into both cities that uses either *JetTrain* technology or 300 km per hour electrified TGV type trains.

Projected ridership and revenues are able to cover estimated operating costs based on the current rail industry costs and work practices for both alternatives. In addition, these revenues would be able to repay all of the estimated $1,835 million capital cost[75] for the CPR alternative plus generate a surplus of $669 million over 30 years, if the project was 100 percent government funded and funds were advanced on a grant basis.[76] In the case of the Greenfield alternative assuming electrified train technology, 73 percent or $2,712 million of the system's initial $3,708 million[77] capital cost is repaid over 30 years.

Based on all of the above, the CPR alternative has significant advantages over the Greenfield alternatives and particularly the Greenfield Electric alternative. These advantages include:

- Significantly lower capital and operating costs
- Less property disruption and complexity to implement (i.e., reduced environmental requirements, property acquisition and engineering and design work)
- Less time required for construction
- Added benefits to Industry and freight operations
- Improved rail and road safety as a result of the rail upgrades.

However, these advantages must be balanced against slightly lower ridership and the associated benefits of the Greenfield alternatives. In addition, choosing the CPR alternative is contingent on the CPR's agreement and cooperation and would require more extensive participation by CPR in implementation of the project that would have to be negotiated upfront.

Here again, the current study differs significantly from the previous 1980s studies in two important respects. First, a high speed technology (i.e., *JetTrain*) did not exist that met North American design standards, allowed mixed freight and high speed passenger rail service and avoided costly electrification. Second, the previous studies lacked both CPR participation and willingness to accept use of the existing CPR line even to access the city centre in Calgary and Edmonton because of technology compatibility concerns. Without these limitations, the current study was able to explore the option of shared high speed passenger and freight use of the existing CPR line as well as a Greenfield Non-Electric alternative, which will be less costly to build and operate than the Greenfield Electric alternative recommended by the previous 1980s studies as well as yielding other implementation advantages.

11.1 Next Steps

Based on the results of the pre-feasibility study, proceeding to the next step of firming up estimates and addressing various key project implementation issues appears justified, particularly considering that it will take five to six years to construct the system after these issues have been resolved. Therefore, a decision to move to the next step likely makes realization of high speed rail at least six to seven years away. Thus, to postpone proceeding to the next step could result in the loss of a window of opportunity to reshape growth and development effectively, as urbanization along the Highway 2 corridor in the absence of such a commitment will continue unfocused.

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[75] The difference between capital cost for the CPR alternative quoted in Chapter 6 of $1,711 million and the figure quoted above of $1,835 million is due to inflation during construction.
[76] Without interest charges on funds advanced.
[77] The difference between capital cost for the Greenfield Electric alternative quoted in Chapter 6 of $3,413 million and the figure quoted above of $3,708 million is due to inflation during construction.

Postponement could also rule out or make development of prime station locations prohibitively expensive, particularly in downtown Calgary.

Some important issues to address as the next steps include:

- While the pre-feasibility study developed a reasonable estimate of expected high speed rail use based on market research, ridership is always the largest project uncertainty. For this reason, an investment grade ridership analysis should be carried out.
- Additional engineering and technical work should be undertaken to firm up both capital and operating costs in areas of greatest uncertainty. This work would be more extensive if the Greenfield alternative is chosen.
- Discussions with CPR should be initiated on how to proceed with the project, possibly leading to the development of a project agreement.
- The Province of Alberta should explore the willingness of the federal and municipal governments to participate in the project.
- The advantages and disadvantages of different project organization and governance structures, including such options as an independent authority, should be explored, particularly in terms of accountability, debt financing capabilities, legal powers and other essential implementation requirements.
- Opportunities to develop partnerships with both airlines and the inter-city bus companies should be investigated.
- Linkages with both the Calgary and Edmonton light rail systems, including station linkages and expansion particularly of the Edmonton system to support high speed rail, should be studied.
- Opportunities and a program to involve private developers in developing and operating the stations should be explored.

ABOUT THE VAN HORNE INSTITUTE

Transportation plays a critical role in the development of an expanding economy in Alberta and Canada. Efficient and low cost transportation services are essential to both industry and the public in a country as large as this. The development of a sound industrial strategy is dependent upon strong public policy, education and progressive legislation and regulation in transportation. The founders of The Van Horne Institute were concerned with the lack of education and research in the fields of transportation and regulated industries and dedicated the Institute to work towards the resolution of these concerns.

With the assistance of The Van Horne, The University of Calgary has developed a masters program in Regulatory Economics. The University of Calgary and SAIT have also collaborated on a four-year degree program in transportation studies. The Institute carries out a vigorous program of public policy research responsive to the issues identified by industry. The Van Horne Institute's ongoing work is supported by member companies and educational institutions whose own work reflects a wide range of transportation and regulated undertakings.

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