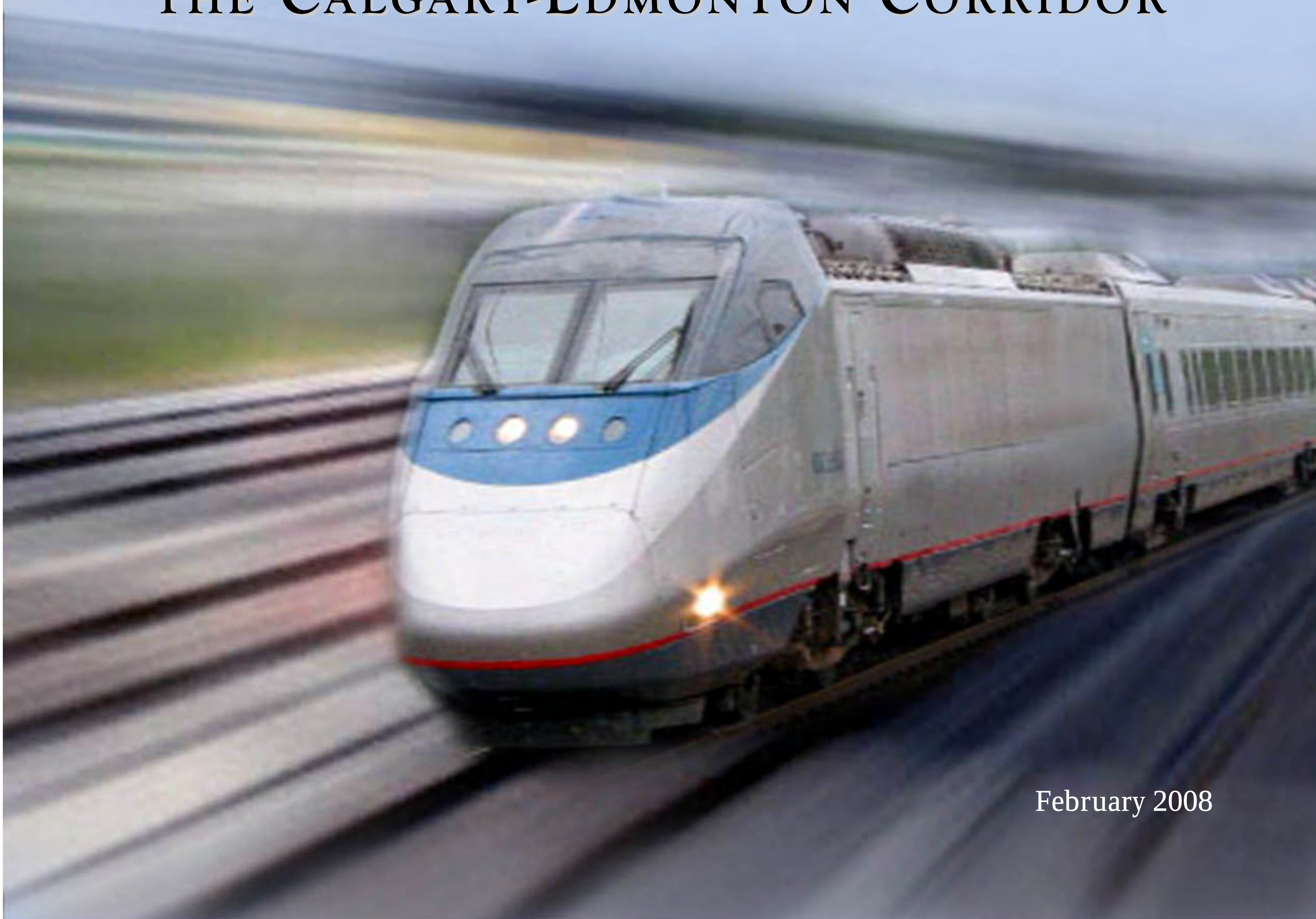
Prepared For

Alberta Infrastructure & Transportation

# Market Assessment of High Speed Rail Service in the Calgary-Edmonton Corridor



February 2008

Prepared by

TEMS, Inc. / Oliver Wyman

This report was prepared by Transportation Economics & Management Systems, Inc. (TEMS) for the Government of Alberta. The report's contents do not necessarily constitute the official policy and position of the Government of Alberta.

# Certification of Forecasts

This is to certify that the 2021 and 2051 Base Case Forecasts for the Four Technologies considered by TEMS and Oliver Wyman, as part of the Alberta Infrastructure and Transportation-Calgary Edmonton High-Speed Rail Project are as follows:

| | | 125 mph | 150 mph | 200 mph | 300 mph |
|---|---|---|---|---|---|
| **Ridership** | **2021** | 1,554,926 | 2,518,190 | 4,136,138 | 5,816,264 |
| **Ridership** | **2051** | 2,821,448 | 4,301,497 | 7,654,689 | 10,745,289 |

February 28, 2008

Dr. Alexander E. Metcalf / President — Date:
TEMS, Inc.

February 28, 2008

Mr. Gilles Roucolle — Date:
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# Executive Summary

After the 700-mile Quebec City-Windsor corridor that is home to about 15 million people, the 200-mile Calgary-Edmonton corridor with its population of more than 2 million is the second route most frequently considered for the implementation of high-speed rail. This is because of the population density in the corridor is second only to the Quebec City-Windsor corridor. Furthermore, the province of Alberta has recently experienced a period of strong economic growth generating a rapid growth in travel in the Calgary-Edmonton corridor. As a result, Alberta Infrastructure and Transportation has requested that an independent investment-grade study aimed at evaluating the potential assessment for high-speed rail services in the Calgary-Edmonton corridor be completed.

The Transportation Economics & Management Systems (TEMS)-Oliver Wyman (OW) team was selected to complete the study.

To fulfill the requirements of an investment-grade study, the assessment of the market for high-speed rail consisted of a number of specific steps.

- Determine existing travel patterns in the corridor by mode.
- A Stated Preference (SP) survey aimed at identifying the properties of the various modes (air, auto, and bus) people use to travel in the corridor, estimating the volumes of travel in those modes, as well as quantifying the passengers' behaviour in their own respective modes of travel.
- Two different modeling techniques, using the same underlying database and economic projections. TEMS and OW use modeling techniques that differ in the evaluation of time savings, modal split and induced demand.
- An analysis of the demand for four different high-speed rail travel modes in the Calgary-Edmonton Corridor. The four different technologies considered for analysis were as follows:
    - Diesel, at speed 125 mph;
    - Turbine Electric, at speed 150 mph;
    - Electric, at speed 200 mph; and
    - Magnetic Levitation, at speed 300 mph.

The main results of this study are as follows:

- It is estimated that nearly 50 million passenger trips occur in the province of Alberta, 10 million of which presently occur between the metropolitan areas of Calgary, Edmonton and Red Deer. Ninety-five percent of the province-wide trips are made by auto, 1.5% by air, and 3.5% by intercity bus.

- Taking in consideration demographic growth only, and assuming no changes in the current level of service, demand for travel in the corridor will grow to 84 million passenger trips by 2021 and to 150 million trips by 2051.

- The consensus ridership forecasts (developed by TEMS and OW) for the slowest rail technology used in this study (125 mph) are 1.5 million person trips in the year 2021 or 2 percent of total trips. The volume of trips for high-speed rail increase with the performance (speed and frequency) of the rail technology used. In the same year 2021, 150 mph is forecasted to attract 2.5 million trips (3 percent), 200 mph 4.1 million trips (5 percent) and a magnetic levitation train capable of reaching a speed of 300 mph, 5.8 million trips (7 percent).

- In the year 2021, the volume of corridor trips diverted to high speed rail is 1.4 million passenger trips with a 125-mph technology, 2.3 million with a 150-mph technology, 3.7 million with a 200-mph technology, and 5 million with a 300-mph technology.

- Given the growth of the overall travel market, high-speed rail ridership increase is approximately 35% in the 10-year period 2021 through 2031, and 43% in the subsequent 20-year period 2031 through 2051.

- Sensitivity analysis on the three most critical input variables, demographic change, congestion levels and gasoline prices have shown that their combined effect can lead in 2021 to a change in ridership and revenues between -30% and +45% with respect to the central case examined.

- The diversion from competitive modes to high speed rail is shown below. The table shows the volume of traffic and the percentage diversion from each mode to high speed rail. For example, the 125 mph rail mode attracts 167,000 Air trips, which represent 17% of all Air trips. It should be noted that the diversion is largely from the growth of new traffic, which will expand by 46 percent by 2016. The percentage diversion from competitive modes remains largely constant over time, up to 2050.

**Makeup of High-Speed Rail Traffic from Competitive Modes**
**(actual volumes in thousands)**

| | | 125 mph | | 150 mph | | 200 mph | | 300 mph | |
|---|---|---|---|---|---|---|---|---|---|
| **2016** | Air | 167 | 17% | 283 | 31% | 583 | 46% | 931 | 74% |
| | Bus | 311 | 14% | 546 | 28% | 843 | 35% | 1,019 | 42% |
| | Auto | 718 | 1% | 1,172 | 2% | 1,815 | 3% | 2,437 | 3% |

A comparison of travel characteristics with different modes is given in the next exhibit, where applicable.

**Comparison of Service Characteristics for Travel on Different Modes in the Corridor**

| Service Comparison | 125 mph | 150 mph | 200 mph | 300 mph | Air | Greyhound | Red Arrow | Auto |
|---|---|---|---|---|---|---|---|---|
| Average travel time (h:min) | 2:00 | 1:45 | 1:35 | 1:00 | 0:45 | 3:45 | 3:15 | 3:00 |
| Frequency (roundtrips/day) | 8 | 10 | 14 | 17 | 20 | 7 | 6 | n/a |
| Fare (in cents/mile) | 25 | 35 | 40 | 60 | 50 | 24 | 30 | n/a |
| Maximum fare one-way Calgary-Edmonton | $56 | $80 | $90 | $120 | $300 | $48 | $60 | n/a |
| Maximum fare one-way from Red Deer | $28 | $40 | $45 | $60 | n/a | $33 | $38 | n/a |

Comparisons were made between TEMS' model and OW's model, and various sensitivities have been tested with values of ridership and revenues associated with the central, best and worst cases. The Exhibits below show the values.

**TEMS Corridor Ridership (in millions)**

| | 125 mph | | 150 mph | | 200 mph | | 300 mph | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **2021** | **2051** | **2021** | **2051** | **2021** | **2051** | **2021** | **2051** |
| **Worst Case** | 1.254 | 1.860 | 2.034 | 2.839 | 3.359 | 5.068 | 4.766 | 7.180 |
| **Base Case** | 1.554 | 2.821 | 2.518 | 4.301 | 4.136 | 7.657 | 5.816 | 10.745 |
| **Best Case** | 2.207 | 4.618 | 3.583 | 7.058 | 5.615 | 11.947 | 7.897 | 16.751 |

**TEMS Corridor Revenues (in millions of 2006 $)**

| | 125 mph | | 150 mph | | 200 mph | | 300 mph | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **2021** | **2051** | **2021** | **2051** | **2021** | **2051** | **2021** | **2051** |
| **Worst Case** | 60.6 | 90.2 | 105.3 | 177.1 | 204.7 | 353.3 | 489.3 | 902.8 |
| **Base Case** | 75.2 | 137.1 | 156.7 | 269.0 | 328.2 | 609.9 | 608.0 | 1,127.9 |
| **Best Case** | 119.2 | 250.6 | 223.0 | 441.7 | 485.3 | 1,035.7 | 825.6 | 1,758.7 |

# 1

# Introduction

## 1.1 Statement and Purpose of Study

### 1.1.1 Study Overview

The objective of this study is to provide investment-grade ridership and revenue estimates for a high-speed passenger rail service for intercity travel between Calgary and Edmonton. The high-speed passenger rail options to be evaluated include 125 mph (miles per hour[1]), 150 mph, 200 mph, and 300 mph technologies. Each of these speeds represents proven technology, which is in service today. The two lower speeds are in commercial operation in North America, while the two higher speed options are operational in Europe and Asia. As a result, the study team was able to obtain actual operating characteristics for each technology and did not have to rely on hypothetical performance characteristics.

In developing the forecasts, the basis of the study teams approach was to treat high-speed rail as an "enhanced" or "new" mode of travel. Rail service has not existed in the Calgary-Edmonton Corridor since the early 1980's, and as a result the analysis had to focus on customer response to high-speed train performance rather than extrapolating existing rail demand. However, even if rail service existed in the corridor today it would be important to evaluate high-speed rail as a new mode of transportation. The reason for this is that the character of individual travellers response to high-speed rail is very different to that for the intermediate speed rail service that, for example, VIA provides in the Central Corridor in Canada.

To meet the modelling needs of evaluating customer response to high-speed rail, the study carried out extensive Stated Preference "SP" surveys and analysis for the Calgary-Edmonton Corridor. The surveys included existing auto, intercity bus and air travellers, and provided a comprehensive understanding of each type of traveller. The behavioural modelling was completed using two different modelling approaches, the TEMS COMPASS™ Model and Oliver Wyman SCA/IAM Models. This meets the requirement of Investment Grade Analysis as proposed by the High-Speed Rail Association.

[1] The Canadian Rail industry still uses imperial measurement system and for this reason miles per hour (mph) are used instead of kilometers per hour (kph).

To validate the results of the forecasts from each of the two modelling systems, the study team compared and then benchmarked against actual ridership and forecasts for other corridors in North America and Europe.

Using the final "agreed" forecasts both project financial and economic cash flows were derived. The Net Profit Value for these cash flows was calculated and the overall financial and economic cash flows for the project estimated.

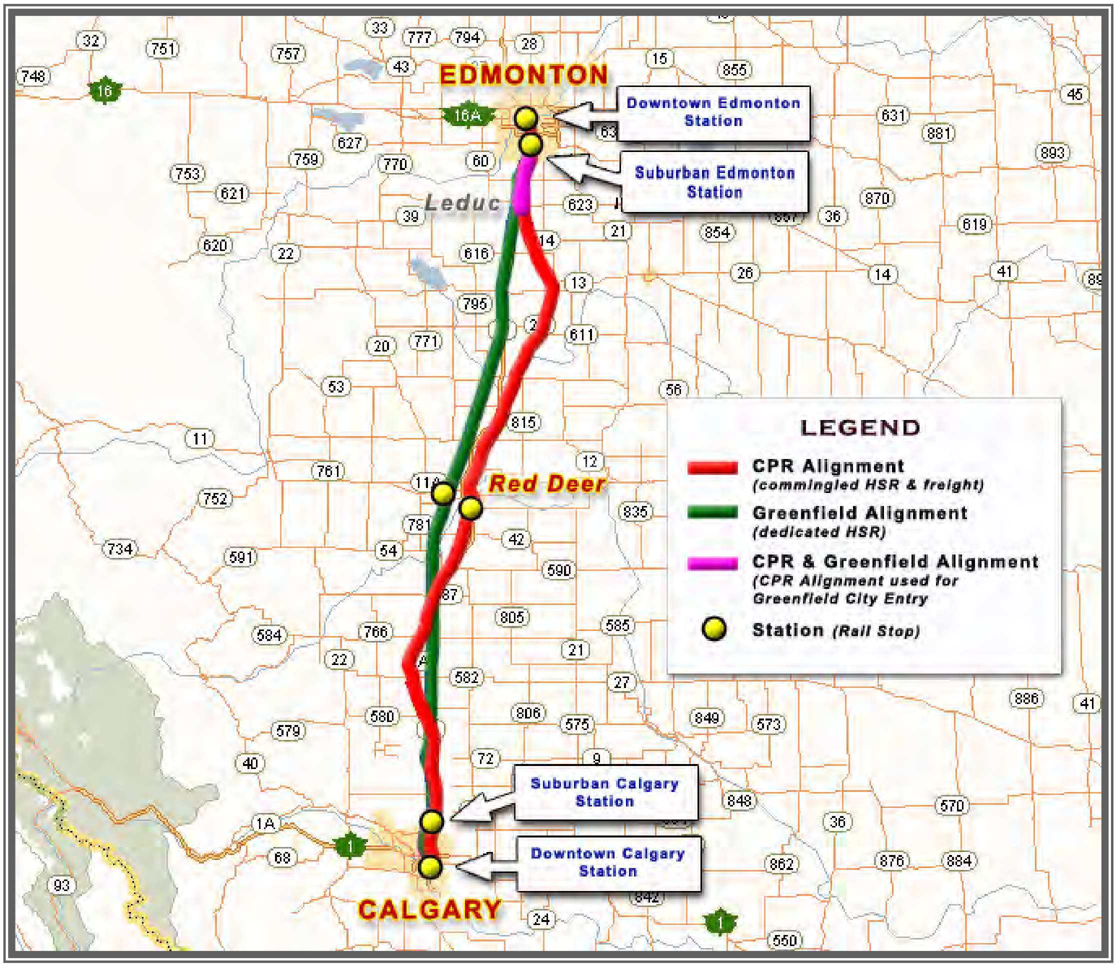
### 1.1.2 Study Corridor

The Calgary-Edmonton High-Speed Rail Project proposes a high-speed passenger rail service between downtown Calgary and downtown Edmonton, see Exhibit 1.1, with intermediate stops in north suburban Calgary, Red Deer and south suburban Edmonton (north of the Ring Road). The corridor is some 300 km in length and has a population of well over two million inhabitants. It contains the major urban areas of Calgary with a population of just over one million people, and Edmonton with a population of just under one million. Both cities and the corridor have grown rapidly in the last ten years. This is due to the performance of the economy of the province that has continued to expand rapidly. In the period 2002-2005, Alberta experienced an annual average growth in GDP estimated at 12.7%, compared with China's 14.8% in the same period [StatsCan, 2006].

The province of Alberta has had the strongest economic growth in Canada for the last three years, led by growth in construction, wholesale/retail trade and manufacturing and by investment in the oil and gas sectors. Recent growth in world oil requirements, and in particular the needs of China and Asia, is likely to maintain the strength of the demand for oil and gas and help remove Alberta from the cyclical growth it has experienced historically with the fluctuating price of oil. It appears unlikely that oil will return to 1990's price levels, and that demand will maintain oil prices at over $50 per barrel (West Texas crude) in the long term.

Despite the strong outlook for the energy sector, Alberta is seeking to diversify its economy and to develop its knowledge-based sector of the economy. This will mean raising the "quality of life" in Alberta to attract the "foot loose" businesses and high paying "service and scientific" jobs. A key feature of "quality of life" improvements for businesses and their staff is the ability to move individuals quickly and efficiently between market centres and "production" locations such as downtown office buildings. For employees "quality of life" relates to living in attractive cities, work places, homes and having the mobility to provide a fulfilled life. Alberta is seeking ways to ensure it can achieve these goals in terms of its land use and transport policies. One concern with its current transportation system is the lack of a fast and effective passenger rail connection between its major cities.

**Exhibit 1.1: Calgary-Edmonton High-Speed Rail Alignment Alternatives**




### 1.1.3 Technology Options

The aim of the study is to identify the ridership and revenue for four technologies capable of four different intercity speeds. Speeds are given in miles per hour. These are as follows:

- 125 mph: A 125 mph rail system has been a successful first step for many European railroads in developing high-speed rail capability. The British HST 125 mph diesel train developed in 1970 is still operational in the UK. It presented a major step forward for British Rail with push-pull "integrated" diesel train sets that were modern, comfortable, reliable and capable of significantly reducing travel times in the highly populated corridors of the UK. Since the 1970's this type of train continues to be developed and today is represented by trains such as Talgo T21, Alstom's Voyager and Siemens ACE. It is proposed that 125 mph HSR option will use the existing CPR railroad right-of-way (Alignment), and would comingle passenger and freight trains providing a low cost option that would not need to purchase land between Edmonton and Calgary. The other higher speed options will need to have a new (Greenfield) right-of-way that will be developed as a dedicated HSR corridor since passenger and freight trains cannot be commingled over 125 mph (See Exhibit 1.1).

- 150 mph: Electrification of diesel trains provides a significant bump in speed to 150 mph. Amtrak's Acela train on the Northeast corridor provides an example of how the Bombardier Jet Train can be enhanced by electrification to give 150 mph operation. The turbine-powered Jet Train prototype is, in theory, capable of 150 mph, but this speed has not been proven in daily revenue service. Accordingly, for the purpose of this investment-grade ridership study, the proven Acela electric train has been selected as the representative technology for the 150 mph service evaluation. This was the speed of the early TGV (Paris-Lyon), and the services on the East and West Coast lines in the UK today, using Alstom's Pendolino and Siemens "Electra" technologies. These electrified integrated trains are designed to operate in "consist" as 6- to 12-car sets, rather than the four- to six-car sets of the typical 125 mph technology.

- 200 mph: The French, Germans and Japanese have all developed 200 mph electrification technology, the most famous of which is the Alstom/Bombardier TGV, which pioneered 185-mph service on the Paris to "Atlantic" routes. These trains are typically developed as "integrated" systems with 8 to 12 cars and a locomotive at each end. The success of these trains in European corridors, coupled with the increased power given by modern AC motors, has resulted in the development of double deck trains to increase capacity in peak hours.

- 300 mph: For speeds of 300 mph the only current candidate is Maglev technology. This system is fundamentally different to a rail technology in that it does not use a steel wheel/steel rail contact, but rather uses magnetic levitation to float above a concrete guide way, as well as to propel the train. Only the Siemens Transrapid Maglev system is in commercial operation, although the Japanese are developing the MLX01. The trains are capable of rapid acceleration and typically operate in consists of two to five cars. Seating capacity is generated by operating the trains at higher frequency than normal steel wheel/steel rail trains, or by linking car sets together if platform lengths permit.

## 1.2 Study Requirements

Alberta Infrastructure and Transportation (AIT) issued an RFP requiring an Independent Investment Grade Market Assessment of high-speed rail services in the 300-km Calgary-Edmonton Corridor. The rail technology options to be evaluated include the full range of high-speed rail: diesel, turbine, overhead electric and Maglev technologies. The study was designed to have four phases: Travel Demand Analysis, Market Analysis, Revenue Analysis and Financial Analysis.

The basis of the study team's approach to Investment Grade forecasting for high-speed rail is to treat it as an "enhanced" or "new" mode of travel. Therefore, the objective is to focus the analysis on the response to the performance of the new mode by taking intercity traveller behavioural attitudes into account, rather than simply extrapolating demand on the basis of historical or current travel characteristics. This was achieved by using an Abstract Mode Stated Preference Survey and a Multimodal Trade-Off Analysis. In modelling the demand for high-speed rail, both TEMS' COMPASS™ and Oliver Wyman's SCA/ISM models have been used to provide forecasts. To ensure the forecasts are accurate and realistic and that the models meet Investment Grade standards, a series of different model structures, forms, functions, and weights have been developed, tested and assessed. This approach will also ensure the types of output needed by the various government and financial institutions can be developed.

Finally, the database model structures and assumptions used have been subjected to a peer review process. In this way, the full impact of the high-speed rail system on regional transportation can be assessed, and ridership and revenue forecasts prepared. For this purpose, AIT set up a technical committee to oversee the work and review all aspects of the data collection and analysis. The panel included the following:

| Panel Member | Title / Organization |
|---|---|
| Bob Brawn | Chairman – Van Horne Institute and Member of the Strategic Transportation Advisory Committee to the Minister of AIT |
| Rod Thompson | Executive Director – AIT |
| Gary Haynes | Director, Transportation and Logistics – AEII |
| Peter Kilburn | Traffic Data and Forecasting Engineer – AIT |
| Meheboob Ishani | Travel Demand Forecasting Engineer – AIT |

## 1.3 Work Plan

The work plan for the study is given in Exhibit 1.2. The study took some 12 months to complete and required regular progress meetings with the AIT Project Manager and Peer Review Panel. The study was split into four phases as requested in the RFP, as follows:

- Travel Demand Analysis;
- Market Analysis;
- Revenue Analysis; and
- Financial and Economic Analysis.

At the end of each of the four phases, a technical memorandum was prepared that described the work activities in that phase, findings and results, and any issues that may have arisen.

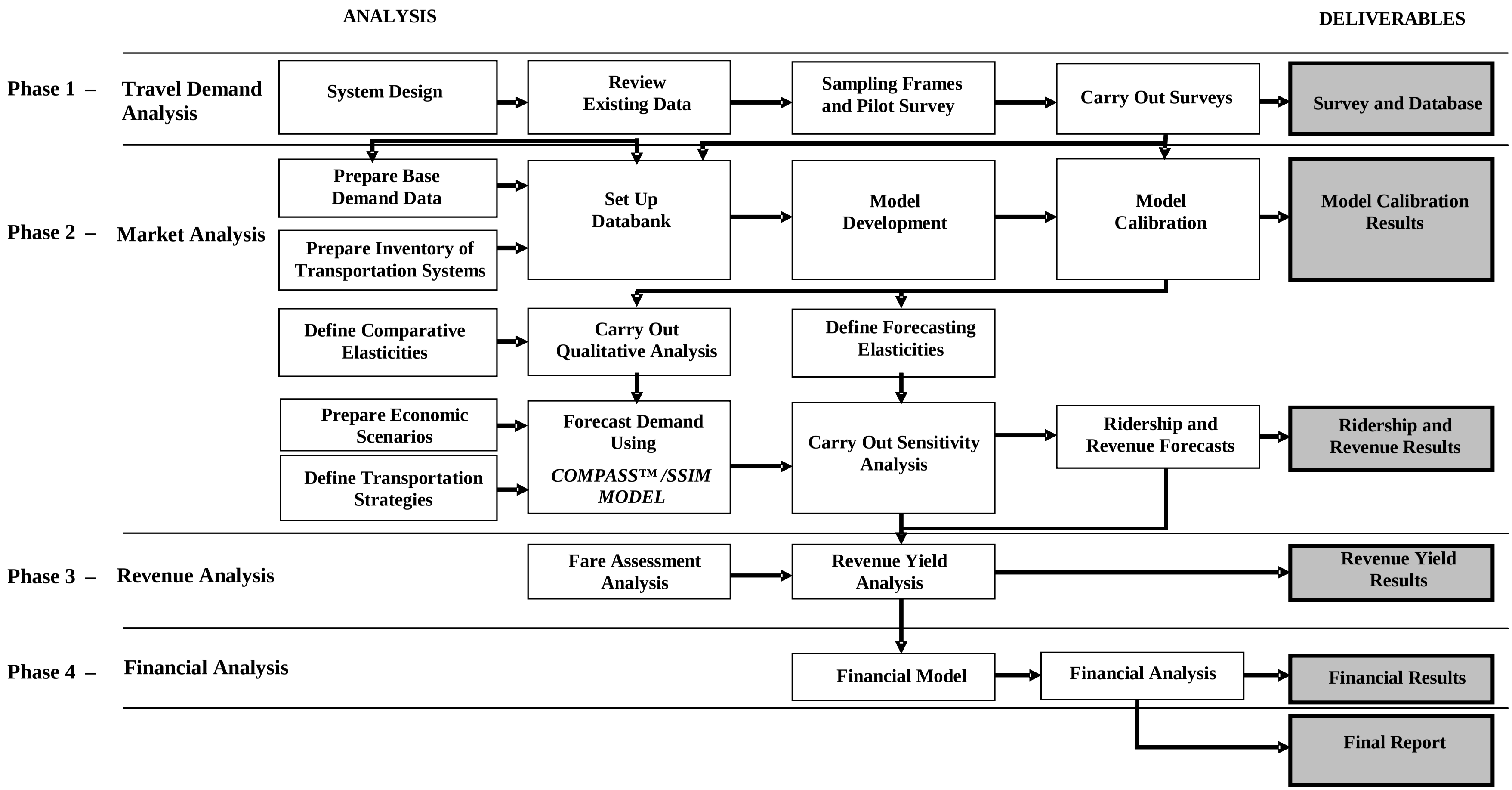
### 1.3.1 Phase 1: Travel Demand Analysis

In this phase, a set of procedures was established to identify available data, identify survey needs, design and execute the surveys, and build a comprehensive study database. The development of an effective database required the assembly of four databases related to intercity travel between Edmonton and Calgary: socioeconomic, origin-destination, network and stated preference.

**Task 1: Review of Existing Data and Identification of Data Development Process**
A thorough review of existing databases, travel data and modal schedules was undertaken. This included AIT travel databases, such as provincial highway forecasts and plans; census data, transit data and highway networks; Edmonton and Calgary's urban modelling databases including networks and survey data; and provincial origin-destination data on auto, bus and air. The review of existing data identified the completeness of the regional travel data, its mode and trip purpose definitions, potential adjustments and updating needed, as well as new data requirements.

Once the basic data needs were established, the next step was to identify how new data would be developed. This included survey methods, sampling frames, design of questionnaires, survey procedures and locations for the surveys. The survey process was established and pilot testing of questionnaires, survey instruments and survey locations (e.g., four highway intercept locations between Edmonton and Calgary) was carried out. Over 40 pilot surveys were conducted for each survey to test the relevance of the proposed survey methods and the questions on each mode and trip purpose. The results of this process were reviewed and the survey methods and questinnaires adjusted, as needed.

## Exhibit 1.2: Project Work Plan



**Task 2: Collection of Origin-Destination, Personal Profile and Stated Preference Data**
A key input to the study was the Abstract Mode Stated Preference Surveys. The Investment Grade status of the study required that new stated preference travel data be collected. The surveys were used to collect origin-destination, personal traveller profile data, as well as Stated Preference data. They were designed to provide insight into the full range of travel behaviour and attitudes of intercity/interurban travellers for each mode option, trip purpose and origin-destination movement. The surveys were conducted using a quota sampling approach. TEMS has developed the Abstract Mode Stated Preference Attitudinal Survey as an approved method of gathering Investment Grade data on traveller origins and destinations, the importance of different modal performance characteristics and the responsiveness of individuals to different travel options.

Quota surveys, which are widely used for public opinion surveys, are based on the development of representative "quotas." As a result, two sets of data were required – data that defined the "travel type" quota and the "profile" quota for the individuals surveyed. The profile data was then used to expand the data to the total population size to ensure the representativeness of the Stated Preference Survey. The profile data was used in conjunction with origin-destination and census data to ensure that the overall travel patterns and the approximately 36-travel type and 16 profile quotas needed were properly characterized and represented. This approach ensured that intercity travel between each of the Edmonton, Red Deer and Calgary segments was an effective picture of the overall pattern of travel in the corridor.

**Travel Type Data**

- Mode: three quota groups – air, bus and auto
- Trip purpose: four quota groups – business, commuter, social and tourism
- Trip length: three quota groups – origin-destination of less than 80 kilometers, 80-250 kilometers and more than 250 kilometers
- Income: four quota groups
- Auto ownership: two quota groups
- Group size: two quota groups

**Personal Profile Data**
In terms of the size of the quota required, a sample as small as 40 individuals was statistically sufficient to define each group. Typically, TEMS will seek 60 to 100 respondents per quota. Over 6,000 surveys were collected to meet Investment Grade standards.

- Air – 1,000 Surveys
- Bus – 700 Surveys
- Auto – 5,000 Surveys

The details of the survey methodology and procedure are outlined in Chapter 3. Briefly, of 24,000 mail survey sent, 5,377 were returned (for a return rate of 22%); 701 Bus Survey and 880 Air Survey questionnaires and were completed.

**Survey Method:** The Stated Preference surveys were conducted by direct interview and a mail-out survey. Intercity bus and air traveller surveys were carried out at bus stations and airports and by direct interview. For auto travellers a license plate survey was completed. This took place on the Queen Elizabeth II (QE2) highway at four locations – south of Edmonton, north of Red Deer, south of Red Deer and north of Calgary. The sites were located close to AIT messaging boards at these locations (see Exhibit

3.3). The license plate data was captured by camera for typical weekday (Tuesday and Wednesday) and a weekend day (Saturday). The license plate data was accompanied by a full-classified count of traffic.

The license plate data was submitted to AIT, who processed the data using information provided by the Alberta Registrar. AIT identified the traveller's address and sent a letter and stated preference survey with a mail-back envelope to the traveller. The returned surveys were collected by TEMS and processed along with the bus and air survey data.

In each case full-day counts were conducted on survey days at the airport, bus terminal and roadside locations. Initially, this data was used to expand the stated preference survey data to a daily basis and then using schedule and Average Annual Daily Traffic (AADT) data to a monthly and yearly basis.

To support AIT in identifying addresses and mailing out the surveys, TEMS provided management input and direction, as needed to AIT staff. Completed surveys were collected and coded by the TEMS project manager who added data on location, date and time.

The surveys were then subjected to a data entry process that involves validating and entering the data in the attitudinal data bank. Validation of the data included a series of range, logic and consistency checks.

**Task 3: Development of the Corridor System Database**
A database was established that contained both the demand and transportation systems network data. All information was filed and subjected to data verification assessments, whereby crosschecks were made on the basic data to confirm its accuracy. The database was based on a 158-zone system in which rural areas were more aggregated, while urban areas were disaggregated to a zone system consistent with existing urban planning models, although at a higher level of aggregation. The AIT Project Manager was given every facility to inspect and assess the quality of the data assembled for use in the study.

### 1.3.2 Phase 2: Market Analysis

**Task 4: Stated Preference Trade-Off Analysis**
Using the Stated Preference Survey data, a Trade-Off Analysis was carried out to identify the relative ranking and values of the "high-speed rail system" and highway, air and bus modes "mode appeal" variables, i.e., the relative attraction of these modes compared to rail, for each rail technology. For the system variables, the analysis was defined by own-mode and cross-elasticities (see Appendix A) of demand for travel time, price and frequency for each mode and trip purpose. The analysis was a two-stage process using algorithms specially developed by TEMS to provide "preference utilities," "own-and cross-elasticities," and (see Appendix A) modal bias estimates. For the "mode appeal" variables, specific rankings, market share and generalized cost values were used to measure the attractiveness of high-speed rail. For a detailed explanation of the technical terms used, see Appendix A.

**Task 5: Model Systems**
At the model specification stage, a range of possible modelling systems was developed and discussed with the AIT Project Manager and Peer Review Panel. These included various forms of the direct demand, induced demand and modal choice models for regional travel. A number of different model structures were specified for calibration. Year 2006 was used as the base year for calibration purposes.

The agreed-upon models were calibrated and the statistical validity of each tested using range, logic and consistency checks. In developing each model system, an interactive assessment was made of the potential role of variables and the ability of the model to represent travel behaviour. The best of the models developed were presented to the AIT Project Manager and Peer Review Panel.

Given the need for an Investment Grade analysis, the design of the model systems was critical. Models were developed that evaluate the potential for rail service in an environment where there is no existing rail service. This poses a number of modelling issues and, in particular, the specification of rail in the modal choice and induced demand models.

**Market Growth Model:** With respect to natural market growth (i.e., growth due to socioeconomic factors), the investment banking community is not so much concerned with the relative predictive power of the "trip generation" models, but rather, the comparison of the forecasts for total growth with historical experience. Because urban models are frequently constrained to reflect limited transportation supply considerations (i.e., limited highway investment), the SAC/ISM and COMPASS™ models also adopt a similar forecasting approach to natural growth. In this way, the results reflect both historical trends and urban investment constraints, where applicable.

**Induced Demand Model:** A key and controversial characteristic of high-speed rail forecasts is induced demand. Induced demand was estimated using the travel utility function derived from the Mode Choice Model, and related to the volume of trips. This essentially generates a demand curve for rail travel that can be explained to the investment banking community within the context of normal demand analysis.

**Mode Choice Model:** To evaluate the choice of mode, the study team used a full general equilibrium utility framework and a specification of rail that is based on the Stated Preference data. This is important as it allows the full range of competitive modes to be effectively analyzed and the potential for rail to be identified. Partial equilibrium models fail to include the full impact of travel utility variables (e.g., highway congestion) across all of the modes. Both the COMPASS™ and SCA/ISM models use a full equilibrium hierarchical logit model for mode choice.

**Task 6: Socioeconomic Scenarios**

A number of socioeconomic variables – population, income, and growth – were used in the models to identify overall travel market growth. The socioeconomic forecasts were made on a zone basis to take into consideration not just overall corridor growth rates, but distributional differences across the province of Alberta. This is particularly important where different growth rates exist between large and small cities and between urban and rural areas. Small differences in socioeconomic forecasts can have substantial impacts on the ridership and revenue forecasts (i.e., a one-percent increase in household income can increase a total market forecast by 30 to 60 percent over 25 to 30 years). As a result, great care was taken in preparing the socioeconomic scenarios and in defining the range of sensitivities to be tested. The study team used a central-, upper- and lower-case projection.

**Task 7: Future Networks or Transportation Strategies**

A number of different high-speed rail strategies were developed for each of the different technology options. These were considered travel time, fare, frequency, and comfort and convenience for the high-speed rail alternatives. The study team will also consider a range of both "system" and "mode appeal" factors as they reflect different levels of market penetration.

Alternative strategies for other transportation modes were developed so that the impact of investment in other modes and changes in fares and services of other modes are incorporated into the forecasts and sensitivity analyses for the forecast years. It has been the European experience that competitive modes will have a "competitive response" to the introduction of high-speed rail. The investment banking community will want this issue explored. This task was undertaken in conjunction with the AIT Project Manager and Peer Review Panel.

**Task 8: Ridership/Revenue Forecasts**
Using the transportation strategies and the socioeconomic scenarios, forecasts for high-speed rail and its competitive modes were prepared. The study team worked with the AIT Project Manager and Peer Review Panel in identifying a set of "core forecasts" and appropriate sensitivity analyses. Estimates were made in terms of passenger numbers, passenger miles, and revenue on an annual basis. For the other modes, overall passenger movements and market shares were estimated. Ridership and revenue forecasts were prepared for five-year intervals between 2011 and 2051. These estimates were refined in Task 10 by a full evaluation of fares and the potential impact of revenue yield management.

**Task 9: Validation of Models and Forecasts**
An important element in the development of investment grade studies is the "validation" of the model systems and forecasts. The study team will use three sets of validation procedures:

**Total Demand Model Performance:** The study team forecast total demand, both within a multimodal context and for individual modes. Experience in previous studies has shown that individual mode forecasts can act as a significant crosscheck on the multimodal forecast, which is an average of the growth rates of the individual modes. This approach makes it easier to compare the multimodal forecast with historical trends.

**Elasticity Analysis:** Using the elasticities estimated in the Trade-Off Analysis, a comparative analysis was made with the elasticities derived by the study team in a range of previous studies carried out in Canada, the U.S., the U.K. and elsewhere. These different studies provided a range of values against which estimates for this study were compared, contrasted, and benchmarked. Close consultation with the AIT Project Manager and Peer Review Panel at this stage has allowed a full discussion and assessment of the elasticity findings. This has been particularly important in validating the forecasts.

**Cross-Model Comparisons:** The investment banking community will be very interested in a comparison of the calibrations of the two models. Differences in parameter forms and functions will need to be fully documented and explained. This analysis showed how different variables perform and how the structures of the models are affecting the forecasts. This impact will be essential in developing a forecast risk profile for Bay and Wall Street investors.

### 1.3.3 Phase 3 – Forecasting

**Task 10: Revenue Analysis**
An important output of the forecasting process is the revenue potential associated with different high-speed rail options. In developing the initial forecasts, the study team used reasonable fares for each option. However, in the revenue yield analysis, a full assessment of fare levels was made. Fares were optimized at higher levels for higher speed technologies. The results of this assessment were used to carry out a Revenue Yield Analysis. The Revenue Yield Analysis was made using the COMPASS™ Model. This analysis can be used to develop various fare structures, e.g., discounted fare systems and route or segment fares based on time of day.

### 1.3.4 Phase 4 – Financial and Economic Analysis

**Task 11: Financial Analysis**

An integral component of the study is the financial analysis. Revenue forecasting requires that cash flows for the project be developed for the life of the project, which is typically 20 to 30 years. Rail infrastructure generally lasts much longer than 30 years, but modern high-speed trains frequently require major overhauls at ten years and have to be replaced after 25 years. This is due to the increased usage associated with high-speed trains whose annual mileage can easily reach 150,000 to 250,000 miles per year. The financial analysis considers all revenues. Key outputs of the analysis include "pro forma" balance sheets of cash flows and estimates of appropriate interest, depreciation, and discount rates appropriate for Bay and Wall Street assessments.

**Task 12: Final Report:**

A final report, which includes an executive summary, has been prepared. The final report describes in detail all aspects of the study and explains the methodology and findings of each step in the analysis. It provides a comprehensive description of the databases, model systems, network alternatives, and forecast results. In preparing the final report, emphasis was placed on the use of graphics to illustrate complex concepts, ideas and results. In accordance with the terms of the RFP, the draft report was submitted to the AIT Project Manager and Peer Review Panel for review and approval. The final report was then finalized and submitted.

## 1.4. Organization of the Report

The report is organized in the following way:

Chapter 1 – Introduction
Chapter 2 – Current Market
Chapter 3 – Stated Preference Survey
Chapter 4 – Economic Scenarios
Chapter 5 – Transport Strategies
Chapter 6 – TEMS Base Case Forecasts
Chapter 7 – Oliver Wyman Methodology and Forecasts
Chapter 8 – Sensitivity Analysis
Chapter 9 – Financial Analysis
Chapter 10 – Conclusions

A certification of the base case forecasts by TEMS and Oliver Wyman is provided.

# 2

# Current Market and Modes

## 2.1 Demand for Travel

The Calgary-Edmonton Corridor is the most urbanized area in the province of Alberta and one of the densest in Canada. It consists of Statistics Canada census divisions No. 11, No. 8, and No. 6. These divisions cover a distance of roughly 400 kilometers, including the entire census metropolitan areas of Calgary and Edmonton, as well as the cities of Airdrie, Red Deer, Wetaskiwin, and Leduc. According to the Canadian census, the population of the Calgary-Edmonton Corridor is over 70% of Alberta's population. It is also one of the fastest growing regions in the country.

The busiest stretch of highway in Alberta, the QE2 (part of Highway 2), spans the corridor. The region also has two major international airports located in Calgary (Calgary International, IATA code: YYC) and Edmonton Capital Region (Edmonton International, IATA code: YEG). The corridor is one of Canada's busiest commuter flight sectors. Many business people fly the route and back in a single business day. In addition, the corridor has an extensive intercity bus system, which is heavily used for business, social, and recreational travel.

## 2.2 Current Transportation System

At the present time, a traveller within the Calgary-Edmonton Corridor can choose between four different travel modes:

- Air (service provided by Air Canada, WestJet, and other minor carriers)
- Bus (service provided by Greyhound and Red Arrow)
- Personal Auto

Auto is the dominant mode accounting for about 91% of estimated trips between the metropolitan areas of Calgary, Edmonton and Red Deer. The remaining 9% of the market is divided between air travel (with an estimated 6%, only between Calgary and Edmonton) and Bus travel, which captures 3% of the trips. The fact that modes as diverse as air and bus with service characteristics similar to those offered by rail can capture about 9% of the market shows the potential for passenger rail in the corridor. A table with these volumes of trips is shown in Exhibit 2.1, where are shown the estimated volumes of travel between

Calgary and Edmonton and Red Deer to both Calgary and Edmonton. Details of the trip generation and validation used to derive the trip volumes in Exhibit 3.1 are given in Chapter 3.

**Exhibit 2.1: Volume of Estimated Yearly Passenger Trips for the Base Year (2006)**

| | Calgary-Edmonton | | Red Deer – Calgary/Edmonton | | Total | |
|---|---|---|---|---|---|---|
| Auto | 5,037,000 | 86% | 3,889,000 | 98% | 8,927,000 | 91% |
| Air | 616,000 | 10% | 0 | 0% | 616,000 | 6% |
| Bus | 236,000 | 4% | 60,000 | 2% | 296,000 | 3% |
| Total | 5,889,000 | 100% | 3,950,000 | 100% | 9,839,000 | 100% |

### 2.2.1 Air Service

The Calgary-Edmonton Corridor is currently served by two major airlines (Air Canada[2] and WestJet[3]) and a number of smaller airline companies. The linear distance between the two airports is 245 km and, therefore, the air journey is very short, with a time between takeoff and landing of approximately 45 minutes. Between these two airports, Air Canada has 17 one-way flights per weekday, and WestJet has seven one-way flights per weekday. The fare charged for a one-way ticket ranges from $39 to $264 (Economy Class) to as high as $375 (on Executive Class) on Air Canada, and in the range $39 to $118 (Economy Class) on WestJet. Air traffic between the cities of Calgary and Edmonton is estimated at roughly 600,000 one-way passenger trips per year and is heavily oriented to business travel. Details on the calculation of these trips can be found in Section 3.8. Schedules for Air travel can be found in Appendix H.

### 2.2.2 Bus Service

The two main bus companies in Alberta provide the bus service in the Calgary-Edmonton Corridor: Greyhound[4] and Red Arrow[5]. Greyhound offers a very extensive service with urban and suburban stops covering a wide part of the Province of Alberta, while Red Arrow offers service to/from Calgary, Edmonton, Red Deer, Fort McMurray, Lake Louise, and Banff. A one-way ticket from Calgary to Edmonton (and vice-versa) on Greyhound costs $48, while the same ticket costs $60 on Red Arrow.

The Greyhound bus schedule for a given weekday from downtown Edmonton to downtown Calgary shows 11 departing buses, three of which have travel time of 5 hours, 50 minutes and higher, with 14 stops or more in between. All other buses are express buses, with travel time no higher than 4 hours, 5 minutes, and no more than three stops in between. Red Arrow only offers express bus service. The schedule posted by Red Arrow in their website shows six daily departures Monday through Thursday (seven on Fridays) from Edmonton to Calgary, three of which do not stop in Red Deer.

Annual traffic between the cities of Edmonton, Red Deer and Calgary is estimated as approximately 295,000 one-way passenger trips per year, with Red Arrow being more focused towards business travel

[2] http://www.aircanada.com/

[3] http://www.westjet.com/

[4] http://www.greyhound.ca/

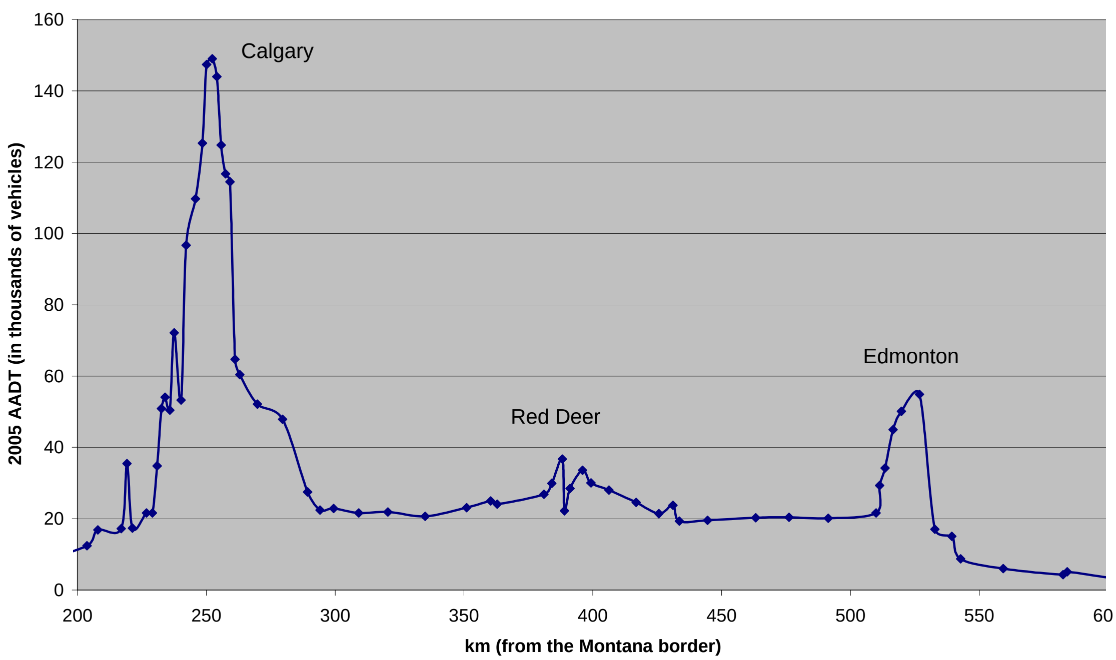
[5] http://www.redarrow.ca/

and Greyhound providing for social travellers. Of these 295,000 trips, 175,000 are estimated for Greyhound and the remaining 120,000 on Red Arrow. Details on the calculation of these trips can be found in Section 3.8. Schedules for Bus travel can be found in Appendix H.

### 2.2.3 Highway Travel

With AADTs at roughly 150,000 (as shown in Exhibit 2.1) in Calgary, the QE2 is the major provincial highway in the province of Alberta, and it makes auto the preferred mode of travel in the Calgary-Edmonton Corridor. TEMS estimated that roughly 6,900 one-way vehicle trips between the metropolitan areas of Calgary and Edmonton occur each day, and 5,249 one-way vehicle trips between Red Deer and the metropolitan areas of Calgary and Edmonton. Highways 21 and 22 are the only alternatives parallel to QE2, but their traffic volumes are negligible when compared with QE2. The AADT (Average Annual Daily Traffic) measured in 2005 in several locations across QE2 between Calgary and Edmonton is shown in Exhibit 2.2. The major business and population centres in the Calgary-Edmonton Corridor are all served by the QE2, like the two major airports (YEG at Nisku, south of Edmonton and YYC, north of Calgary), along with the population centres of Airdrie, Red Deer, Wetaskiwin, and Leduc. In average driving conditions, an auto journey between Calgary and Edmonton takes approximately 2½ to 3 hours. Congestion occurs primarily approaching the metropolitan areas of Calgary and Edmonton, and often in Red Deer, where intercity travel is combined with local urban travel.

**Exhibit 2.2: AADTs in Several Locations on QE2 in the Calgary-Edmonton Corridor (2005)**



## 2.3 Nature of the Calgary-Edmonton Corridor

For the purpose of investigating travel patterns in the province of Alberta, with special reference to the Calgary-Edmonton Corridor, TEMS developed a Provincial Zone System. The character of the zone system is shown in Exhibit 2.3, while Exhibits 2.4 and 2.5 provide close-ups of the metropolitan areas of Calgary and Edmonton.

**Exhibit 2.3: Zone System for the Province of Alberta**


The zone system comprises 158 zones forming the province of Alberta. Zones 1-31 form the city of Edmonton while zones 49-76, plus 79, 112 and 142 form the city of Calgary. The zone system has been assembled as a hybrid zone system between the Census Forward Sortation Area (FSA), which is a collection of postal codes in the province, and the transportation zone systems of the cities of Edmonton and Calgary. A complete list of the zones is given in Appendix C.

**Exhibit 2.4: Edmonton Region**

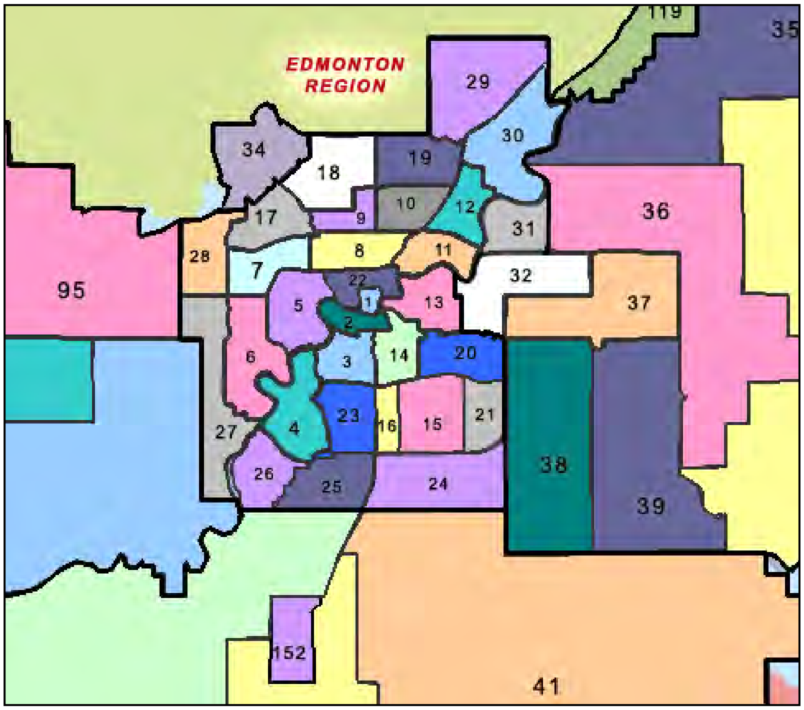
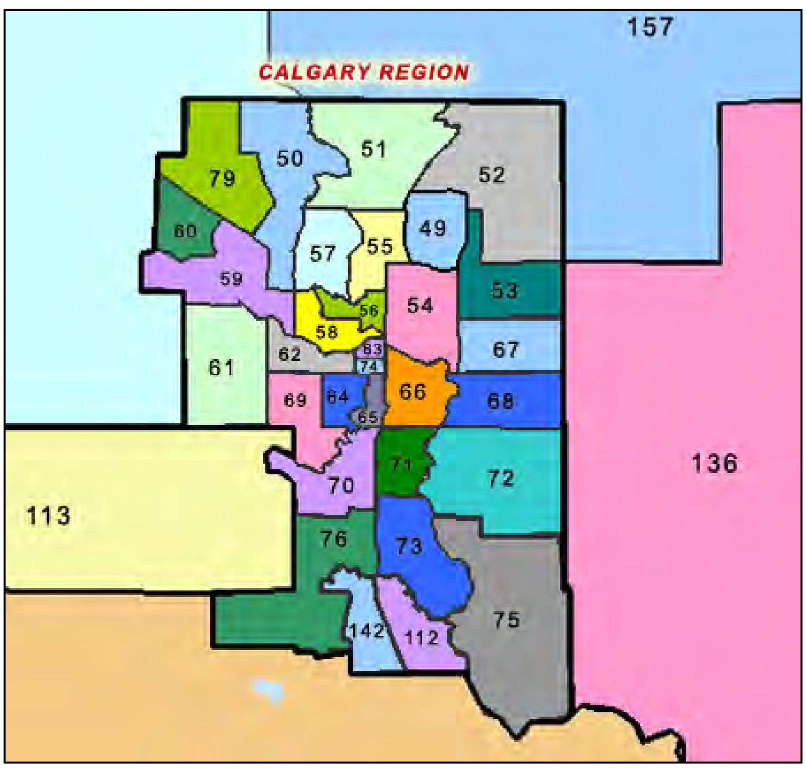



**Exhibit 2.5: Calgary Region**



### 2.3.1 Transport Networks and Generalized Cost

Based on information from the province of Alberta, as well as time and distance impedance factors for zone-to-zone travel received from the cities of Calgary and Edmonton, the consultant team prepared transportation networks to represent base and forecast years for all available modes of transport. An important characteristic of the networks is that they use stated preference surveys of corridor users to produce generalized cost travel impedance for each O/D movement.

Travel impedance associated with the routes within the system was estimated using a generalized cost concept, which incorporates the sum of both travel time and vehicle operating cost of a point-to-point trip within the system. Because the generalized cost variable was used to estimate the impact of improvements in the transportation system on the overall level of trip making, it needs to incorporate all the key modal attributes that affect an individual's decision to make trips. In the case of both the private mode (auto) and public modes (*i.e.*, rail, bus and air), the generalized cost of travel also includes all aspects of travel time (access, egress, in-vehicle times), travel cost (fares, tolls, parking charges), schedule convenience (frequency of service, convenience of arrival/departure times) and reliability.

The generalized cost of travel is typically defined in travel time (i.e., minutes) rather than dollars. Costs are converted to time by applying appropriate conversion factors. Detail of the formulation and computation of the generalized cost are given in Appendix A, together with the networks for all modes.

# 3

# Stated Preference Survey

## 3.1 The Role of the Stated Preference Survey

The investment grade criteria used in this study required that the travel model developed for the study use a rigorous process that conforms to industrial and academic standards to assess whether or not the High Speed Rail system (HSR) would be a viable travel alternative. Travel demand analysis hinges on properly representing the travel choices made by the people surveyed and, specifically, their underlying behavioural motives. The key to modelling these travel choices lies in identifying primary behavioural motivators and calibrating them against existing, revealed, travel choices. Standard modelling procedures require that all elements of these complex choices be properly represented in order to provide realistic solutions.

In addition to the standard challenges of developing a transportation model, modelling a new mode like HSR, which is not present at the current stage in the corridor, adds an extra challenge. Little is known about the public's response to this new mode of travel from existing local data. Therefore, to allow the public's perceptions for HSR to be properly assessed, Stated Preference (SP) analyses were adopted. Since SP lacks the empirical basis of revealed behaviour analysis a very high level of statistical analysis is needed together with careful validation. The validation of SP results for this study required careful consideration of behaviour in the Calgary-Edmonton Corridor and how it compares with behaviour elsewhere. The best validation process requires the use of appropriate empirical data to justify the model coefficients and parameters derived with SP analysis.

In modelling future travel behavioural patterns, several issues are critical, including the characteristics of a new travel mode, changing household behaviour, economic and social development, land and network capacity constraints and growth policies. This suggests that each corridor is different, and that systematic deviations among observations and predictions can be expected in the modelling process [Garling *et al.*, 1998], depending on the variation in policy adopted in each corridor. However, an investment grade demand model must have a range of error of less than 20 percent. As a result, the modelling approach adopted by the study team requires the use of the most effective procedures possible. While a wide range of different methodologies, all with different strengths and weaknesses are available for use, several are recognized as the most effective and have become standard practice for investment grade analysis. The study team and the peer review panel agreed upon the use of these survey procedures and modelling structures to assess the viability of a HSR passenger rail system in the Calgary-Edmonton Corridor.

## 3.2 Survey Approach

The SP survey was designed to minimize error and maximize the representativeness of the survey. These procedures included the following design criteria.

### 3.2.1 Quota Sample

The abstract mode SP survey was designed to be conducted using a quota sampling approach. A quota sample, as opposed to a random survey, is particularly useful for ensuring that all the important modal attributes are measured within a reasonable sample size [Kish, 1995]. The quota survey, which has now been widely adopted for public opinion surveys, is based on the development of representative "quotas" of the travelling public. For the purposes of the Calgary-Edmonton survey it was decided that the prime quota groups would be based on the mode of travel (auto, bus and air) and the trip purpose (business or non-business). In addition, data would also be collected on trip length and income, which have been found to influence travel demand. In terms of the size of the quota required, it has been shown that a sample as small as 40 individuals is statistically sufficient to define each group. Typically, TEMS will seek 60 to 100 respondents to ensure representativeness of the quota. In this case it was decided that much larger samples be developed.

### 3.2.2 Questionnaire Design

In developing the questionnaire used in the survey, TEMS considered a number of factors pertaining to the Calgary-Edmonton Corridor. To begin with, since the rail mode is not currently present, the survey focused on existing modes. This approach was used in order to ensure that individuals were responding to a real-life situation of which they have direct experience. This ensured that the problem of individuals giving misleading or emotive responses was minimized. In addition, to ensure the consistency of responses, questions were "enveloped." By asking respondents the same question a number of different ways it is possible to judge the reliability of the response and validate the answer. A copy of the survey forms can be found in Appendix B.

### 3.2.3 Trade-off Options

To incorporate the rigorousness of the choice by individuals with respect to the tradeoff questions, a probability scale was incorporated in the questionnaire format. This offered a respondent not just a choice of alternative A or B, but also a graduated choice. The probability scale contained five selection levels:

- Prefer A a lot
- Prefer A a little
- Indifferent
- Prefer B a little
- Prefer B a lot

The advantage of this scale is that, first, it allows the individual to express their preferences in a more precise manner and, second, it allows the analyst reviewing the results to see whether there are consistent patterns of answers. If an individual always strongly or weakly prefers the same option, the questions were probably not correctly balanced for the traveller's choices. The results of this SP survey showed that the vast majority of respondents (over 70%) gave a consistent pattern of answers, validating the effectiveness of the questionnaire design.

Preliminary research was done in order to formulate questions that describe tradeoffs in time and cost that reflect real-life situations a traveller may experience in the Calgary-Edmonton Corridor and that allows them to express their perceived importance of key transportation characteristics. A typical question, therefore, asked an individual to choose between two alternatives A and B, for example:

| | | |
|---|---|---|
| **Choice A**: | Travel Time: 2 hours | Travel Cost: $120 |
| **Choice B**: | Travel Time: 4 hours | Travel Cost: $ 80 |

A respondent who chooses A over B values a time saving of two hours worth at least $40, while a respondent choosing B does not. By asking sufficient questions (within a quota sample) the way an individual values time, money, frequency, and other transportation characteristics of importance can be determined. Typically, it is found that individuals will make different choices according to the particular circumstances of their journey, which is why a differentiation is made by purpose of travel. Travellers tend to value time more when their journey is for business than for a social trip. Alternatively, social travellers will frequently prefer to spend time rather than money, as they are limited by their own income, which typically means they are willing to pay less than a business. The value of all these factors was included in the SP tradeoff questions.

### 3.2.4 Survey Design

The questionnaires for all modes were designed to elicit two types of information (the survey forms are available in Appendix B). The first part concentrates on profile questions on the traveller and the trip, and it includes questions on the trip origin and destination, the purpose of travel, the frequency of travel, and finally two questions on the employment status and the income group. The second part of the questionnaire asks about an individual's travel trade offs. In the survey there was one question for auto on VOT and two for the transit modes to investigate time and frequency VOT and VOF tradeoffs.

The various modes of transport (Air, Red Arrow, Greyhound and auto) have their own characteristics that necessitate first a different questionnaire for each one of them, but also a different technique in approaching a traveller in order to elicit a meaningful response.

In the case of terminal surveys, like in a bus station, respondents prefer to answer tradeoff questions in private and in a check-box format. The presence of a surveyor nearby is important in order to clarify any request of clarifications from the respondent. In order to ensure that the travellers are the most representative for the purpose of this study, travellers in the proximity of the boarding areas for express buses in the corridor were selected by the survey crew. This was a primary concern for the Greyhound surveys because their Calgary and Edmonton main terminals are large areas where several boarding zones are present. It did not represent a concern for the Red Arrow surveys because their main terminals are small and confined and all Red Arrow buses offer express service.

Air surveys are "terminal" surveys, too, but they necessitated a different approach primarily because of the security concerns that are linked with air travel. TEMS aimed at interviewing travellers flying between Calgary and Edmonton; therefore, it was necessary to perform the survey questionnaire at the boarding areas for those two destinations, past security checkpoints. For this purpose, TEMS hired the

Edmonton-based market research firm Pivotal Research, whose employees have security clearances to work near boarding areas, under TEMS supervision.

The main survey effort in time and resources was devoted to the highway survey because auto travellers represent the vast majority of travellers in the corridor, and surveying auto passengers presents its own set of challenges. To begin with, not all auto travellers are potential rail travellers. Hence, there is the need of devising a survey structure that selects auto passenger vehicles that fit the following pre-requisites:

- Travelling in the corridor
- Licenses registered in the Province of Alberta
- Not a commercial vehicle
- Not a rental car

After preliminary discussion with AIT, TEMS proposed a manned camera survey to take pictures of vehicles in selected spots along QE2 Highway between Calgary and Edmonton. The advantage of a manned camera with respect to an automatic one is that the photographer himself is able to avoid taking pictures of commercial vehicles (when their commercial nature is obvious, as in the case of trucks or large industrial vehicles). A subsequent validation of data is performed when it is possible to eliminate non-Alberta license plates, as well as rental vehicles, because they have a specific license numbering.

After a sample of license plates was selected for mail out and transmitted to AIT's Registrar, the survey was designed with particular care in order to clarify in advance any questions that may arise on the part of the respondent, who in this case will not have the benefit of a surveyor present in order to answer them.

Regardless of the travel mode under investigation, the surveys were then subjected to a data entry process to enter and validate the data and establish the attitudinal data bank. Validation of the data will include a series of range, logic and consistency checks.

## 3.3 Air Survey

As mentioned in Section 3.2, the Airport surveys necessitated special permission for non-passengers to enter the boarding area; hence TEMS hired the licensed Edmonton-based firm Pivotal Research[6] to carry out the survey under TEMS on-site supervision. All Edmonton interviews were performed at the Edmonton International Airport (YEG) and all Calgary interviews at Calgary International Airport (YYC). The schedule for the interviews, as well as the total number of surveys collected is shown in Exhibit 3.1 on the next page. Only Air Canada and WestJet flights have been selected for the survey interviews.

[6] http:// www.pivotalresearch.ca

**Exhibit 3.1: Air Survey Results**

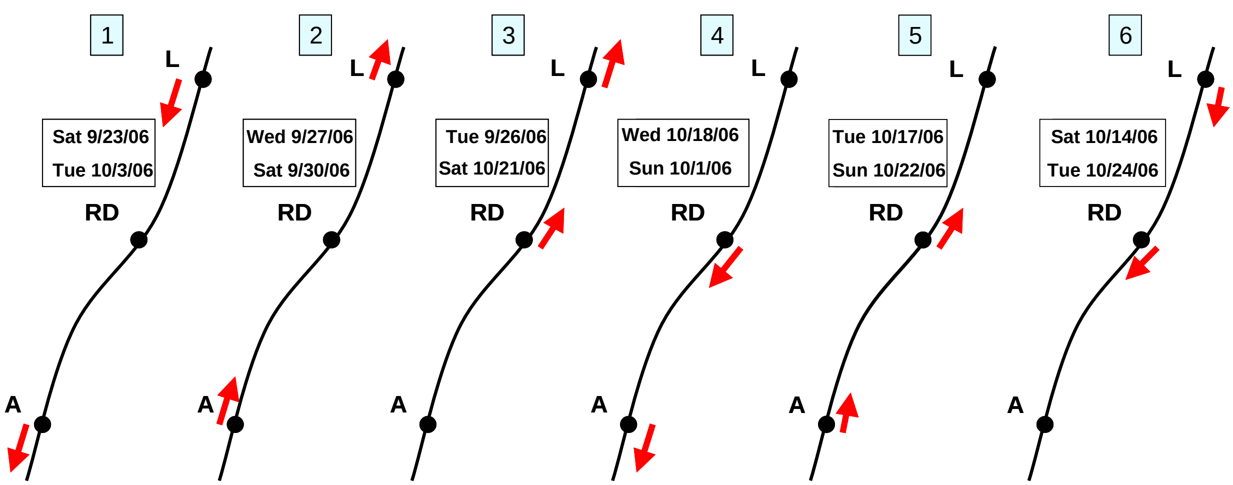
| Day of Week | Date | Location | Surveys |
|---|---|---|---|
| Thursday | 30-Nov 2006 | Edmonton | 91 |
| Friday | 1-Dec 2006 | Edmonton | 87 |
| Saturday | 2-Dec 2006 | Edmonton | 82 |
| Sunday | 3-Dec 2006 | Edmonton/Calgary | 90/290 |
| Monday | 4-Dec 2006 | Calgary | 240 |
| Total | | | 880 |

## 3.4 Highway Survey

The majority of trips between Edmonton and Calgary occur by auto, hence an extensive survey effort was undertaken to capture the behavioural characteristic of this market share. In the time period September 21 to October 24, 2006 TEMS arranged for pictures to be taken of vehicles in different locations along QE2.

By developing a series of camera strategies not only were vehicle license plates taken, but an estimate of the volume of traffic along QE2 could be derived. The two cameras used in the survey were always pointed in the same directions of travel, in order to derive a sample of the flow of vehicles between the two points. In addition, if a photographer located along QE2 near Calgary could take a picture of a specific vehicle and the same vehicle is then photographed later on near Edmonton, it was possible to identify vehicles that travelled the entire length of the segment and their proportion of the total traffic. The schedule of the photographic survey is outlined in the Exhibit 3.2 below. The red arrow indicates the direction the camera was pointing toward.

**Exhibit 3.2: Camera Strategies for the Highway survey ("L" is for Leduc, "A" is for Airdrie Crossfields and "RD" is for Red Deer)**



### 3.4.1 Survey Organization

The locations for the camera survey were agreed between TEMS and AIT's Regional Safety Officers. The locations were chosen as to provide a sufficient angle for a photographer to capture the back license plate of a vehicle, and at the same time provide safety of the surveying crew. The four locations chosen along QE2 (south to north) were as follows:

- Township Road 285 overpass, near Crossfield (no access ramp from QE2)
- McKenzie Road overpass, near Gasoline Alley, south boundary of Red Deer
- Aspelund Road 597 overpass, north of Red Deer
- Township Road 490 overpass (Glen Park Road), south of Leduc

Variable messaging signs were posted on the days of survey operation to inform travellers of the presence of surveyors (see Exhibit 3.3).

**Exhibit 3.3: Variable Messaging Sign Informing Travellers of the Survey in Progress**


### 3.4.2 Data Processing

The table in Exhibit 3.4 shows the number of valid license plates captured during the survey. Only a very small volume of pictures resulted in invalid licenses that could not be used in the sample. The most frequent reasons of why a picture was rejected were as follows:

- The license plate was not registered in the Province of Alberta.
- The license plate referred to a rental vehicle.
- The visibility of the license plate was impaired (by, for example, a light bicycle rack, mud, or a passing vehicle in another lane).
- Poor definition of the picture due to weather.

This further filtering of the data resulted in the data shown in the exhibit below. The right column, "Pictures," shows the total number of pictures available for processing, while the column "Licenses" shows the valid number of license plates processed.

**Exhibit 3.4: Results of the Survey Camera Work**

| DOW | Date | Location | Direction | Licenses | Pictures |
|---|---|---|---|---|---|
| Saturday | 23-Sep 2006 | Leduc | SB | 2066 | 2968 |
| Saturday | 23-Sep 2006 | Crossfields | SB | 2201 | 2706 |
| Tuesday | 26-Sep 2006 | Leduc | NB | 1389 | 1941 |
| Tuesday | 26-Sep 2006 | Red Deer | NB | 2339 | 2637 |
| Wednesday | 27-Sep 2006 | Leduc | NB | 1947 | 2145 |
| Wednesday | 27-Sep 2006 | Crossfields | NB | 2241 | 2429 |
| Saturday | 30-Sep 2006 | Leduc | NB | 2788 | 2897 |
| Saturday | 30-Sep 2006 | Crossfields | NB | 2857 | 3236 |
| Sunday | 1-Oct 2006 | Red Deer | SB | 1688 | 2146 |
| Sunday | 1-Oct 2006 | Crossfields | SB | 2271 | 2434 |
| Tuesday | 3-Oct 2006 | Leduc | SB | 1715 | 1938 |
| Tuesday | 3-Oct 2006 | Crossfields | SB | 1538 | 1714 |
| Saturday | 14-Oct 2006 | Leduc | SB | 2160 | 2227 |
| Saturday | 14-Oct 2006 | Red Deer | SB | 2657 | 2882 |
| Tuesday | 17-Oct 2006 | Red Deer | NB | 2349 | 2462 |
| Tuesday | 17-Oct 2006 | Crossfields | NB | 1245 | 1299 |
| Wednesday | 18-Oct 2006 | Red Deer | SB | 1755 | 1927 |
| Wednesday | 18-Oct 2006 | Crossfields | SB | 2033 | 2505 |
| Saturday | 21-Oct 2006 | Leduc | NB | 2054 | 2372 |
| Saturday | 21-Oct 2006 | Red Deer | NB | 2725 | 3260 |
| Sunday | 22-Oct 2006 | Red Deer | NB | 2869 | 3075 |
| Sunday | 22-Oct 2006 | Crossfields | NB | 2076 | 2397 |
| Tuesday | 24-Oct 2006 | Leduc | SB | 2050 | 2265 |
| Tuesday | 24-Oct 2006 | Red Deer | SB | 1488 | 2045 |
| Total | | | | **50501** | **57907** |

In total, TEMS produced a database of more than 50,000 valid license plates. Out of this number, 24,000 license plates (2,000 per survey day) were selected to be transmitted to the AIT Registrar in order to begin mailing the questionnaires. In selecting 2,000 licenses per day, at AIT's request, TEMS included all the "matched" licenses (vehicles that are recognized to have crossed two screen lines versus unmatched ones that only crossed one), and a complementary number of unmatched licenses, randomly selected. Every license plate number was separately recorded, so to minimize the chance that a vehicle owner would receive more than one survey. Of these 24,000 letters mailed, 5,377 were returned, for a return rate of 22%. Of these 5,377 surveys, 734 (13.6%) were from matched license plates. This attribution was possible because survey forms destined to "matched" license plates had a small typographical detail added (a miniscule "M" added at the bottom of the form). In order to further ensure the privacy of the travellers whose vehicle license plates were recorded, TEMS did not see the addresses associated to each license plate, nor keep a copy of the license plates database.

## 3.5 Bus Survey

During the time period November 15-19, 2006, interviews were arranged at the bus terminals for Red Arrow and Greyhound. Two different survey questionnaires were developed for the two bus transit companies because of the different services and fares provided. A survey manager and two surveyors per terminal were dispatched to interview those passengers who were boarding an express bus directed to either Edmonton/Calgary or Red Deer.

As discussed in Chapter 2, the Greyhound bus schedule[7] for a given weekday from downtown Edmonton to downtown Calgary shows 11 departing buses, three of which have travel time 5 hours 50 minutes and higher, with 14 stops or more in between. All other buses are express buses, with travel time no higher than 4 hours 5 minutes, and no more than three stops in between. Only these express routes were considered for the survey. Red Arrow[8] only offers express bus service, hence all Red Arrow routes to either Edmonton/Calgary or Red Deer were considered for the survey. The schedule posted by Red Arrow in their website shows six daily departures Monday through Thursday (seven on Fridays) from Edmonton to Calgary, three of which do not stop in Red Deer. The stations where the survey took place are as follows:

**Exhibit 3.5: Bus Survey Locations**

| City | Company | Address |
|---|---|---|
| Calgary | Red Arrow | Fording Place – 101, 205 9th Avenue SE, Calgary, AB |
| | Greyhound | Main Terminal, 877 Greyhound Way S.W., Calgary, AB |
| Edmonton | Red Arrow | Holiday Inn Express Plaza, 10014 - 104th Street, Edmonton, AB |
| | Greyhound | Greyhound Bus Depot 10324 – 103rd Street, Edmonton, AB |
| Red Deer | Red Arrow | Holiday Inn 6500 - 67th Street, Red Deer, AB |
| | Greyhound | 4303 Gaetz Avenue, Red Deer, AB |

A total of 701 questionnaires were filled for both bus companies, with the details given in the Exhibit below:

[7] http://www.greyhound.ca/.
[8] http://www.redarrow.ca/.

**Exhibit 3.6: Bus Survey Results**

| DOW | Date | Location | Red Arrow | Greyhound |
|---|---|---|---|---|
| Wednesday | 15-Nov | Calgary | 59 | 125 |
| Thursday | 16-Nov | Edmonton | 65 | 96 |
| Friday | 17-Nov | Red Deer | 16 | 55 |
| Saturday | 18-Nov | Calgary | 35 | 98 |
| Sunday | 19-Nov | Edmonton | 57 | 95 |
| Total | | | 232 | 469 |

## 3.6 Survey Profile Results

The traveller profile and key behaviour factors identified in the surveys are shown below. All Exhibits give in brackets the number of valid responses to each question. As expected, the questions on Income and Residence have the lowest number of valid answers.

### 3.6.1 Air Survey

Exhibits 3.7 through 3.12 show some characteristic of Air travel in the corridor, derived from 880 surveys. The vast majority of travellers are business travellers (54%), high-earners (51%) and employed full-time (78%). They are individually not frequent travellers, although as a group they dominate air travel.

**Exhibit 3.7: Air Survey Results – Distribution by Trip Purpose**

| | Responses | |
|---|---|---|
| Purpose | Actual | Percent |
| ***Business*** | 472 | 54% |
| ***Personal Business*** | 81 | 9% |
| ***Recreation/Vacation*** | 91 | 10% |
| ***Visiting Friends/Relations*** | 159 | 18% |
| ***Shopping*** | 8 | 1% |
| ***Attend School*** | 44 | 5% |
| ***Attend Social Event*** | 21 | 2% |
| ***Other*** | 0 | 0% |
| ***Total*** | 876 | 100% |

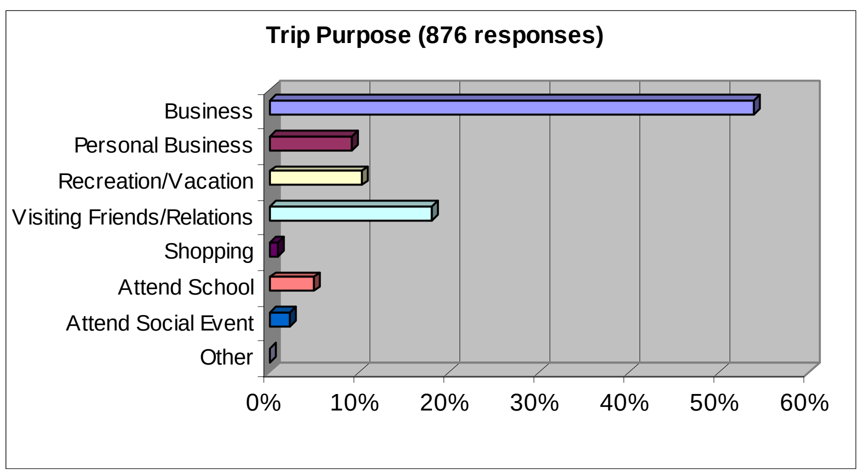



**Exhibit 3.8: Air Survey Results – Distribution by Income**

| | Responses | |
|---|---|---|
| Household Income | Actual | Percent |
| ***Less than 30,000*** | 58 | 7% |
| ***30,000 to 59,000*** | 103 | 13% |
| ***60,000 to 99,999*** | 224 | 28% |
| ***100,000 or more*** | 402 | 51% |
| ***Total*** | 787 | 100% |

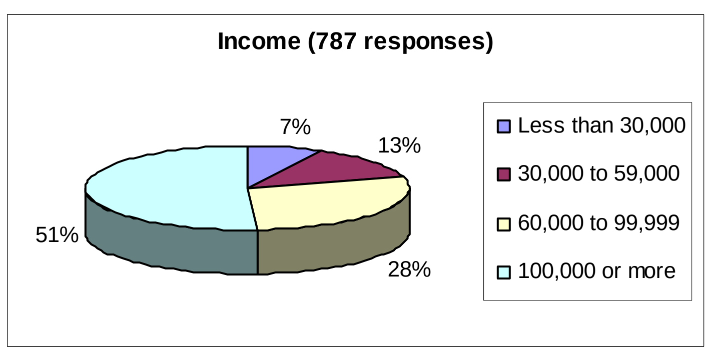


**Exhibit 3.9: Air Survey Results – Distribution by Employment Status**

| Employment Status | Responses Actual | Responses Percent |
|---|---|---|
| *Employed Full-time* | 676 | 78% |
| *Employed Part-time* | 87 | 10% |
| *Other* | 105 | 12% |
| *Total* | 868 | 100% |

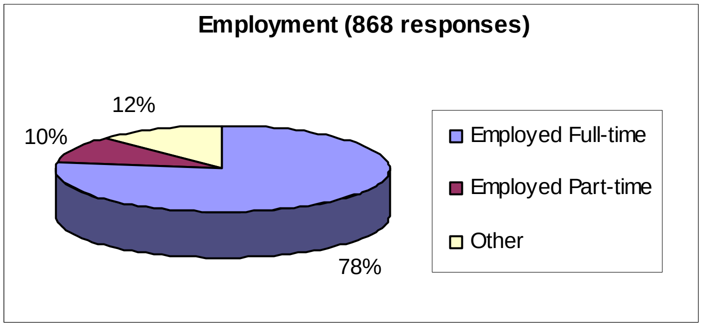



**Exhibit 3.10: Air Survey Results – Distribution by Trip Frequency**

| Trip Frequency | Responses Actual | Responses Percent |
|---|---|---|
| *Once a week* | 22 | 3% |
| *Twice a month* | 59 | 7% |
| *Once a month* | 147 | 17% |
| *Twice a year* | 159 | 18% |
| *Less than once a year* | 488 | 56% |
| *Total* | 875 | 100% |

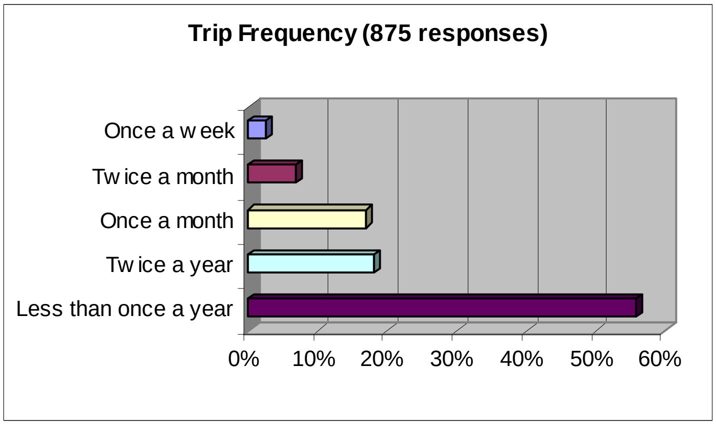



**Exhibit 3.11: Air Survey Results – Distribution by Trip Completion Mode**

| Trip Completion Mode | Responses Actual | Responses Percent |
|---|---|---|
| *Personal Auto* | 208 | 24% |
| *Rental Car* | 116 | 13% |
| *Air* | 53 | 6% |
| *Ride from family/friends* | 181 | 21% |
| *Bus* | 192 | 22% |
| *Other* | 125 | 14% |
| *Total* | 875 | 100% |

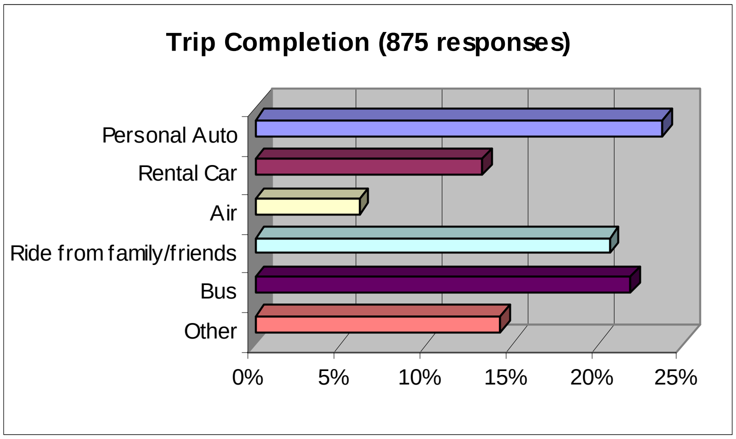
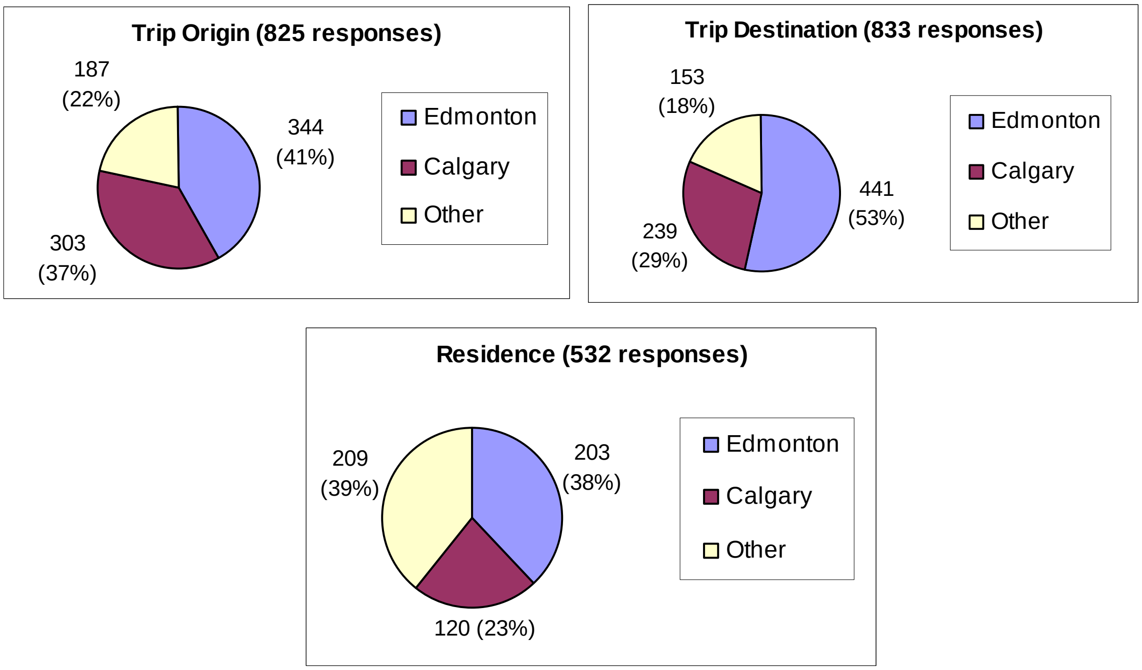


**Exhibit 3.12: Air Survey Results – Distribution by Trip Origin, Destination and Residence**




### 3.6.2 Auto Survey

A key issue in the analysis of license plates was the incorporation of matched license plates, which crossed two screenlines versus unmatched that only crossed one. Overall, it was found that the social profile indicators in this sample are very similar between matched and unmatched, the only difference being in the origin/destination of their journeys. Approximately 26% of the respondents travel for business, 32% to visit friends/relatives, and the remaining 42% is shared among the other purposes. Respondents in the matched sample are more likely to come from (and/or going to) either Calgary or Edmonton (approx. 60% versus 45%). This is an expected result, given that respondents in a matched sample are known to have travelled between screenlines in the camera survey. The results are based on 5,377 returned surveys.

**Exhibit 3.13: Highway Survey Distribution by Trip Purpose**

| | Responses | |
|---|---|---|
| Purpose | Actual | Percent |
| ***Business*** | 1346 | 26% |
| ***Personal Business*** | 801 | 15% |
| ***Recreation/Vacation*** | 617 | 12% |
| ***Visiting Friends/Relations*** | 1709 | 33% |
| ***Shopping*** | 304 | 6% |
| ***Attend School*** | 36 | 1% |
| ***Attend Social Event*** | 149 | 3% |
| ***Other*** | 206 | 4% |
| ***Total*** | 5168 | 100% |

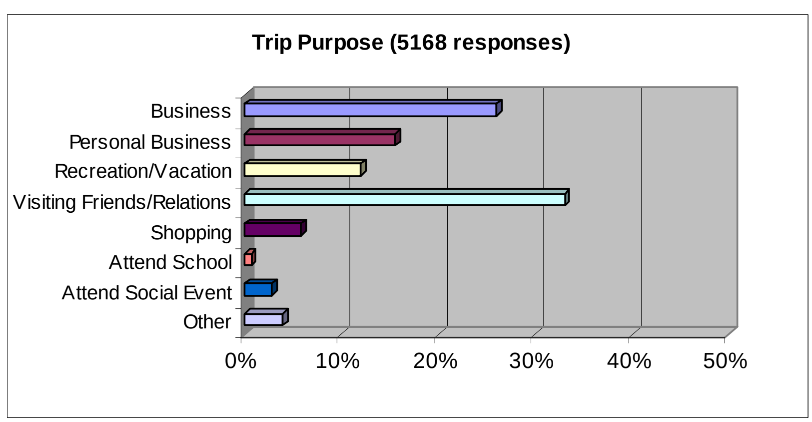


**Exhibit 3.14: Highway Survey Distribution by Income**

| | Responses | |
|---|---|---|
| Household Income | Actual | Percent |
| *Less than 30,000* | 251 | 5% |
| *30,000 to 59,000* | 997 | 20% |
| *60,000 to 99,999* | 1507 | 31% |
| *100,000 or more* | 2142 | 44% |
| *Total* | 4897 | 100% |

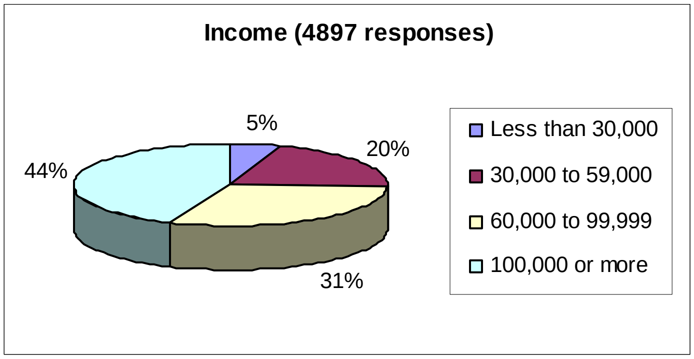



**Exhibit 3.15: Highway Survey Distribution by Employment Status**

| | Responses | |
|---|---|---|
| Employment Status | Actual | Percent |
| *Employed Full-time* | 3503 | 68% |
| *Employed Part-time* | 488 | 9% |
| *Other* | 1180 | 23% |
| *Total* | 5171 | 100% |

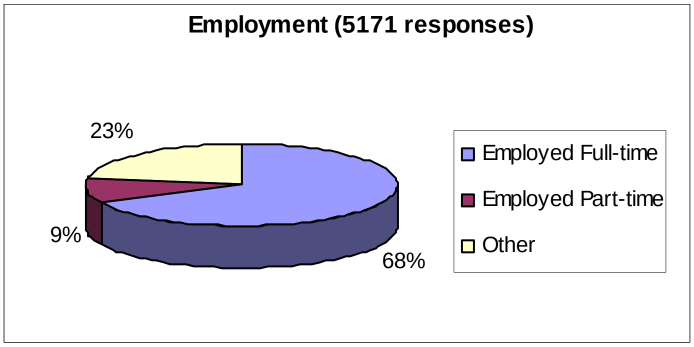



**Exhibit 3.16: Highway Survey Distribution by Trip Frequency**

| | Responses | |
|---|---|---|
| Trip Frequency | Actual | Percent |
| *Once a week* | 1200 | 23% |
| *Twice a month* | 742 | 14% |
| *Once a month* | 1026 | 20% |
| *Twice a year* | 838 | 16% |
| *Less than once a year* | 1368 | 26% |
| *Total* | 5174 | 100% |

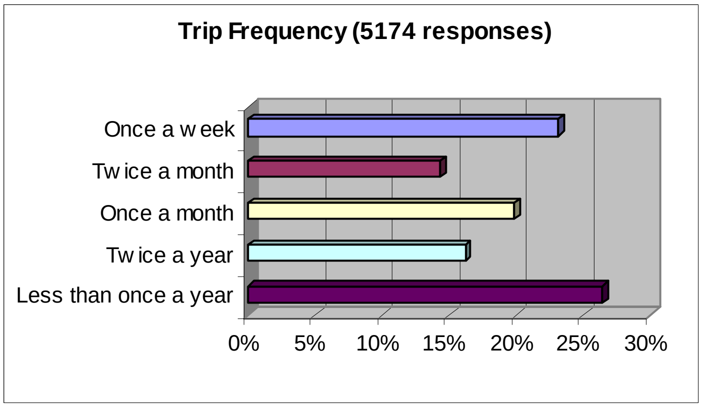


**Exhibit 3.17: Highway Survey Distribution by Trip Occupancy**

| Occupancy | Responses | |
|---|---|---|
| | Actual | Percent |
| *1 Occupant* | 1389 | 28% |
| *2 Occupant* | 2311 | 46% |
| *3 or more* | 1303 | 26% |
| *Total* | 5003 | 100% |

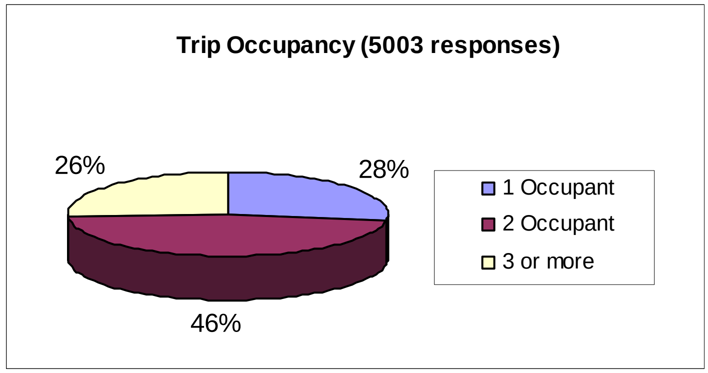
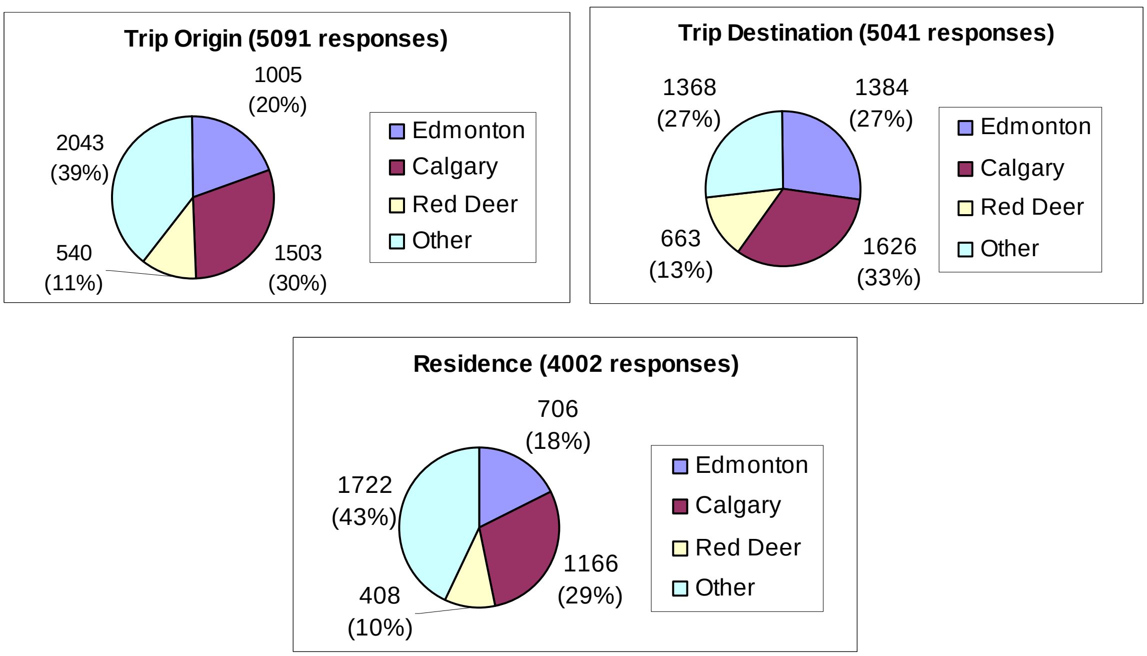



**Exhibit 3.18: Highway Survey Distribution by Trip Origin, Destination and Residence**




## 3.6.3 Bus Survey – Greyhound

Greyhound is the most inexpensive travel option in the corridor and the market profile shows that their typical customers are visitors (Exhibit 3.19), low-income earners (Exhibit 3.20), will not use their own car at the destination (Exhibit 3.21), and roughly one-third of them are neither going to nor from Edmonton, Calgary or Red Deer. The results are based on 469 surveys.

**Exhibit 3.19: Greyhound Survey Distribution by Trip Purpose**

| | Responses | |
|---|---|---|
| **Purpose** | **Actual** | **Percent** |
| ***Business*** | 65 | 17% |
| ***Personal Business*** | 55 | 15% |
| ***Recreation/Vacation*** | 53 | 14% |
| ***Visiting Friends/Relations*** | 153 | 41% |
| ***Shopping*** | 3 | 1% |
| ***Attend School*** | 11 | 3% |
| ***Attend Social Event*** | 5 | 1% |
| ***Other*** | 31 | 8% |
| ***Total*** | 376 | 100% |

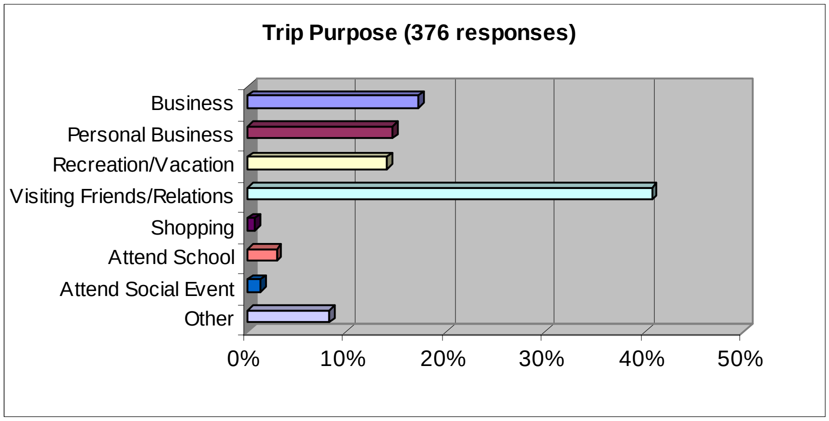



**Exhibit 3.20: Greyhound Survey Distribution by Income**

| | Responses | |
|---|---|---|
| **Household Income** | **Actual** | **Percent** |
| ***Less than 30,000*** | 81 | 31% |
| ***30,000 to 59,000*** | 76 | 29% |
| ***60,000 to 99,999*** | 59 | 22% |
| ***100,000 or more*** | 46 | 17% |
| ***Total*** | 262 | 100% |

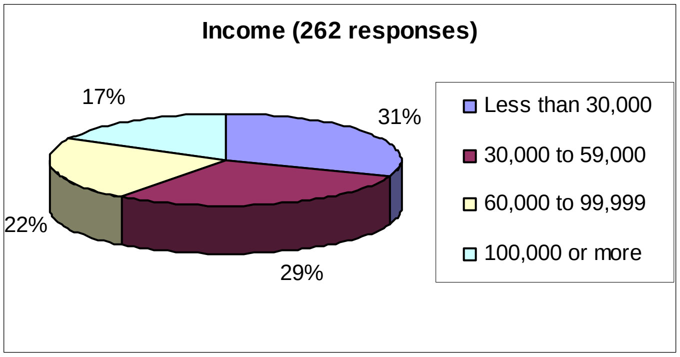



**Exhibit 3.21: Greyhound Survey Distribution by Employment Status**

| | Responses | |
|---|---|---|
| **Employment Status** | **Actual** | **Percent** |
| ***Employed Full-time*** | 180 | 54% |
| ***Employed Part-time*** | 46 | 14% |
| ***Other*** | 109 | 33% |
| ***Total*** | 335 | 100% |

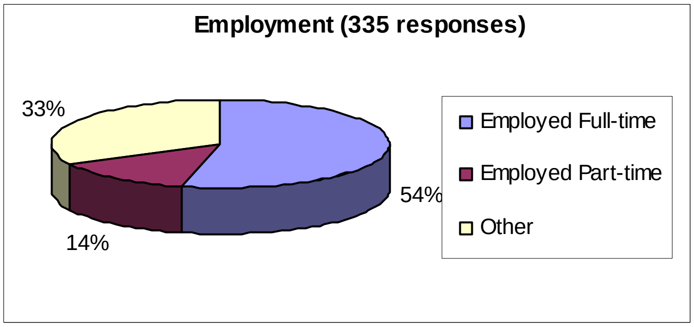


**Exhibit 3.22: Greyhound Survey Distribution by Trip Frequency**

| Trip Frequency | Responses Actual | Responses Percent |
|---|---|---|
| ***Once a week*** | 18 | 5% |
| ***Twice a month*** | 43 | 11% |
| ***Once a month*** | 70 | 19% |
| ***Twice a year*** | 109 | 29% |
| ***Less than once a year*** | 136 | 36% |
| ***Total*** | 376 | 100% |

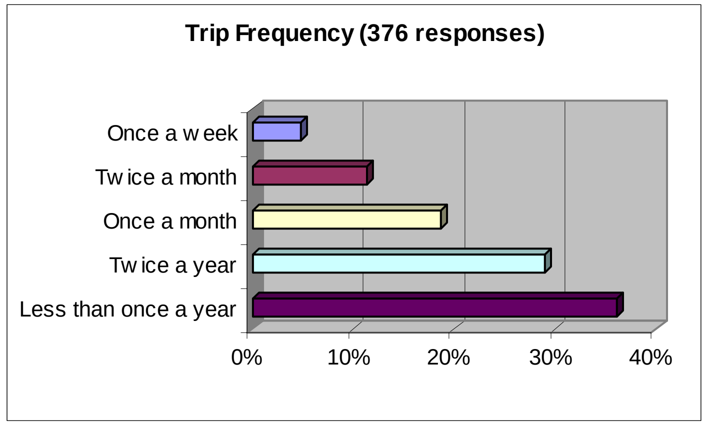



**Exhibit 3.23: Greyhound Survey Distribution by Completion Mode**

| Trip Completion Mode | Responses Actual | Responses Percent |
|---|---|---|
| ***Personal Auto*** | 64 | 17% |
| ***Rental Car*** | 3 | 1% |
| ***Air*** | 19 | 5% |
| ***Ride from family/friends*** | 109 | 29% |
| ***Bus*** | 151 | 40% |
| ***Other*** | 29 | 8% |
| ***Total*** | 375 | 100% |

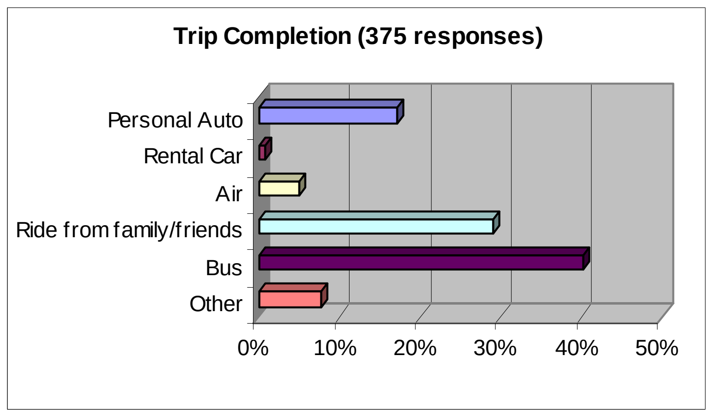
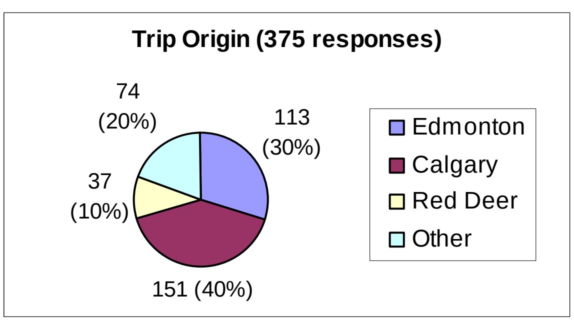
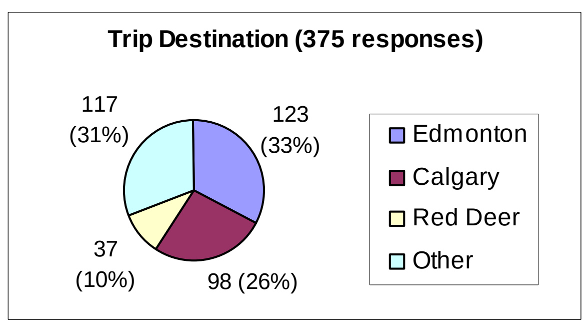
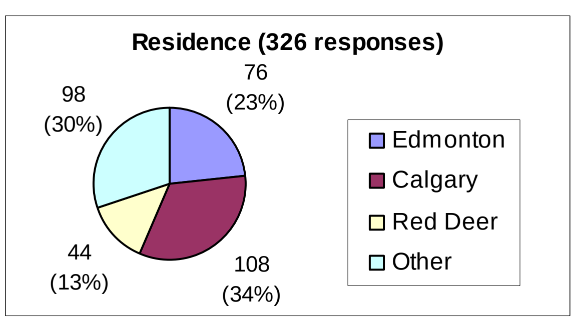



**Exhibit 3.24: Greyhound Survey Distribution by Trip Origin, Destination and Residence**



### 3.6.4 Bus Survey – Red Arrow

Red Arrow provides a rather different bus service than Greyhound, an entirely express service with more attention to comfort (wider seats, wireless internet on board, etc.), and this is reflected in the profile of their customers. Forty-two percent of Red Arrow ridership is on business travel, with a 35% of high-income earners. The results are based on 232 surveys.

**Exhibit 3.25: Red Arrow Survey Distribution by Trip Purpose**

| | Responses | |
|---|---|---|
| Purpose | Actual | Percent |
| *Business* | 84 | 42% |
| *Personal Business* | 32 | 16% |
| *Recreation/Vacation* | 13 | 7% |
| *Visiting Friends/Relations* | 59 | 30% |
| *Shopping* | 1 | 1% |
| *Attend School* | 3 | 2% |
| *Attend Social Event* | 1 | 1% |
| *Other* | 7 | 4% |
| *Total* | 200 | 100% |

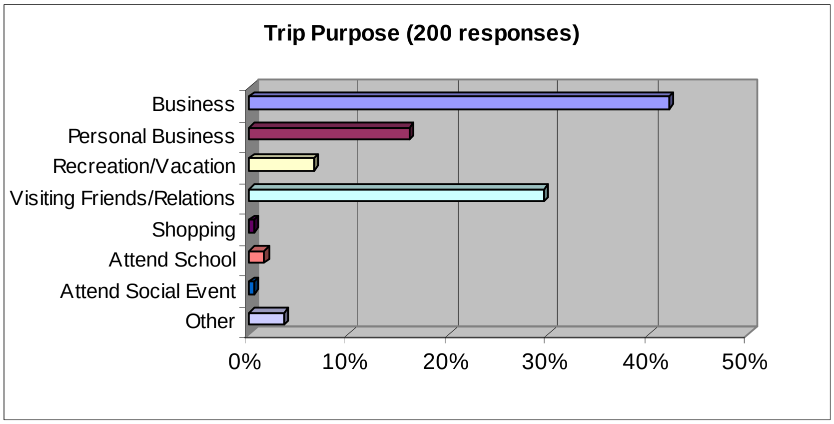



**Exhibit 3.26: Red Arrow Survey Distribution by Income**

| | Responses | |
|---|---|---|
| Household Income | Actual | Percent |
| *Less than 30,000* | 26 | 21% |
| *30,000 to 59,000* | 20 | 16% |
| *60,000 to 99,999* | 35 | 28% |
| *100,000 or more* | 43 | 35% |
| *Total* | 124 | 100% |

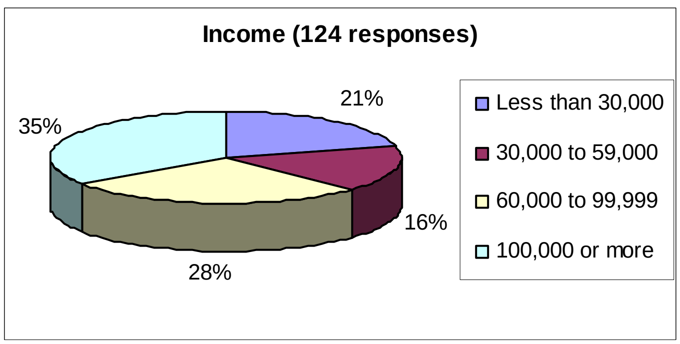
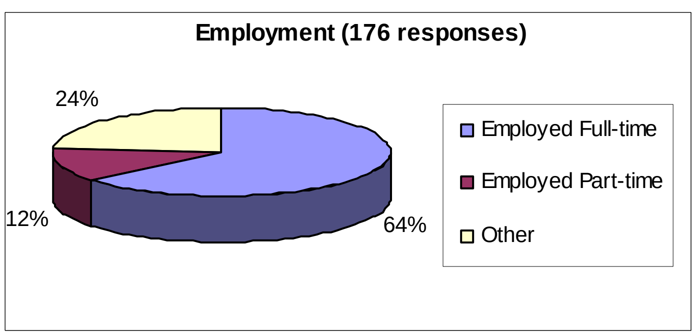


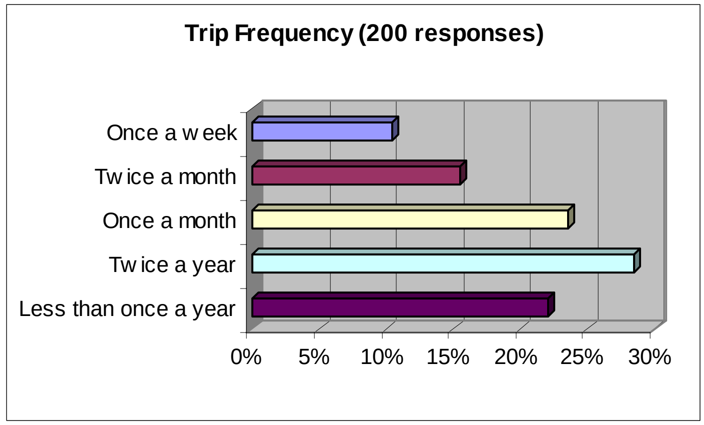

**Exhibit 3.27: Red Arrow Survey Distribution by Employment Status**

| | Responses | |
|---|---|---|
| Employment Status | Actual | Percent |
| *Employed Full-time* | 113 | 64% |
| *Employed Part-time* | 21 | 12% |
| *Other* | 42 | 24% |
| *Total* | 176 | 100% |



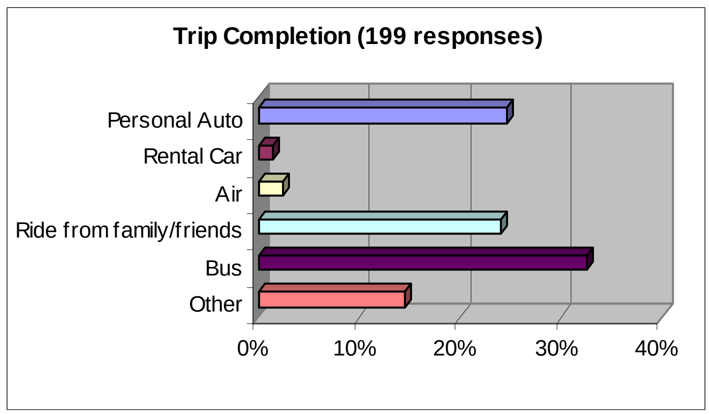
## Exhibit 3.28: Red Arrow Survey Distribution by Trip Frequency

| | Responses | |
|---|---|---|
| **Trip Frequency** | **Actual** | **Percent** |
| ***Once a week*** | 21 | 11% |
| ***Twice a month*** | 31 | 16% |
| ***Once a month*** | 47 | 24% |
| ***Twice a year*** | 57 | 29% |
| ***Less than once a year*** | 44 | 22% |
| ***Total*** | 200 | 100% |

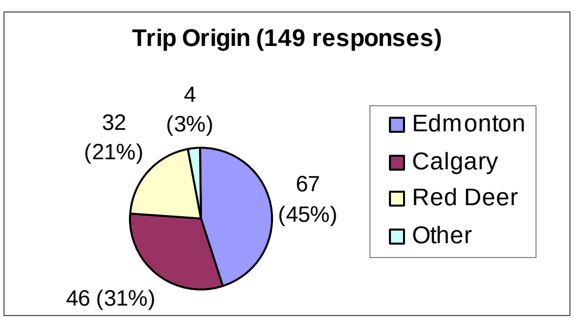


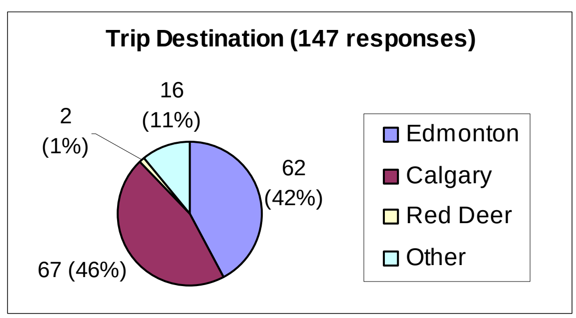

## Exhibit 3.29: Red Arrow Survey Distribution by Completion Mode

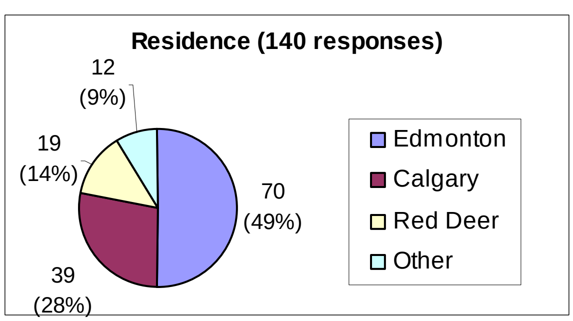
| | Responses | |
|---|---|---|
| **Trip Completion Mode** | **Actual** | **Percent** |
| ***Personal Auto*** | 49 | 25% |
| ***Rental Car*** | 3 | 2% |
| ***Air*** | 5 | 3% |
| ***Ride from family/friends*** | 48 | 24% |
| ***Bus*** | 65 | 33% |
| ***Other*** | 29 | 15% |
| ***Total*** | 199 | 100% |




## Exhibit 3.30: Red Arrow Survey Distribution by Origin, Destination and Residence



## 3.7 Survey Analysis: Values of Time / Value of Frequency

A critical result of the SP Survey is findings on Values of Time (VOT) and Value of Frequency (VOF). The *value of time* (VOT) (and associated Value of Frequency, Value of Access) is the most important parameter used to quantify the different behaviour of each user, with respect to important factors, like fuel cost, congestion level, etc, are altered. The VOT estimates the amount of money an individual is willing to pay to reduce travel time (VOT) or have an improved frequency of service (VOF).

### 3.7.1 Variability of the VOT

As described by Mackie [Mackie *et* al, 2001], it is commonly accepted in the current technical literature that the major influences on an individual's value of time are the following.

- The journey purpose (whether for business, commuting or leisure);
- the mode of travel;
- the time at which the journey is made; and
- the journey length.

The COMPASS™ Model System is equipped to include each one of these discriminating factors in the simulation process:

- The purpose of the journey is the single most important discriminating factor that defines the value of time of a traveller. The current practice in transport modelling accepts that business travel has considerably higher average value of time than non-business travel (whether for the purpose of commuting or leisure). It is, therefore, essential, in order to understand the change in time of traffic volumes, that trip matrices are split by purpose, for each purpose has a well-defined average value of time.

- The mode of travel is another very important factor that differentiates users' response to changes in utility of travel. The same traveller will have different observed values of time whether he/she completes his/her journey by train or his/her own vehicle.

- The time of the journey needs careful consideration (especially in any forecasting problem that deals with hourly traffic volumes) for traffic in different hours of the day does not necessarily grow at the same rate. This disparity is also reflected in the different composition of traffic at different times of the day. For example, it is natural to expect, in a corridor linking residential areas to centers of employment, that peak hour traffic would be composed mainly of commuter travellers, while the middle hours of the day would be instead full of leisure and some business travellers. These categories of travellers have different VOT, hence the knowledge of the composition of traffic at different times of the day is an important factor in terms of the quality of a traffic forecast. For the purpose of this report, however, this differentiation will not be taken into consideration because the results from the auto survey did not allow us to extract the time of travel of a respondent.

- Finally, there is enough empirical evidence to suggest that the journey length has some impact on the VOT of a traveller (see, for example, [Calfee and Winston, 1998; TEMS, 2003]). To tackle this problem, the COMPASS™ Model System can include two types of models, a *short* model option and a *long* model option. What option model is eventually used depends on whether the distance between origin and destination is greater or not than a specified threshold that is usually between 30 and 80 kilometers. Considering the scale of the study area (the distance between Edmonton and Calgary is approximately 300 kilometers) most trips of interest for HSR are of distance higher than this range, hence the variation of VOT with distance was not included in the simulation procedure.

### 3.7.2 Analysis and Survey Results

All survey forms included questions to determine the time/cost and frequency/cost tradeoffs travellers make on the existing modes of travel. The determination of an average value of time (VOT) and the average value of frequency (VOF) is done in two steps.

- First, by assigning a VOT to each answered tradeoff questionnaire that shows a "trading" pattern, i.e., a pattern of answers where a respondent crosses or marks the "no preference" line to become a "trader" as opposed to an individual who does not mark the line and is defined as a non-trader (the survey forms are shown in Appendix B).

- Second, by fitting a continuous distribution of VOT in order to allocate those respondents who did not "trade," i.e., whose VOTs are, therefore, outside the range present in the questionnaire. This second step is very often ignored on the basis that the survey population is normally distributed. However, there is theoretical and empirical evidence that suggests that the distribution of VOT for a traveller is lognormal (*i.e.* not distributed normally, but is biased positively or negatively around the mean value, with a long tail for high values) (see, for example, [Rogers *et al.*, 1970]). The theoretical arguments [Oort, 1969; Mackie et al., 2001] are based on the assumption that the VOT is linearly correlated with the wage rate, which is known from demographic research to be lognormally distributed. The empirical evidence is instead derived through various types of surveys [HCG, 1990; Gunn et al., 1999; Wardman, 2001; Hensher and Button, 2002; Hensher and Green, 2003; TEMS, 2003; Fosgerau, 2006].

As a result, in an investment grade study the second step is a potential correction to the VOT estimates. In the analysis performed, it was found that the revised values required only minor adjustment showing that the initial surveys provided a good representation of each quota group, and that the "non trader" respondents were both small in number, and equally balanced between high and low values. For Values of Time the only exception was in the case of air business travellers whose value was raised from $41.00 per hour to $52.70 per hour. The impact of the adjustment is shown in Exhibits 3.31 through 3.34.

**Exhibit 3.31: Values of Time for Traders in the Survey Questionnaire**

| Trip Purpose/Transport Mode | Air | Greyhound | Red Arrow | Auto |
|---|---|---|---|---|
| Business | 41.00 $/hr | 11.91 $/hr | 14.11 $/hr | 18.64 $/hr |
| Non-business | 33.36 $/hr | 9.14 $/hr | 13.01 $/hr | 16.11 $/hr |

**Exhibit 3.32: Corrected Values of Times to Account for Non-traders**

| Trip Purpose/Transport Mode | Air | Greyhound | Red Arrow | Auto |
|---|---|---|---|---|
| Business | 52.70 $/hr | 13.21 $/hr | 16.71 $/hr | 21.43 $/hr |
| Non-business | 34.41 $/hr | 9.16 $/hr | 14.61 $/hr | 16.81 $/hr |

Exhibits 3.33 and 3.34 show the results of the same analysis with the value of frequency, VOF. The biggest correction in this case was our business travellers that were adjusted from $41.7 per hour to $45.00 per hour.

**Exhibit 3.33: Values of Frequency for Public Modes for Traders in the Survey Questionnaire**

| Trip Purpose/Transport Mode | Air | Greyhound | Red Arrow |
|---|---|---|---|
| Business | 41.66 $/hr | 8.20 $/hr | 12.24 $/hr |
| Non-business | 37.12 $/hr | 7.98 $/hr | 11.19 $/hr |

**Exhibit 3.34: Corrected Values of Frequency to Account for Non-traders**

| Trip Purpose/Transport Mode | Air | Greyhound | Red Arrow |
|---|---|---|---|
| Business | 44.97 $/hr | 8.20 $/hr | 12.24 $/hr |
| Non-business | 37.12 $/hr | 7.98 $/hr | 11.31 $/hr |

The net effect of these adjustments is to slightly raise VOT and VOF, which slightly suggests that travellers will be slightly more sensitive to improved travel times and frequencies than suggested by the uncorrected numbers.

### 3.7.3 Values of Time/Frequency for High-Speed Rail

Values of time/frequency for HSR were derived by direct comparison to the corresponding values for auto and air, with the assumption that all rail technologies would fall in between these two modes. The value of time for rail travel was evaluated as a weighted average between auto and air according to the level of service offered by rail, which is why, most rail technologies have values of time closer to air than auto. A scheme of this attribution is shown in Exhibit 3.35. Exhibit 3.36, instead, shows the values of time/frequency for HSR derived with this method.

**Exhibit 3.35: Hierarchy of HSR Placement for HSR Values of Time and Frequency**

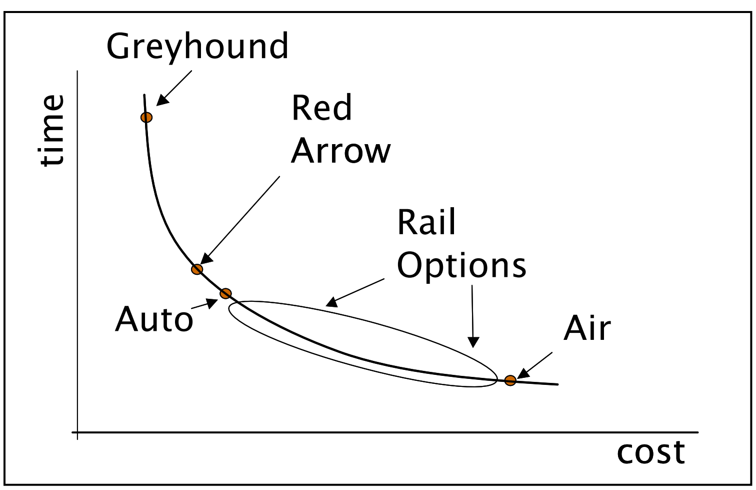


**Exhibit 3.36: VOT/VOF for the Four HSR Technologies Considered**

| | VOT ($/hr) | | VOF ($/hr) | |
|---|---|---|---|---|
| Purpose | Business | Other | Business | Other |
| 125 mph | 40.81 | 27.05 | 34.82 | 29.17 |
| 150 mph | 44.05 | 29.06 | 37.59 | 31.34 |
| 200 mph | 47.73 | 31.33 | 40.72 | 33.79 |
| 300 mph | 51.83 | 33.87 | 44.22 | 36.54 |

## 3.8 Survey Analysis: Data Expansion

In Chapter 2, the trips between different urban areas were presented in Exhibit 2.1. These trips were derived by the following analysis.

The responses from the survey questionnaires allowed TEMS to produce a matrix and map of geographical movements by mode between the study zones outlined in Section 2.3. The procedure to obtain province-wide origin/Destination (O/D) trip matrices from the survey data is made of four steps as listed below:

- Form a database of origin/destination pairs from the returned survey questionnaires;
- estimate a causal relationship between O/D patterns, demographic variables and generalized cost of travel;
- expand the data to the entire territory of the Province of Alberta; and
- validate O/D trip matrices by matching seeded trips to known traffic volumes in selected screen lines.

Not all surveys, of course, reported complete information on the origin and destination of each trip. In most circumstances, travellers report easily the postal code of the origin (this often being their residence), but they often do not know the postal code of their destination. The sample of available survey origin-destination patterns allowed us to fit the causal relationship of the form

$$\log T_{ij}^{mp} = \alpha_0^{mp} + \alpha_1^{mp} \log\left[SE_{ij}^{mp}\right] + \alpha_2^{mp} GC_{ij}^{mp}$$

for all O/D pairs ($i,j$), and all modes $m$ and purposes of travel $p$. The term $SE_{ij}^{mp}$ within square brackets represents the demographic contribution to trip generation, and its functional form, a combination of population, employment and income, is described in detail in Appendix A. The various α coefficients are the result of the calibration shown in the table in Exhibit 3.37. The α coefficient measures the power of each variable and its importance in trip making.

The coefficients shown in the table below were then used to perform a data expansion to produce province-wide trip matrices. The validation of the matrices was done by comparison of these trips to the known traffic volumes on the corridor for the year 2006.

For the auto trip matrix the estimated trip volumes were rescaled to match traffic at four screen-lines, shown in the table in Exhibit 3.38. The exhibit shows the AADT (Average Annual Daily Traffic), and the one way passenger flow at each screenline. This provides the passenger volumes comparison used to calibrate the estimated origin destination matrix shown in Exhibit 3.39.

**Exhibit 3.37: Coefficients of the O/D Trips Calibration for the Survey Results**

| Coefficient | | $\alpha_0$ | $\alpha_1$ | $\alpha_2$ |
|---|---|---|---|---|
| Auto | Business | -5.58 | 0.32 | -0.013 |
| | Other | -6.08 | 0.35 | -0.012 |
| Air | Business | 1.40 | 0.25 | -0.037 |
| | Other | 1.03 | 0.29 | -0.017 |
| Greyhound | Business | -5.12 | 0.28 | -0.059 |
| | Other | -5.65 | 0.31 | -0.074 |
| Red Arrow | Business | -5.26 | 0.33 | -0.031 |
| | Other | -7.10 | 0.35 | -0.025 |

**Exhibit 3.38: Screen-lines Used for Validation of Trip Matrices**

| Line | From | To | AADT | Estimated One Way Passenger Volume |
|---|---|---|---|---|
| SL1 | N OF 566 E OF BALZAC | S OF 567 AT AIRDRIE | 47890 | 21383 |
| SL2 | N OF MCKENZIE INTERCHANGE | S OF GAETZ AVE RED DEER | 36710 | 15657 |
| SL3 | N OF 12 W OF LACOMBE | S OF 2A NE OF LACOMBE | 21400 | 8582 |
| SL4 | N OF AIRPORT RD (EDM INTL) | S OF 19 and 625 W OF NISKU | 50120 | 22404 |

The data expansion yielded the daily one-directional passenger vehicle (PV) daily trip matrix shown in Exhibit 3.39. Volumes of trips between origin and destination and between destination and origin are equal in both directions. Specifically, since there are 3,450 passenger vehicles per day from Calgary CMA to Edmonton CMA and vice versa, there is a total of 6,900 PV/day between both cities. It was found in the survey that the average car occupancy was 2.0, and as a result the annual one-way person traffic volume is estimated at 5.037 million person trips a year.

By this same method, trips to/from Red Deer have been estimated with at 3,202 PV/day between Red Deer and Calgary, and 2,047 PV/day between Red Deer and Edmonton, for a total of 5,249 PV/day originated from Red Deer. With an average occupancy of 2.0, as obtained in the survey, this volume of vehicle trips translates into 3.890 million person trips between Red Deer and both Calgary and Edmonton.

Bus traffic has been computed with the assumption that seating capacity is 54 seats for Greyhound and 36 seats for Red Arrow. The one-way frequency is 8 buses/day for Greyhound (express buses only) and 6 buses/day for Red Arrow (by definition, they are all express). From the survey it was calculated that the seat occupancy is 42% for Greyhound and 58% for Red Arrow. Multiplying the seat occupancy by the total number of seats available it was found that there was 257,166 trips/year in both directions (i.e., Edmonton-Calgary and vice versa). This number was adjusted upwards using a seasonal factor 1.1485 to account for seasonality (the survey was carried out in November, a month with slow traffic). The seasonal factor was derived from annual counts of traffic in the corridor. The total bus traffic between the cities of Calgary, Edmonton and Red Deer at 295,367 trips/year. The breakdown between Greyhound and Red Arrow gives 174,724 trips on Greyhound per year and 120,642 on Red Arrow per year.

**Exhibit 3.39: Super-Zone to Super-Zone (Division) Flows of Daily Passenger Vehicles Trips in the Province of Alberta**

| | Destination | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Origin | | **Medicine hat** | **Lethbridge** | **Fort Macleod** | **Hanna** | **Strathmore** | **Calgary** | **Stettler** | **Red Deer** | **Rocky Mtn H** | **Camrose** | **Edmonton** | **Cold Lake** | **Athabasca** | **Edson** | **Canmore** | **Fort Mcmurray** | **Slave Lake** | **Grande Cache** | **Grande Prairie** |
| **1** | **Medicine Hat** | 506 | | | | | | | | | | | | | | | | | | |
| **2** | **Lethbridge** | 1562 | 9817 | | | | | | | | | | | | | | | | | |
| **3** | **Fort Macleod** | 401 | 3114 | 1042 | | | | | | | | | | | | | | | | |
| **4** | **Hanna** | 134 | 629 | 0 | 1593 | | | | | | | | | | | | | | | |
| **5** | **Strathmore** | 536 | 248 | 178 | 895 | 508 | | | | | | | | | | | | | | |
| **6** | **Calgary** | 778 | 596 | 377 | 176 | 7846 | 247927 | | | | | | | | | | | | | |
| **7** | **Stettler** | 35 | 49 | 0 | 298 | 292 | 249 | 182 | | | | | | | | | | | | |
| **8** | **Red Deer** | 8 | 39 | 18 | 149 | 980 | 1601 | 1441 | 10046 | | | | | | | | | | | |
| **9** | **Rocky Mtn H** | 0 | 0 | 0 | 0 | 121 | 1412 | 120 | 138 | 0 | | | | | | | | | | |
| **10** | **Camrose** | 0 | 4 | 0 | 29 | 24 | 57 | 512 | 69 | 4 | 2074 | | | | | | | | | |
| **11** | **Edmonton** | 11 | 6 | 21 | 60 | 544 | 3450 | 1086 | 1024 | 304 | 4248 | 273211 | | | | | | | | |
| **12** | **Cold Lake** | 0 | 0 | 0 | 1 | 0 | 0 | 30 | 10 | 0 | 342 | 1312 | 132 | | | | | | | |
| **13** | **Athabasca** | 0 | 0 | 0 | 0 | 0 | 5 | 3 | 137 | 37 | 165 | 2136 | 319 | 6294 | | | | | | |
| **14** | **Edson** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 79 | 21 | 85 | 1842 | 0 | 258 | 0 | | | | | |
| **15** | **Canmore** | 0 | 268 | 1053 | 0 | 66 | 9510 | 0 | 77 | 172 | 0 | 200 | 0 | 0 | 895 | 192 | | | | |
| **16** | **Fort Mcmurray** | 0 | 0 | 0 | 0 | 0 | 38 | 0 | 0 | 0 | 0 | 520 | 1 | 163 | 0 | 0 | 8235 | | | |
| **17** | **Slave Lake** | 0 | 0 | 0 | 0 | 0 | 29 | 0 | 0 | 0 | 0 | 318 | 0 | 1224 | 31 | 0 | 0 | 347 | | |
| **18** | **Grande Cache** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 113 | 0 | 909 | 65 | 0 | 0 | 423 | 0 | |
| **19** | **Grande Prairie** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 161 | 0 | 113 | 98 | 0 | 0 | 1626 | 165 | 5757 |

Regarding air traffic, the assumptions for the calculations of air traffic were a seating capacity of 52 for Air Canada's aircrafts and an average of 136 for WestJet (their fleet has 13 planes with capacity of 119, 49 with capacity of 136 and 6 of capacity of 166). The weekend schedule shows 23 flights per day in both directions for Air Canada and 10 for WestJet. The weekday schedule shows 33 flights per day in both directions for Air Canada and 14 for WestJet. From the survey results we have found a capacity of 80%. This may be a lower estimate considering that surveyors could not determine in all circumstances what type of aircraft was being boarded. Also, from the survey results we estimated that 59% of weekday travellers were Calgary-Edmonton travellers, all other connecting. For the weekends this percentage dropped to 42%. Hence we obtained 536,529 Calgary-Edmonton trips/year, which adjusted upwards with the seasonality factor 1.1485 yields 616,229 trips/year.

The overall trip volumes were previously shown in Chapter 2, Exhibit 2.1, and are repeated in Exhibit 3.40 below.

**Exhibit 3.40: Volume of Estimated Yearly Passenger Trips for the Base Year (2006)**

| | Calgary-Edmonton | | Red Deer-Calgary/Edmonton | | Total | |
|---|---|---|---|---|---|---|
| **Auto** | 5,037,000 | 86% | 3,889,000 | 98% | 8,927,000 | 91% |
| **Air** | 616,000 | 10% | 0 | 0% | 616,000 | 6% |
| **Bus** | 236,000 | 4% | 60,000 | 2% | 296,000 | 3% |
| **Total** | **5,889,000** | **100%** | **3,950,000** | **100%** | **9,839,000** | **100%** |

### 3.8.1 Auto Trip Validation

In order to validate the auto trip volumes estimated in the TEMS data expansion process, a comparison between yearly trip volumes in the Calgary – Edmonton corridor was made with the only other studies that have estimated the potential for auto traffic for the whole Edmonton-Calgary corridor (i.e.,1983 Transmark/IBI study [Transmark, 1983], the Van Horne study [Van Horne, 2004], and AIT internal estimate). These studies each estimated the volume of auto traffic between Edmonton and Calgary, and provided a direct comparison with the new TEMS estimates.

The Van Horne's estimate of 5.268 million passenger trips is between Calgary-Edmonton and was not for the whole CMA. As a result, the Van Horne estimates were updated using the ratio of populations CMA/city to update the population growth, and a trip elasticity to estimate the increase trip making due to the increased population. For Calgary, the population ratio CMA/city is 1.08, while for Edmonton it is 1.41, and the trip elasticity for demographic growth was estimated at 0.7 based on the total COMPASS™ demand model calibration (Appendix A).

An additional validation of the trip volumes between Calgary, Edmonton and Red Deer can be achieved by the sample of matched license plates that were collected during the photographic survey whose results were detailed in Exhibit 3.4. This additional validation is obtained by examining the times when all pictures were taken to then obtain a time interval where possible vehicles could have been matched. Given that the hourly traffic on the days of the camera survey is known on locations close to the camera sites, it is then possible to obtain an estimate of the number of passenger vehicles that have travelled between two screen lines. However, this methodology incorporates several uncertainties, mostly related to the definition of a viable time interval for possible matches:

- In order to obtain a time interval when vehicles were expected to pass between screen lines, an average speed has to be estimated; for example, a vehicle whose license plate was recorded in, say, Leduc travelling southbound, could appear in Crossfields approximately 2½ hours later. This approximation helps us define what time interval we expect to find matches; however, vehicles' travel times may be scattered around this average in various ways.

- Screen lines were set quite far apart from each other (Leduc & Red Deer, for example, are approximately 125km apart), hence each location had its own climate. For example, in one instance, cameras could not operate for a few hours in the morning in Leduc because of fog while at the same time a camera in Red Deer was perfectly functioning. As a result, the time interval to find matches could diminish.

- The cameras used in the survey were manned (user-operated) and photographers were quite visible to travellers, making them prone to interruptions (for example, by local enforcement officers on patrol).

- As mentioned in Chapter 2, the two cameras on location do not necessarily record vehicles travelling between screen lines successfully. For example, for the security of the photographers, cameras are located sideways with respect to the road. In this situation, a vehicle travelling in the lane further away from the camera could be hidden in front of the camera lens by a passing truck in the nearby lane. This way a number of matched license plates could not be retrieved.

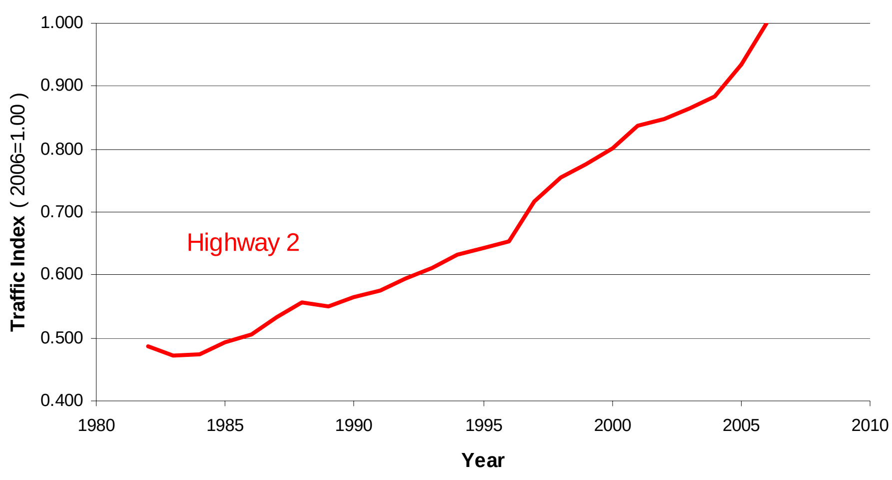
Underestimating the time interval when matches could be found would lead to overestimation of traffic between screenlines, and vice versa. With these uncertainties, we were able to conclude by this method that the volume of Calgary-Edmonton (CMAs) traffic is between 1,800 pv/day and 4,200 pv/day (pv stands for passenger-vehicles).

The Transmark/IBI estimate was prepared in 1982-1983, with trips measured in 1981. The trips were updated by assuming a three percent yearly growth, which reflects the actual growth in highway traffic over the period.

The AIT estimate[9] is that the traffic in Calgary-Edmonton nearly doubled in this 25-year span. An estimate of the traffic index with AADTs measured at the traffic station in Leduc, as shown in the Exhibit below, gives the estimated trend. The trips generated by this expansion process were compared with other estimates of trips in the corridor.

[9] Provided by Alberta Infrastructure and Transportation Program Management Branch, Network Planning and Performance Section.

**Exhibit 3.41: Auto Traffic Growth for Edmonton-Calgary Trips Measured with Highway 2 ATR Traffic Index (AIT)**




Finally, the estimates from the different studies are shown in Exhibit 3.42.

**Exhibit 3.42: Annual Trip Volumes Calgary CMA – Edmonton CMA in Three Different Studies**

| Study | Auto Volume (in million trips/year) |
|---|---|
| [Transmark, 1983] | 1.372 |
| [Transmark, 1983] adjusted to 2006 | 4.104[10] |
| [Van Horne, 2004] (cities only) | 5.268[11] |
| [Van Horne, 2004] adjusted to CMA | 7.071[12] |
| TEMS Study (2006-2007) | 5.037[13] |
| Alberta Infrastructure and Transportation (2006) | 3.800[14] |

The volumes derived in the present study are reasonably close to the AIT estimate of 3.8 million. The AIT estimate of 3.8 million is base on an average occupancy rate of 1.87. However, an occupancy rate of 2.03 was derived in the TEMS corridor surveys. If the survey estimates were applied, it raises the AIT traffic volume to 4.125 million trips/year, which is even closer to the TEMS estimate of 5.04 million. The same comparison can be made for Red Deer traffic used in the Van Horne study and TEMS Expansion Process.

10 Adjusted with a 3% growth factor for the 25-years period 1981-2006.

11 Original estimate quoted in [Van Horne, 2004].

12 Adjusted to include an extimation of the extra trips generated in the areas outside city limits, but within CMAs.

13 Estimate from TEMS Data Expansion Section 3.8

14 Independent estimate from the Alberta Infrastructure and Transportation Program Management Branch, Network Planning and Performance Section.

**Exhibit 3.43: Annual Trip Volumes from Red Deer to both Edmonton and Calgary**

| Study | Auto Volume (in million trips/year) |
|---|---|
| [Van Horne, 2004] (cities only) | 5.100 |
| [Van Horne, 2004] adjusted to CMA | 5.640 |
| TEMS Study (2006-2007) | 3.889[10] |

The generated trips for the corridor are plotted against distance in order to obtain a description of the auto trip length function of travellers. Exhibits 3.44 and 3.45 show the distribution of trip lengths by purpose. The shapes of these distributions are typical with a vast majority of trips being with short distance, with a diminishing tail of long-distance trips. The average trip lengths are of 47km and 43km, respectively.

**Exhibit 3.44: Daily Trip Length Function for Business Travellers**

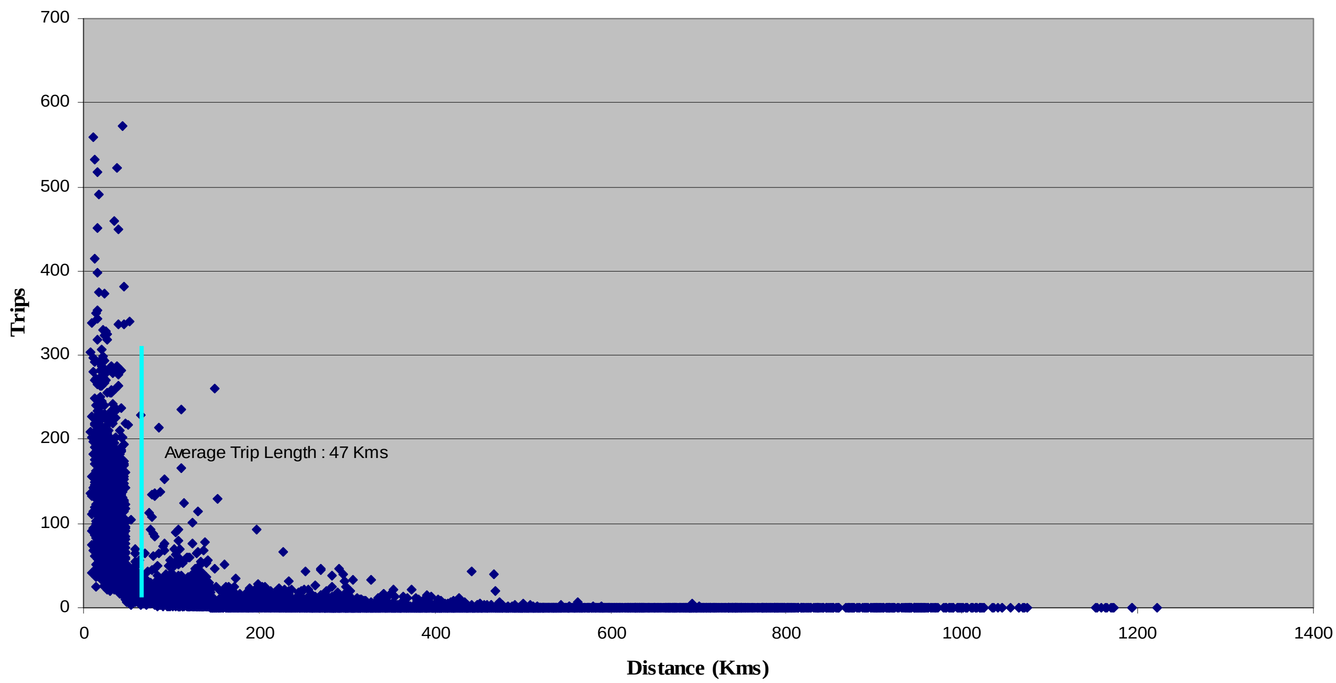
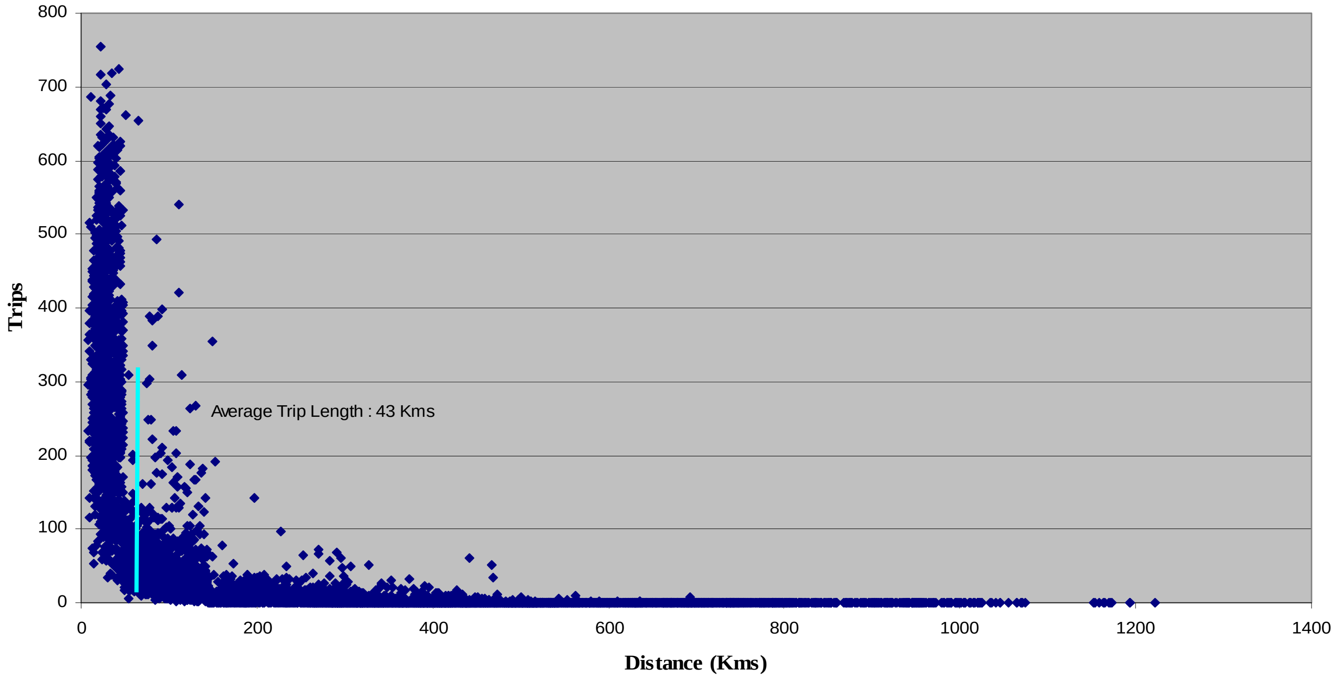


**Exhibit 3.45: Daily Trip Length Function for Other Travellers**



# 4

# Economic Scenarios

## 4.1 Economic Database and Sources

The development of long-term forecasts using the COMPASS™ Demand Forecasting Model requires the preparation of socioeconomic scenarios for the base-year (2006) and the forecast years 2011-2051 at five-year intervals. Previous research has shown that the key socioeconomic variables required to forecast intercity passenger traffic include population, employment, and average household income[15]. Projections were made for each of the 158 transportation zones in the province of Alberta that forms the Study Area.

In order to evaluate the potential range of change in the economy, projections for the socioeconomic variables were made for three growth scenarios: high (aggressive), low (conservative) and central (moderate). The high-growth scenario assumed comparatively high population and employment growth particularly in urban areas. The low case has much slower growth in urban areas, with growth gradually slowing down at the end of the forecasting period. The central-case scenario was used for the base case analysis.

Statistical base and historical data on population, employment, average household income, and number of households was obtained from the 1991, 1996, 2001 and 2006 Census of Canada [StatsCan, 2007; Alberta First, 2007]. Data for Edmonton zones (which correspond to the Edmonton traffic districts [City of Edmonton, 2007a]) was obtained from the City of Edmonton demographic database [City of Edmonton, 2007b].

Projections on population, employment and average household income were developed using official projections at the national, provincial and local levels. These projections were analyzed and processed using the Demographic Projections Model developed by TEMS. During the model calibration process, data on population, employment, and income for the base and forecast years was adjusted to the zone system of the study area. Projections for subdivisions in Edmonton Region (outside the city) were allocated to the corresponding zones that included these subdivisions. Projections for traffic regions in Edmonton City were corrected using 2003-2030 projections by traffic regions prepared by Applications Management Consulting Ltd. And the new projections for Edmonton City prepared by the same firm.

[15] Data on the number of households is used on the intermediate stage of database development.

Details of the sources used for each demographic variable are described below.

### 4.1.1 Population

Long-term population projections for census divisions in the province of Alberta for the three scenarios (low, moderate and high) were obtained from Alberta Finance [Alberta Finance, 2004]. Central case population forecasts for census divisions were prepared by comparing the above-mentioned projections with 2006 Census data and choosing the Alberta Finance forecasts that best correlated with recent data. For example, in the Calgary division recent population growth corresponds to the moderate scenario from Alberta Finance and, in the Edmonton division, to the moderate-high scenario. At the same time, population in the Red Deer and Fort McMurray divisions is more likely to grow according to the high scenario and, the Lethbridge or Athabasca divisions, according to the low scenario. In general, the moderate-low population forecast made by Alberta Finance was selected as a central case.

In TEMS' Demographic Projections Model forecasts made for the province and divisions were integrated with the forecasts made for the cities (subdivisions) and even smaller areas. For example, population and employment projections for study zones in the City of Edmonton were prepared using the long-term forecasts for the corresponding Edmonton traffic districts [City of Edmonton, 2005]. For the Calgary city and region, population projections for the study zones were made using the long-term population forecasts for transportation zones developed by the City of Calgary and reflected in the Calgary Regional Transportation Model [City of Calgary, 2007].

**Exhibit 4.1: Population Projections (2006-2051) for Alberta Study Area – 3 Scenarios**


Long-term and medium-term population projections available for the major cities or subdivisions in the study area (such as Calgary [City of Calgary, 2003], Strathcona County [Strathcona, 2007], Red Deer [City of Red Deer, 2006], Lethbridge [City of Lethbridge, 2001], Medicine Hat [City of Medicine Hat, 2007] and

Grande Prairie [City of Grand Prairie, 2006]) were also used. Use of historical (1991-2006) trends for each subdivision together with all available official population projections (including projections at the national level through 2056) [StatsCan, 2005] resulted in developing population projections by study zone for the three scenarios and the 45-year forecasting period, see Exhibit 4.1.

### 4.1.2 Employment

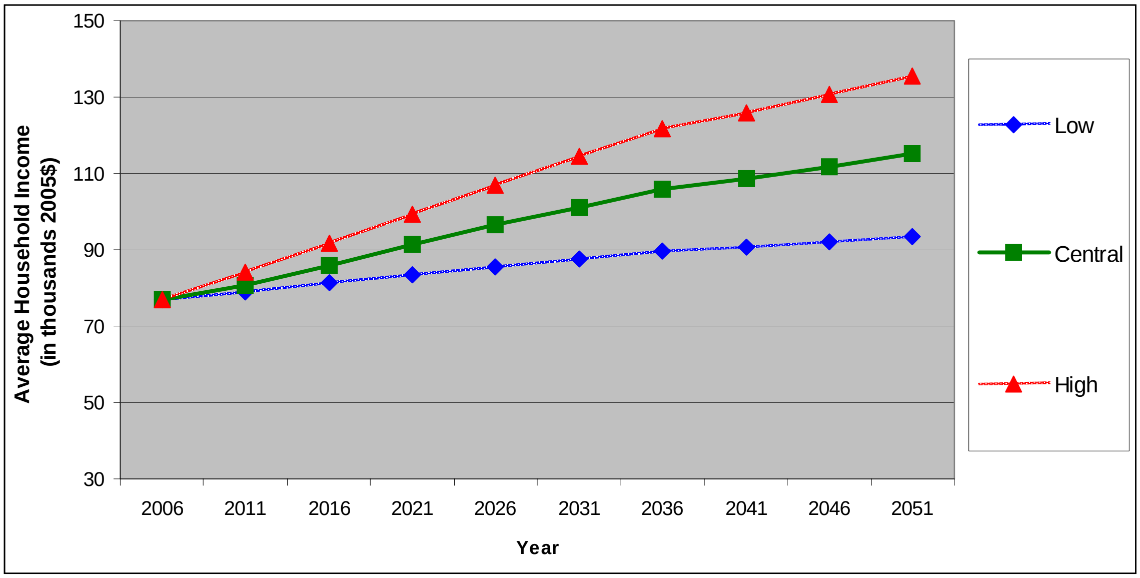
Using long-term population projections by age group (low, moderate and high) for census divisions in the province of Alberta from Alberta Finance, employment projections for economic regions from Alberta Human Resources & Employment [Alberta HR, 2006] and historical trends on employment rate for each census division from Statistics Canada, TEMS developed employment projections by census division for the three scenarios. Base and forecast year data on employment allocation for the study zones in the City of Edmonton and the City of Calgary were derived from the City of Edmonton employment forecasts and projections from the Calgary Regional Transportation Model. Historical growth rates in each subdivision were used to develop the final projections for employment by zone. Exhibit 4.2 shows overall provincial projections.

**Exhibit 4.2: Employment Projections (2006-2051) for Alberta Study Area – 3 Scenarios**


### 4.1.3 Average Household Income

Long-term projections on average household income by study zone were made using historical trends for each sub-division and projections from Canadian Demographics [2004]. Exhibit 4.3 shows the income projections for the Alberta study area for the three scenarios.

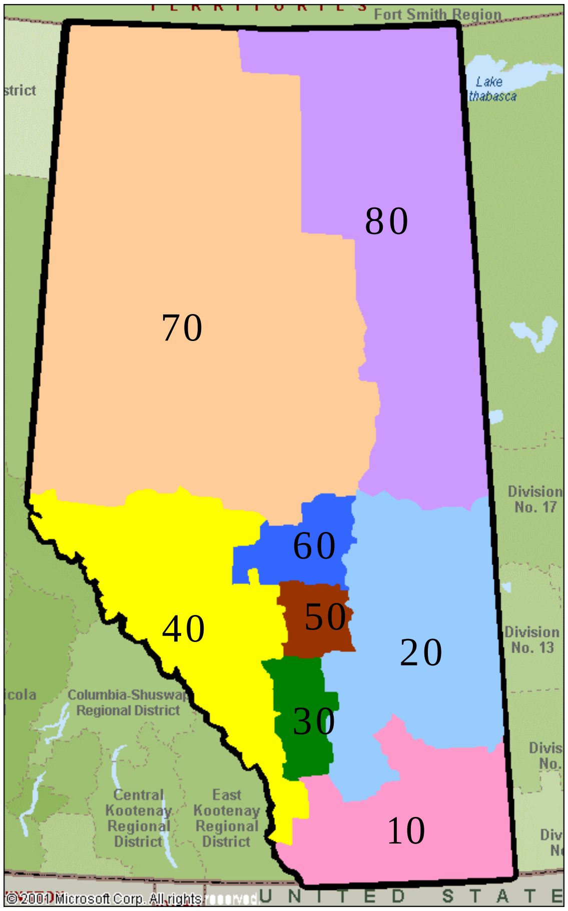
**Exhibit 4.3: Average Income Projections (2006-2051) for Alberta Study Area – 3 Scenarios**




## 4.2 Alberta Economic Regions

The zone system shown in Exhibit 2.3 has been aggregated to show the current demographic characteristics and the future forecasts for each of the Alberta Economic Regions. These are a standard zone representation for the province of Alberta, frequently used to project the provincial economic performance. The Alberta Economic Regions are shown in the Exhibit 4.4.

**Exhibit 4.4: Albert Economic Regions**




- 10. Lethbridge – Medicine Hat
- 20. Camrose – Drumheller
- 30. Calgary
- 40. Banff – Jasper – Rocky Mountain House
- 50. Red Deer
- 60. Edmonton
- 70. Athabasca – Grande Prairie – Peace River
- 80. Wood Buffalo – Cold Lake

The zones comprising the Economic Regions are shown in Appendix D.

## 4.3 Comparative Regional Projections

In the Exhibits that follow we show the population, employment and income data for the Calgary and Edmonton Economic Regions (*i.e.*, 30,60) separately, as well as for the remaining Economic Regions (*i.e.*,10,20,40,50,70,80) . The Calgary and Edmonton Economic Regions have been singled out because of their larger base and their higher growth with respect to the rest of the Province. This relationship is maintained even in the case of the Average Household Income, with the exception of Wood Buffalo-Cold Lake Economic Region, which has high income due to the rising incomes associated with oil production. The Economic Regions are labeled using the numeral system shown in the legend in Exhibit 4.4. It should be noted that the Edmonton and Calgary Economic Regions are larger than the respective CMAs. The raw data used to produce Exhibits 4.5—4.10 is given in Appendix D.

**Exhibit 4.5: Population of the Calgary and Edmonton Economic Regions**

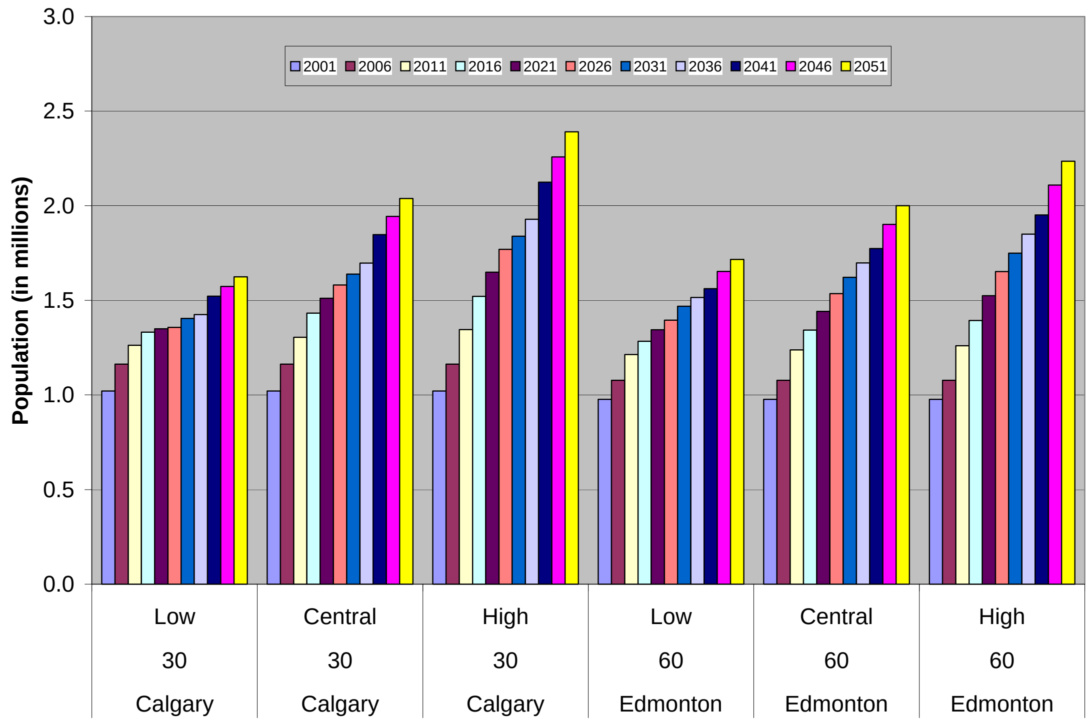



**Exhibit 4.6: Population of the Remaining Economic Regions**

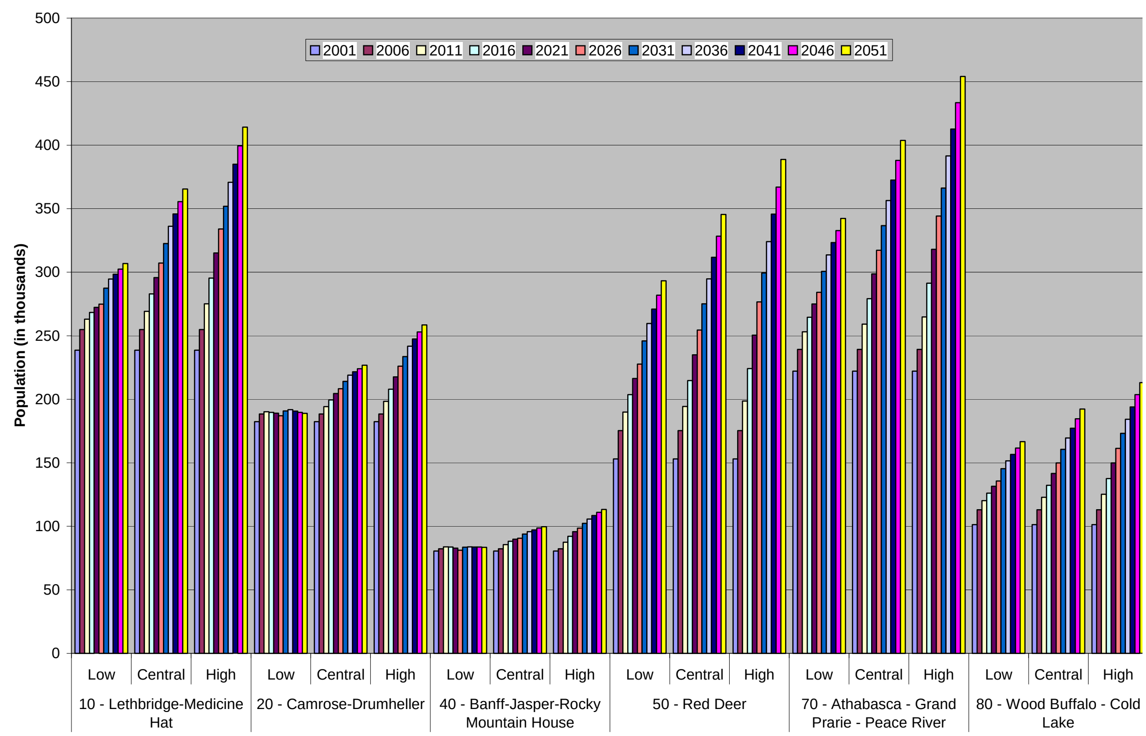


**Exhibit 4.7: Employment in the Calgary and Edmonton Economic Regions**

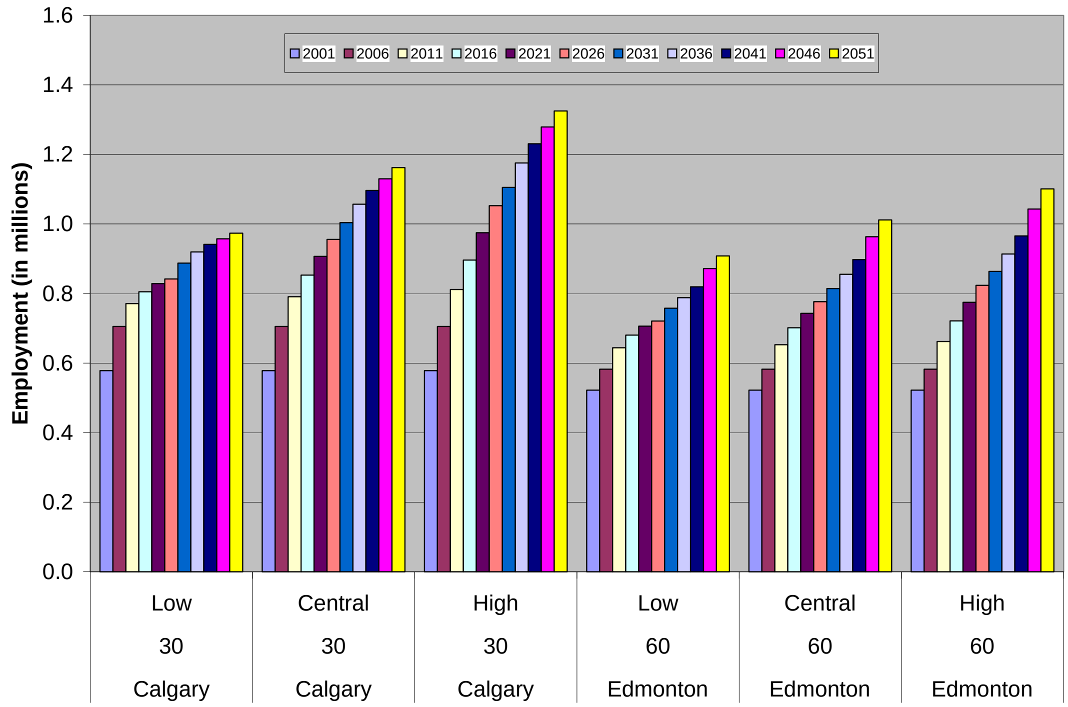



**Exhibit 4.8: Employment in the Remaining Economic Regions**

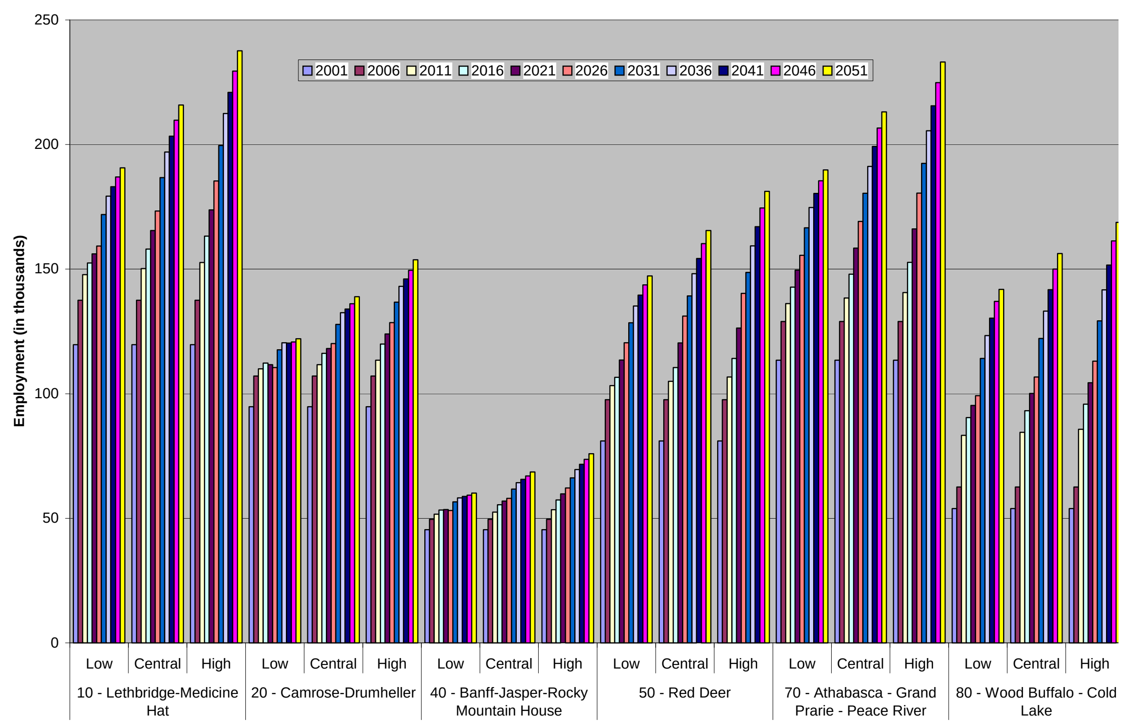


**Exhibit 4.9: Average Household Income in the Calgary and Edmonton Economic Regions (in 2005 $)**

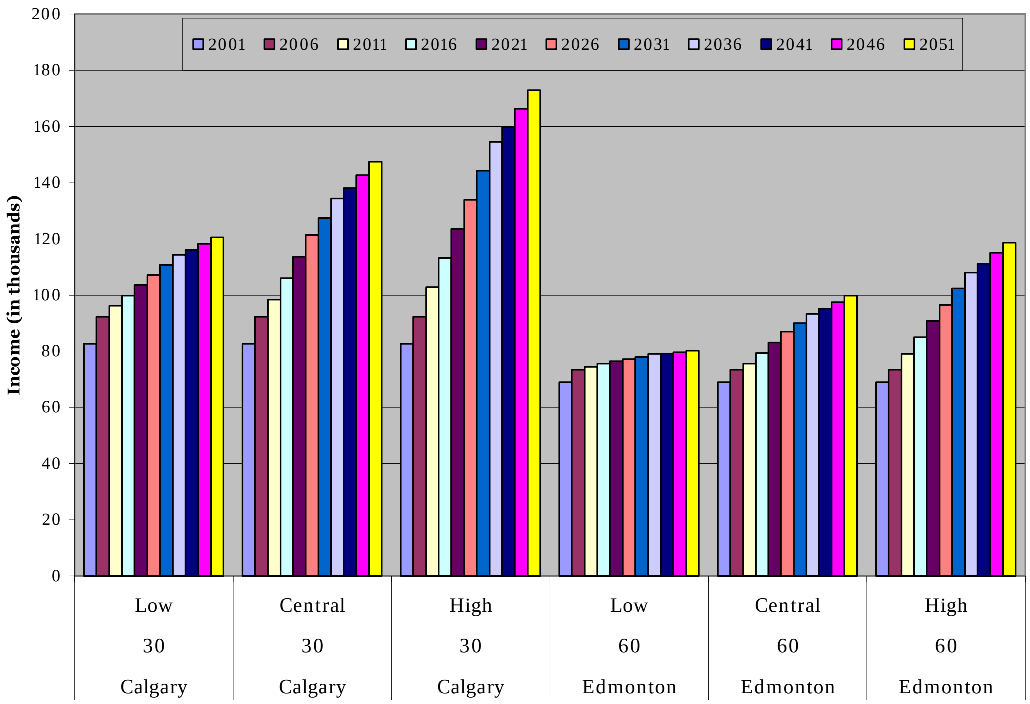
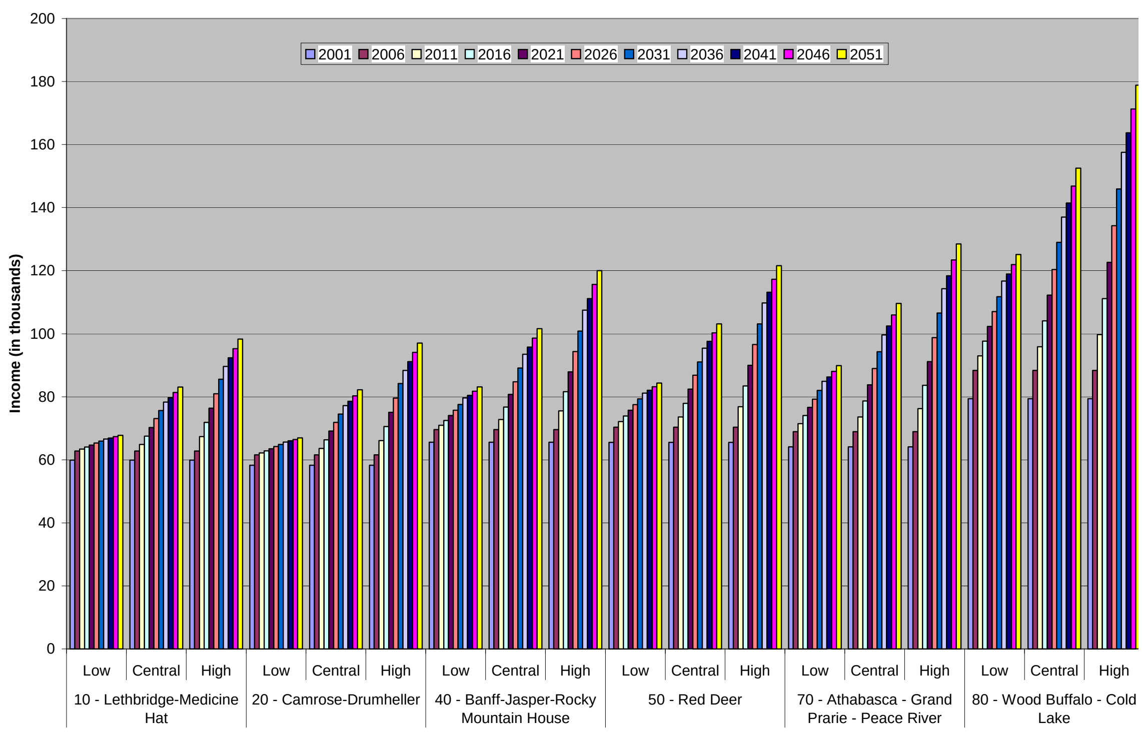



**Exhibit 4.10: Average Household Income in the Remaining Economic Regions (in 2005 $)**



The economic future presented in Exhibits 4.5 through 4.10 of the Province of Alberta Regions shows moderate to high growth for all three indicators being used in this study. Population in the Calgary Region will increase in the period 2001-2051 in the range from 50% to almost 100%, and approximately 50% to 70% in the Edmonton Region. High demographic growth is also forecasted in the Economic Regions 10 (Lethbridge), 50 (Red Deer) and 70 (Athabasca), and 80 (Wood Buffalo) while moderate to low population growth is expected in the regions 20 (Camrose) and 40 (Banff).

Employment is higher in the Calgary and Edmonton Economic Regions, though the greatest increases in the 50-year period are projected in Calgary, plus the regions 10 (Lethbridge), 70 (Athabasca) and 80 (Wood Buffalo).The Calgary region which has approximately 700,000 jobs is forecast to grow into the range 900,000 to 1.2 million by 2051. The Edmonton region is forecasted to grow from approximately 600,000 jobs into the range 900,000 to 1.1 million jobs by 2151. In the same time span, Athabasca's employment is forecast to double, while employment in Wood Buffalo is forecasted to nearly triple (from 60,000 to 140,000-180,000).

Average Household Income projections are also high in the Calgary Region and the Wood Buffalo Region, while moderate to low growth is expected in the rest of the province. In the Wood Buffalo Region, especially, average household income is expected to grow from $90,000 in 2006 to $130,000-$180,000 by 2051, in real terms (2005 dollars).

## 4.4 Conclusions

The Alberta economy, as with many resource economies, has historically been faced with cyclical fluctuations due to significant fluctuations in the price of oil. However, it would appear that in the next 30 to 50 years the economy will both perform at a higher level, and be more stable due to the growth of world demand for oil, and the increased cost of exploration. As a result, oil prices are likely to remain high and the Alberta economy should sustain a long period of economic expansion. Our forecasts reflect this more stable environment and its strong growth potential.

# 5

# Transport Strategies

## 5.1 High-Speed Rail Strategies

High-Speed Rail (HSR) strategies have been developed for each of the different technology options. The rail technology options evaluated include the full range of high-speed technologies – diesel/electric (125 mph), turbine and overhead electric (150 mph) and overhead electric (200 mph), and maglev (300 mph). For development of demand forecasts, the options consider "system variables" such as travel time, fare, frequency, as well as, "mode appeal" variable such as comfort, convenience, and quality of stations and trains for each of the high-speed rail alternatives.

For development of these strategies, prior studies – particularly the 1983 Transmark/IBI study of Calgary/Edmonton HSR and the more recent 2004 Van Horne analysis, as well as recent HSR analyses from other corridors were reviewed and revalidated by a simulation analysis, to determine their suitability to form the base for this analysis. Exhibit 5.1 summarizes the results of the previous studies.

**Exhibit 5.1: Service Options Developed by Previous Studies**

| Study | 1983 Transmark / IBI | | | 2004 Van Horne Institute | | | | |
|---|---|---|---|---|---|---|---|---|
| Travel Time (Mins) | 150 | 120 | 90 | 160 | 130 | 105 or 106 | 80 or 97 | 60 |
| Frequency (Round Trips/Day) | 8 | 12 | 16 | - No Eval - | 10 | 10 | 10 | - No Eval - |
| Top Speed | -- Not Specified -- | | | 100 mph/ 160 kph | 125 mph/ 200 kph | 150 mph/ 240 kph | 200 mph/ 320 kph | 300 mph/ 500 kph |
| Rail Technology | | | | Regular Diesel Loco + Psgr Cars | Diesel or Turbine | Turbine or Electric | Electric | Maglev |

For validating these running times, schedule feasibility was verified by simulating a variety of technology options and intermediate station stopping patterns using TEMS' LOCOMOTION™ software. Station Stops were assumed as follows:

- **No-Stop Scenario**: Express downtown Edmonton to downtown Calgary
- **One-Stop Scenario**: Adds a stop at Red Deer
- **Three-Stops Scenario**: Adds suburban Edmonton and Calgary stops

Non-stop, one-stop and three-stop services were assessed that led to development of a range of possible travel times for each speed option. This study develops demand forecasts for 125 mph, 150 mph, 200 mph and 300 mph technologies using the performance characteristics of generic trains. Representative equipment types for each speed range are shown in Exhibit 5.2.

**Exhibit 5.2: Examples of Generic Train Technologies**

125 mph Talgo

150 mph Bombardier Jet Train or Acela

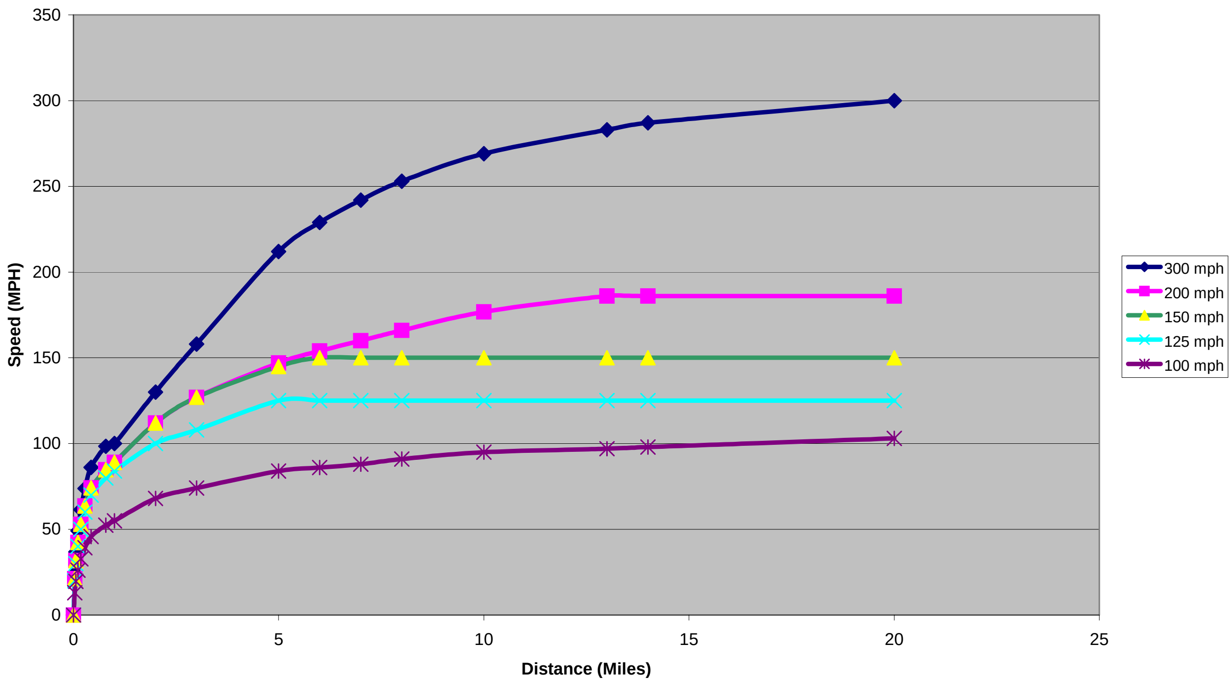
200 mph Alstom TGV

300 mph Siemens Maglev

As shown in Exhibit 5.2, North American passenger train operators have benefited from the extensive global technology development as railways around the world have upgraded their passenger systems to high-speed rail operations. Over the past few years, true high-speed rail has become a reality in North America with the introduction of Bombardier's Acela technology in the U.S. Northeast. The electric-powered Acela, specifically designed to meet US DOT equipment standards, has been further developed into the *Jet Train* diesel-fueled option. The Jet train is powered by 3750kW aircraft-type gas-turbine engine, modified to use standard diesel fuel for compatibility with the railroad-operating environment.

Train performance curves for representative equipment types, shown in Exhibit 5.3, reflect the acceleration capabilities of various rail technologies starting with conventional locomotive-hauled trainsets (the P42 option) up through Maglev. For conducting these simulations, the train sets shown in Exhibit 5.2 were selected as generic options that are representative of their respective technology class.

**Exhibit 5.3: Train type/Technology Acceleration Curves**




It can be seen that purpose-built high-speed trainsets, such as the Talgo T21, can offer considerably improved performance over conventional trains that are based on modified freight designs. Conventional locomotive hauled trainsets have a practical top speed of about 100 mph, whereas purpose-built diesel trains can achieve 125 mph. For higher speeds, electrified trains are needed. The U.S. Acela is about 45% heavier than a comparable TGV, because of modifications needed to comply with the U.S. Federal Railroad Administration's Tier II buff strength requirement. Acela weighs 567 metric tons with six passenger cars, for a capacity of only 328 seats[16]. In contrast, TGV Atlantique weighs 484 metric tons for ten cars with a capacity of 485 seats.[17] Up to its top speed of 150 mph, the Acela accelerates just as fast as a TGV due to its very high power to weight ratio. Acela's weight penalty however, expresses itself in terms of a higher operating cost and lower revenue generating capacity than a comparable TGV. The electric Eurostar train offers 794 seats and the Korean TGV 935 seats, which represents practically the upper limit of today's rail technology. Some European diesel-powered 125 mph trainsets offer up to 500 seats, but if U.S. safety regulations are replicated in Canada, added vehicle weight would reduce the practical capacity of such trains down to 300-350 seats.

The Van Horne 2004 study assumed Bombardier's Jet Train would represent both the 125 mph and 150 mph speed ranges. However, this study develops forecasts based on a selection of a "generic" equipment option that would be appropriate for each speed range, and which assumes diesel-electric rather than turbine technology for the 125 mph train, and proven electric rather than turbine technology for the 150 mph train. There exists in fact a wide range of rail equipment options that could meet the performance requirements assumed by this analysis. For example, Bombardier Transportation itself manufactures 20 different intercity and high-speed products, including seven different high-speed locomotives, electric and diesel-powered trains in both self-propelled and locomotive-hauled configurations. Bombardier has participated in development of many of the world's leading high-speed rail systems, including four

[16] See: http://www.railfaneurope.net/tgv/acela.html

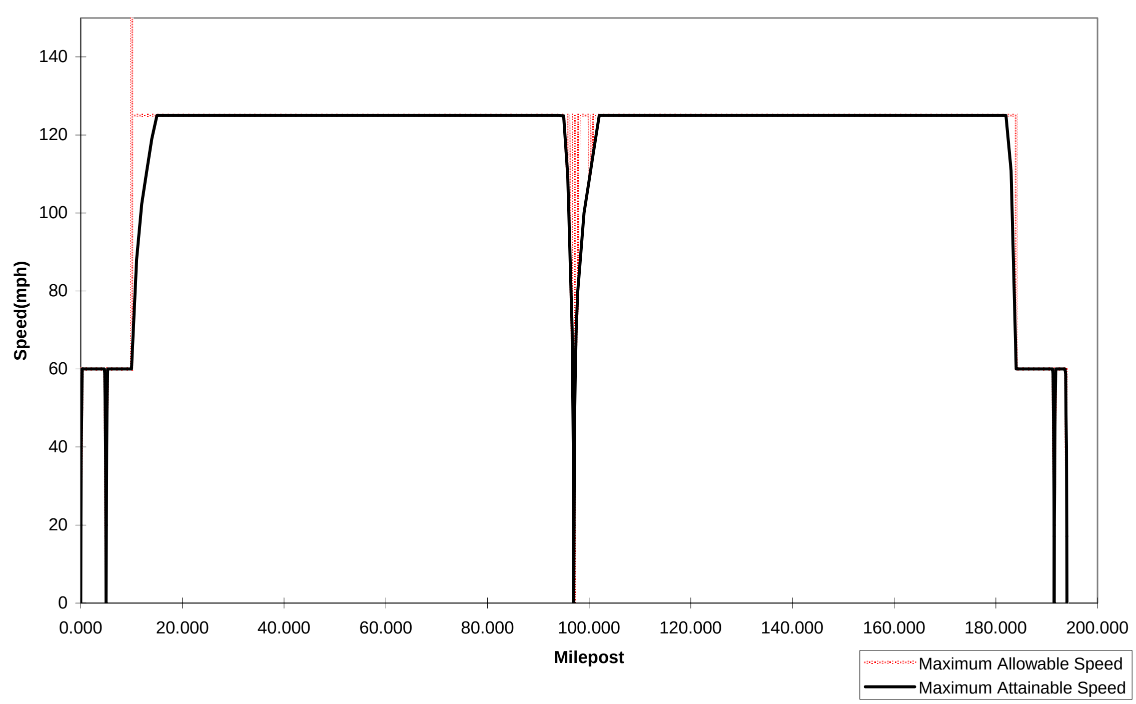
[17] See: http://www.railfaneurope.net/tgv/formations.html - atl

different 200 mph, the ICE trains used in Germany and the Netherlands, Italy's ETR 500, China's Xinshisu, Spain's Talgo and America's Acela.[18] Siemens, Talgo and Kawasaki are also known to offer competitive equipment options that could meet the performance specification of this report.

For estimating travel times, the LOCOMOTION™ software considers train performance capabilities along with the technical characteristics of the route including grades, curves, and speed limits passing through towns. However, the Van Horne study suggested options for easing existing curves on the CP Rail alignment or else for building a new line on a Green Field alignment. Based on this plan, it was assumed that curves would not be an issue for a tilt-capable train on the CP alignment nor for non-tilting electric trains on a Green Field alignment. The travel time simulation did reflect an assumed speed limit of 60 mph on the portion of urban rail alignment in Edmonton and Calgary that would be shared with freight trains. The Maglev simulation, of course, did not need to reflect such a restriction since that system would have to be implemented on a new, dedicated guideway.

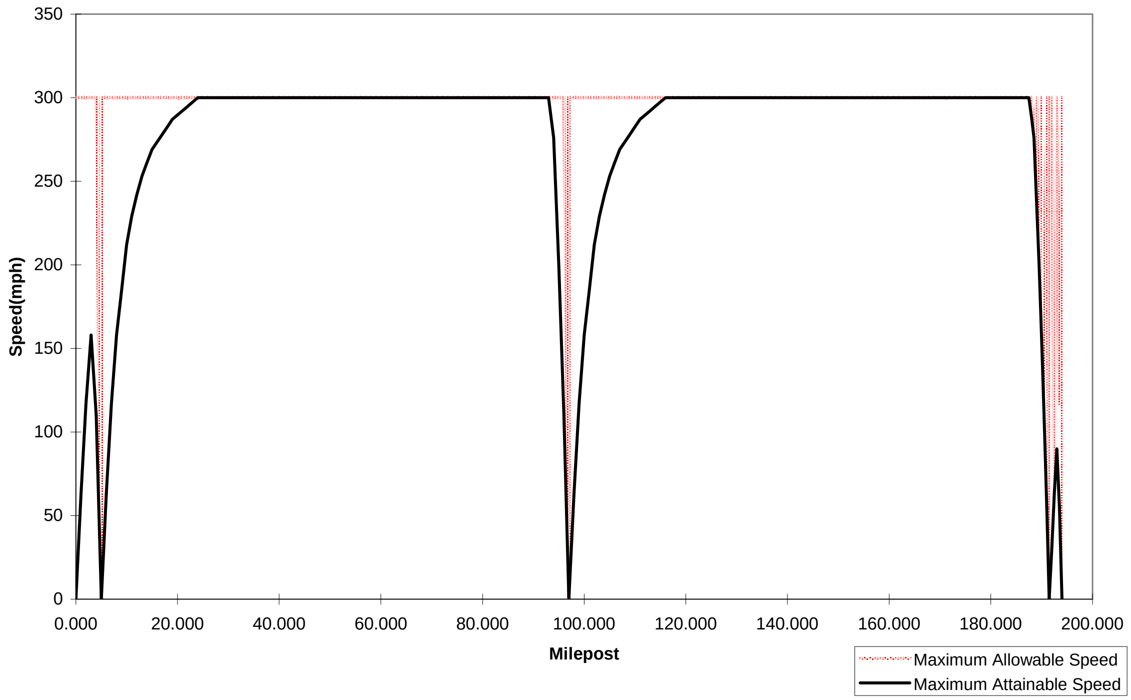
Several simulations were developed, reflecting different combinations of stopping patterns, speeds and equipment technology options. However, Exhibits 5.4 and 5.5 show the results of the 125 mph simulation of a diesel train as compared to the 300 mph Maglev. In both examples, the trains stop at suburban stations in Edmonton and Calgary, as well as at Red Deer. With three intermediate stops, the schedule for a 125 mph train would be two hours, and for the Maglev it would be one hour. These results are summarized in Exhibit 5.6.

**Exhibit 5.4: 125 mph Talgo – Calgary to Edmonton Speed Profile**




[18] See: http://www.railway-technology.com/contractors/suburban/bombardier5/press19.html

**Exhibit 5.5: 300 mph Maglev – Calgary to Edmonton Speed Profile**




This analysis recognizes that since higher speed technologies generate more ridership, it is necessary to increase train frequency as the speeds go up. As travel demand grows, there are two options for adding capacity: either run longer trains, or add more schedule frequencies. There are definite technological limits to the ability to add cars to a passenger train – unless more power is also added, a larger trainset may not be able to achieve the scheduled running times. In addition, station platform lengths may constrain the maximum size train that can be operated.

Therefore, once the maximum train size has been reached, more train frequency must be added to provide capacity for increasing ridership. If Canada allows European trains to be operated in the Calgary-Edmonton Corridor, then lighter weight trains can be deployed that will have a higher carrying capacity, less wear and tear on tracks and wheels, better energy efficiency and better economics. The safety implications for operating European-designed trains in North America would have to be carefully assessed to determine whether such trains could be compatible with Canadian requirements. However, to reflect current North American operating realities, planned train frequencies have been adjusted upwards in the higher speed scenarios to reflect the higher forecast ridership.

It is desirable to maintain a minimum base line level of train frequency at all stops, particularly important suburban stations such as have been proposed at Edmonton and Calgary. For suburban stops to be effective, most trains must stop there, or else riders will tend to shun these stops and instead use the downtown stations where more travel choices are available.

However, once base line frequencies start to rise above six to eight trains per day, there is an opportunity to provide express services that can start skipping some intermediate stops. This opportunity has been reflected in the proposed service plan, as shown in Exhibit 5.6. More express trains result in a direct improvement to the average speed of the services, and has even a greater impact on customers' perceptions of these speeds.

**Exhibit 5.6: Edmonton to Calgary Train Frequencies and Average Running Times**

| Technology | Diesel | Turbine Electric | Electric | Maglev |
|---|---|---|---|---|
| Stops/Speed | 125 mph/ 200 kph | 150 mph/ 240 kph | 200 mph/ 320 kph | 300 mph/ 500 kph |
| No-Stop | 1 /1:50 | 1 /1:36 | 1 /1:24 | 2 /0:45 |
| One-Stop | 1 /1:55 | 2/ 1:40 | 4 /1:30 | 5 /0:50 |
| Three-Stops | 6 /2:00 | 7 /1:48 | 9 /1:40 | 10 /1:00 |
| All Day Average | 8 /1:58 | 10 /1:45 | 14 /1:36 | 17 /0:55 |

In Exhibit 5.6, prospective running times including five percent slack, were developed using the LOCOMOTION™ simulation software, and then the results were validated with those obtained from previous studies. As can be seen, fewer station stops lead to faster end-to-end running times. Higher speed technologies such as the Maglev pay the highest penalty for adding stops, but also generate the highest ridership, and therefore can maximize the use of express service. The lowest planned train frequency for each speed category, has been used to develop a conservative assessment of the average running time that would be produced by the service.

The times developed in Exhibit 5.6 all fall within the reasonable range of train performance that has been assessed by previous studies. For example, the Van Horne study developed a 2:10 running time for 125 mph technology, 1:45 for a 150-mph service, and 1:37 for a 200 mph service. The LOCOMOTION™ times in Exhibit 5.6 all come very close to those that were developed by Van Horne, except that the projected 125 mph schedules are a little faster. This reflects the substitution of a diesel-powered technology for the turbine train at 125 mph, since the diesel is also able to achieve 125 mph and can accelerate faster than the turbine.

It is assumed that the number of trains will start out at the low end in the early years, but will be gradually increased over time as demand grows. However, all the frequency ranges overlap at 14 daily frequencies to enable an “apples-to-apples” comparison of the different speed options, while holding train frequency constant. This comparison at a common frequency is carried out in Chapter 8.

**Exhibit 5.7: Speed/Frequency Ridership Scenarios**

| Trains/Day | 8 | 12 | 14 | 16 | 18 | 20 |
|---|---|---|---|---|---|---|
| 125 mph/ 200 kph | X | X | X | X | | |
| 150 mph/ 240 kph | | X | X | X | | |
| 200 mph/ 320 kph | | | X | X | X | |
| 300 mph/ 500 kph | | | X | X | X | X |

## 5.2 Competitive Mode Strategies for Air and Bus

In order to forecast the market for high-speed rail, it is necessary to consider the future as well as current service characteristics of all competing modes. The emphasis is on major developments in the next decades, developments that may induce significant modal shifts, particularly in the period immediately following the introduction of the high-speed rail service. The following arguments briefly outline the key trends in and changes to the competing transport modes, which could have significant impacts.

For the Bus service, it may be considered the possibility that Greyhound and Red Arrow may shift the location of their downtown stations, in order to avoid competition with the high-speed rail mode. Alternatively, Red Arrow may still keep its downtown Edmonton station to concentrate its service to the Edmonton-Fort McMurray trips, because a large share of Edmonton-Red Deer-Calgary trips that are currently on Red Arrow are likely to shift to HSR once the system is implemented.

Regarding the Air service, the HSR mode may provide in future access to the airports YYC and YEG. Under the station plan being considered in this study, HSR is not planned to access either international airport. However, a future suburban Calgary HSR station will likely be located in closer proximity to an airport than a suburban station in Edmonton.

## 5.3 Resource Cost and Highway Development

A key input of the Alberta High-Speed Rail Study is the assumptions regarding oil prices. Oil prices impact the operating costs for all modes; auto, air, bus, and rail. The impact is different by mode with the effect being greatest for auto and air where fuel prices are a large percentage of total cost. Bus and rail modes are less impacted as fuel is typically only ten percent or less of operating costs. (Ref. Ohio Hub Intercity Passenger Rail Business Plan)

In discussions with Alberta Infrastructure and Transportation, and Alberta Employment, Immigration and Industry, the following strategy with respect to oil prices is proposed.

### 5.3.1 Oil Price

- **Base Case:** Use the current 2007 [Economist, 2007b] oil price of $65 per barrel (US) for West Texas Crude, which gives a cost of $1.05 per liter for gas at the pump.
- **Upper Case:** Use an oil price of $100 per barrel (US) for West Texas Crude, which gives an estimated cost of $1.50 per liter for gas at the pump.
- **Lower Case:** Use an oil price of $55 per barrel (US) for West Texas Crude, which gives a $0.96 per liter for gas at the pump.

The main factor in setting the Upper Case Assumption is continued rapid growth in world demand for oil, and a weak response by government in developing alternative fuels (less than 10 percent of fuel consumption from ethanol), and a weak response by the auto industry in developing hybrid vehicles (e.g., less than 30 percent of the car fleet being hybrid vehicles).

The main factor in setting the lower case assumption is strong but gradually moderating growth in world demand. It is assumed that growth is mitigated by the inability of markets to keep expanding without a cooling off period, environmental pressures, as well as a strong drive by North American economies to develop alternative fuels (i.e., increase dramatically the creation of ethanol by using sugar cane as well as corn). It is worth noting sugar cane is grown extensively in Africa, the Caribbean, and Latin America, and costs only 65-70 percent of corn to make ethanol. For example, Brazilian sugarcane-based ethanol costs only 22 cents a liter compared with 30 cents a liter for corn-based ethanol [Economist, 2007a]. In addition, it is assumed under this alternative that there will be significant increase in the percentage of hybrids in the car fleet (e.g., 60 percent).

**Modal Impacts**

The variable and average percent of operating costs are shown below. For each mode, the impact of oil price can be estimated by applying the high and low scenario to average or variable cost (see Exhibit 5.8.). The chart in Exhibit 6.8 estimates what impact can a rising cost of oil have on the different modes of travel, while the chart in Exhibit 6.9 estimates the perception of such cost based on purpose of travel.

**Exhibit 5.8: Fuel as a Percentage of Variable and Average Cost**

| Mode | Fuel as a Variable Cost Percentage | Fuel as an Average Cost Percentage |
|---|---|---|
| Auto[19] | 95 | 10 |
| Air[20] | 30 | 20 |
| Rail[21] | 15 | 10 |
| Bus[22] | 20 | 15 |

It is considered that Average and Variable Cost should be used to adjust modal fares as shown in Exhibit 5.9. Average cost is used for business fares, and reflects full ticket prices while variable cost is used for commuters and others and reflects discounted fares.

**Exhibit 5.9: Fuel Costs by Mode and Purpose**

| Mode | Business | Commuter | Other |
|---|---|---|---|
| Auto | Average | Variable | Variable |
| Air | Average | --- | Variable |
| Rail | Average | --- | Variable |
| Bus | Average | Variable | Variable |

In applying the Economic Scenarios and Transportation Strategies with the exception of congestion each scenario was applied across the whole forecasting period.

### 5.3.2 Highway Congestion

Another set of assumptions regarding highway congestion has to be made in order to represent in the forecasts the effect of worsening traffic flows due to congestion, especially on the QE2 within the Calgary – Edmonton Corridor, and within the urban areas of Calgary and Edmonton in order to properly assess access times for the urban rail stations. In this study, we have assumed different congestion growth rates according to the scenario for simulation, with respectively –

- low scenario: no change in travel time;
- central case: increase in travel time of half of a percent per year in urban areas; and
- high scenario: increase in travel time of one percent per year in urban areas.

[19] CAA estimate for 2007
[20] Air Canada estimate adjusted from year 2000
[21] VIA rail operating costs 2006
[22] Greyhound estimate adjusted from year 2000

# 6

# TEMS Ridership and Revenue Forecasts

This Section provides a high-level description of the methodology used by TEMS to produce ridership and revenue forecasts for high-speed rail in the Edmonton-Calgary corridor. The role of TEMS analysis is to provide the base case analysis for the high-speed rail options and in particular to establish the following:

- total demand for travel in the Edmonton-Calgary corridor;
- the level of Induced Demand associated with specific high-speed rail options;
- the impact of high-speed rail in the corridor in terms of model diversion and mode choice; and
- estimates of rail ridership and revenues from 2011 to 2051.

## 6.1 Description of the COMPASS™ Model System

The COMPASS™ Model is structured on three principal models: Total Demand Model, Induced Demand Model, and Hierarchical Modal Split Model. For this study, these three models were calibrated separately for two trip purposes, i.e., Business and Other (commuter, personal, and social). For each market segment, the models were calibrated on origin-destination trip data, network characteristics, and base year socioeconomic data.

The models are calibrated on the base year data. In applying the models for forecasting, an incremental approach known as the "pivot point" method is used. By applying model growth rates to the base data observations, the "pivot point" method is able to preserve the unique travel flows present in the base data that are not captured by the model variables. Details on how this method is implemented are described in Appendix A.

### 6.1.1 Total Demand Model

The Total Demand Model provides a mechanism for assessing overall growth in the travel market. The total number of trips between any two zones for all modes of travel, segmented by trip purpose, is a function of the socioeconomic characteristics of the zones and the total utility of the transportation system that exists between the two zones. For this study, trip purposes include Business and Other, and socioeconomic characteristics consist of population, employment, and per-capita income.

### 6.1.2 Induced Demand

In the Induced Demand Model, the utility function provides a measure of the quality of the transportation system in terms of the times, costs, reliability and level of service provided by all modes for a given trip purpose. A utility function is calibrated that provides a logical and intuitively sound method of estimating the impact on travel making given a change in the quality of the transportation system. An improvement in utility will result in travel between zones increasing, as the quality of the transportation system is improved by providing new facilities and services that reduce travel times and costs. Conversely, if travel conditions are made worse due to congestion or increased travel costs such as gas prices, the model will predict a fall in traffic.

### 6.1.3 Hierarchical Modal Split Model

The role of the Hierarchical Modal Split Model is to estimate relative modal shares, given the Total Demand Model estimate of the total market. The relative modal shares are derived by comparing the relative levels of service offered by each of the travel modes. The COMPASS™ Hierarchical Modal Split Model uses a nested logit structure, which has been adapted to model the intercity modal choices available in the study area. As shown in Exhibits 6.1 and 6.2, four levels of binary choice are calibrated. Several hierarchical structures were tested, and two hierarchies were adopted in this study to model "slow" (125 mph and 150 mph) and "fast" (200 mph and 300 mph) HSR technologies.

The main feature of the Hierarchical Modal Split Model structure is the increasing commonality of travel characteristics as the structure descends. The first level of the hierarchy separates private auto travel – with its spontaneous frequency, low access/egress times, low costs, and highly personalized characteristics – from the public modes. The two hierarchies then differ in the structure of the combined utility for the public modes.

The hierarchical structure shown in Exhibit 6.1 is constructed as a series of binary choices where the lowest level of the hierarchy separates rail, a potentially faster, more reliable, and more comfortable mode, from the bus mode. The hierarchical structure shown in Exhibit 6.2 is constructed so that the HSR mode competes directly with the air – the fastest, most expensive and perhaps most frequent and comfortable public mode – as both being "fast" modes. The combined utility of the public modes competes then directly against auto to form the total demand. Details on the formulation and calibration of the total demand model are given in Appendix A.

**Exhibit 6.1: Hierarchical Modal Split Structure for "slow" HSR Technologies**

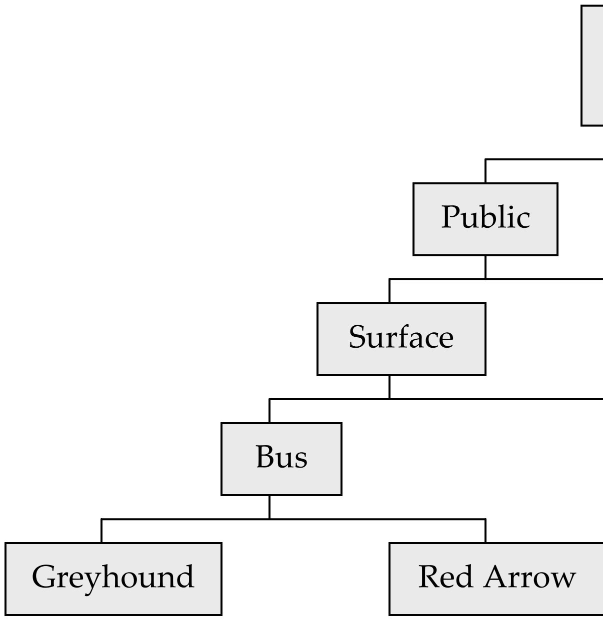
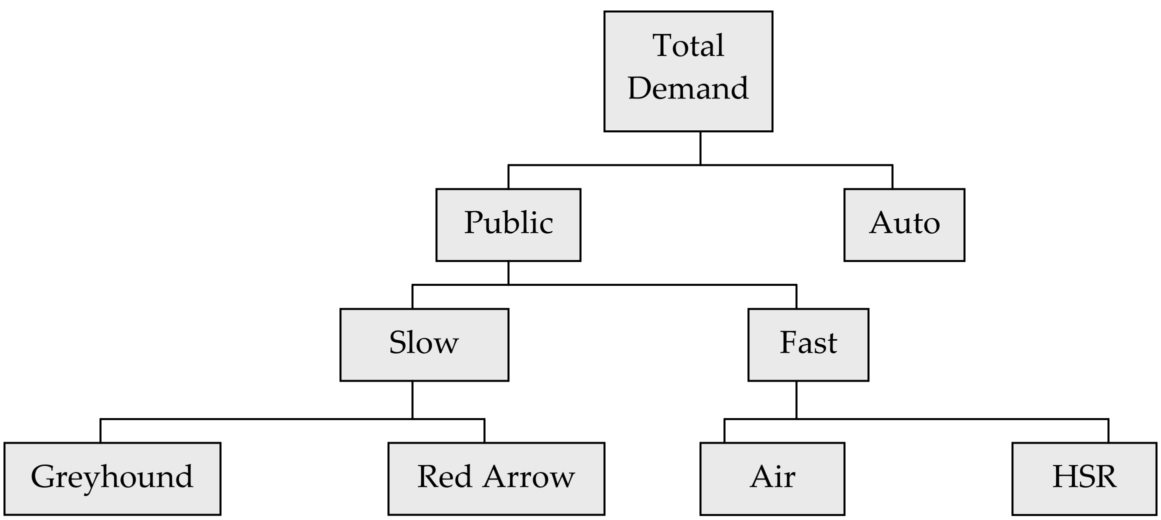



**Exhibit 6.2: Hierarchical Modal Split Structure for "fast" HSR Technologies**




## 6.2 Corridor Traffic without High-Speed Rail

In absence of a high-speed rail option, and without any changes in the level of service for all modes from today (*i.e.*. congestion, capacity, etc.), trip volumes will increase rapidly in the corridor due to demographic growth. Exhibit 6.3 shows the projected increase of total traffic on existing modes in the corridor.

**Exhibit 6.3: Projected Volume of Traffic in Absence of High-Speed Rail**

| Year | Auto | Air | Red Arrow | Greyhound | Total |
|---|---|---|---|---|---|
| 2006 | 47,545,000 | 744,000 | 835,000 | 729,000 | 49,853,000 |
| 2011 | 58,826,000 | 919,000 | 1,023,000 | 900,000 | 61,669,000 |
| 2016 | 69,063,000 | 1,078,000 | 1,202,000 | 1,057,000 | 72,401,000 |
| 2021 | 79,757,000 | 1,246,000 | 1,388,000 | 1,220,000 | 83,613,000 |
| 2026 | 89,932,000 | 1,405,000 | 1,565,000 | 1,376,000 | 94,279,000 |
| 2031 | 100,854,000 | 1,575,000 | 1,755,000 | 1,543,000 | 105,729,000 |
| 2036 | 112,308,000 | 1,754,000 | 1,954,000 | 1,719,000 | 117,737,000 |
| 2041 | 121,546,000 | 1,898,000 | 2,115,000 | 1,860,000 | 127,421,000 |
| 2046 | 132,368,000 | 2,068,000 | 2,303,000 | 2,026,000 | 138,767,000 |
| 2051 | 142,733,000 | 2,229,000 | 2,484,000 | 2,185,000 | 149,633,000 |

Demand for travel in the corridor is set to triple in the time period 2006-2051, increasing from almost 50 million in 2006 to almost 150 million in 2051. Clearly this increase in demand will challenge the existing modes in terms of capacity, and provides an environment conducive to the development of new travel options.

## 6.3 Ridership and Revenue Forecasts for the Base Case

### 6.3.1 High-Speed Rail Ridership Forecasts

TEMS prepared forecasts of ridership and associated revenues for HSR on a five years basis until the year 2051 using the base case strategies (see Chapter 5), and scenarios (see Chapter 4). The operational assumptions that apply to the whole study period behind these forecasts are summarized in the table in Exhibit 6.4 below. The travel time in the second row refers to end-to-end average time from downtown Calgary to downtown Edmonton and the frequency refers to the number of roundtrips per day. The fare is given in cents per mile for the long segments (i.e., Red Deer to suburban Calgary and Red Deer to suburban Edmonton), plus a premium for the short segments; additionally, the maximum one-way fare is presented between downtown stations.

The table in Exhibits 6.5 and 6.6 shows the forecasted level of HSR demand per year (in million trips) for the four technologies considered. The 125 mph forecast shows demand increasing from 1.1 million trips in 2011 to 2.8 million trips in 2051. The impact of improved service in the first year 2011 causes an increase of ridership for 150 mph (with respect to 125 mph) of 68%, of 200 mph (with respect to 150 mph) of 56%, and of 300 mph (with respect to 200 mph) of 41%.

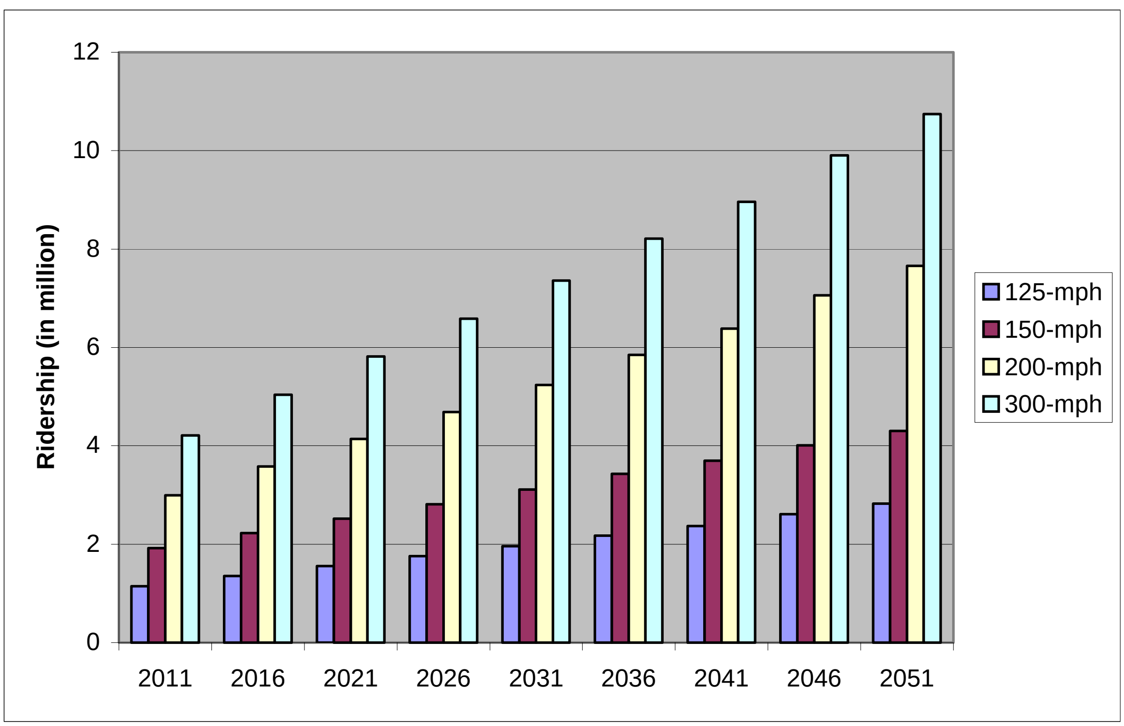
**Exhibit 6.4: Base Case Strategies for HSR**

| | 125 mph | 150 mph | 200 mph | 300 mph |
|---|---|---|---|---|
| Average travel time (h:min) | 2:00 | 1:45 | 1:35 | 1:00 |
| Frequency (roundtrips/day) | 8 | 10 | 14 | 17 |
| Fare (in cents/mile) | 25 | 35 | 40 | 60 |
| Maximum fare one-way Calgary-Edmonton | $56 | $80 | $90 | $120 |
| Maximum fare one-way from Red Deer | $28 | $40 | $45 | $60 |

**Exhibit 6.5: Table of Annual Ridership Forecast in the Years 2011-2051 (in millions)**

| Year | 125 mph | 150 mph | 200 mph | 300 mph |
|---|---|---|---|---|
| 2011 | 1.143 | 1.917 | 2.995 | 4.212 |
| 2016 | 1.353 | 2.226 | 3.581 | 5.036 |
| 2021 | 1.555 | 2.518 | 4.136 | 5.816 |
| 2026 | 1.756 | 2.811 | 4.685 | 6.586 |
| 2031 | 1.958 | 3.108 | 5.236 | 7.358 |
| 2036 | 2.176 | 3.431 | 5.851 | 8.212 |
| 2041 | 2.372 | 3.696 | 6.385 | 8.960 |
| 2046 | 2.606 | 4.011 | 7.058 | 9.903 |
| 2051 | 2.821 | 4.301 | 7.657 | 10.745 |

**Exhibit 6.6: Chart of Annual Ridership Forecast in the Years 2011-2051**



To obtain these forecasts, no adjustment was made to the operational assumptions in Exhibit 6.4 in any of the forecasts year. Similarly, no competitive response to the introduction of HSR was implemented in the other modes of travel, *i.e.,* there is no change in service in Air, Bus, or Auto. The share of business travelers present in the first forecast year is shown in the table in Exhibit 6.7.

**Exhibit 6.7: Business and Non Business Travel Share in 2011**

| Travel | 125 mph | 150 mph | 200 mph | 300 mph |
|---|---|---|---|---|
| Business | 320,000 | 959,000 | 1,528,000 | 2,148,000 |
| Percentage of Total | 28% | 50% | 51% | 51% |
| Non Business | 823,000 | 959,000 | 1,468,000 | 2,064,000 |
| Percentage of Total | 72% | 50% | 49% | 49% |

The total ridership for 125 mph is composed of 28% business travel while all other technologies attract approximately 50% of business travel. This reflects the fact that the higher speed technologies attract commuter, social, and tourist traffic at a rate similar to business traffic. The identification of the share business/non-business travel is important in determining high-speed rail revenues. Typically, business travelers pay a premium fare, which is ten percent higher and non-business travelers pay a discounted fare, which is typically ten percent lower than the average fare.

### 6.3.2 Market Shares

TEMS' forecasting software, COMPASS™, allows for the computation of modal market share for the corridor. The definition of the corridor's "catchment" area is made in terms of HSR trips. Any areas for which HSR can effectively compete are considered part of the catchment area. As a result, the extension of the network for HSR greatly enlarges the market shares used in the simulation beyond the cities of Calgary and Edmonton. For example, while we estimated roughly 300,000 yearly bus trips between the cities of Calgary, Red Deer and Edmonton, HSR can capture bus trips between, say, Lethbridge, Medicine Hat and Red Deer, as well as all short-distance trips within the limits of a CMA, hence including all those trips between these locations as a potential HSR market. As a result, the volume of bus trips present in the market shares are much higher than just trips between Calgary, Red Deer and Edmonton, in the case of Air and Red Arrow, encompassing a large share of province-wide trips. Also, for auto and bus, short distance trips are part of the market share, since they can be captured as short distance HSR trips. This greatly increasing the computation of market share beyond the volume of trips estimated between the cities of Calgary and Edmonton. As a result, while diverted trips from public modes to HSR consists mainly of trips within the corridor, the market shares include trips from other locations in the province as well.

Exhibit 6.8 shows the computed province-wide market shares of potential interest to HSR. There are 744,000 air trips, forming 1.49% of the market, 729,000 Greyhound trips (1.46% of the market), 835,000 Red Arrow trips (1.66% of the market) and 47.5M auto passenger trips (comprising 95% of the market). The result of this analysis is presented in the four pie charts in the following Exhibits 6.9 through 6.12.

**Exhibit 6.8: Modal Market Share for the Base Year (2006, actual volumes in thousands)**

| | Actual | Percent |
|---|---|---|
| ***Auto*** | 47,545 | 95.37% |
| ***Air*** | 744 | 1.49% |
| ***Greyhound*** | 729 | 1.46% |
| ***Red Arrow*** | 835 | 1.66% |
| ***Total*** | **49,853** | **100%** |

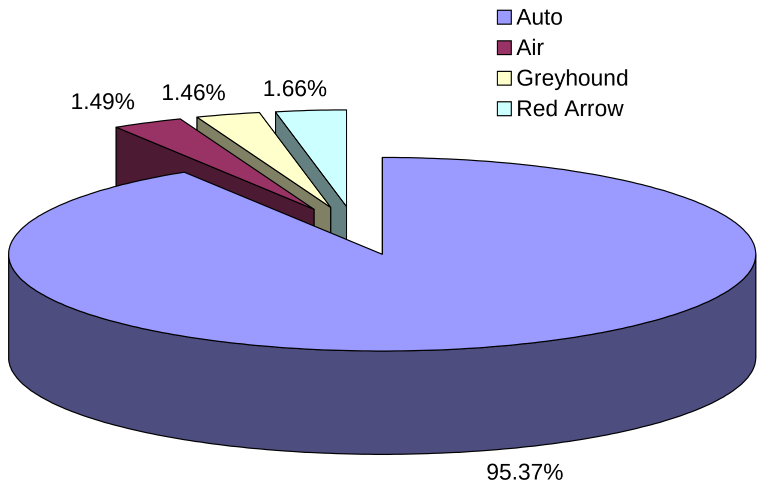
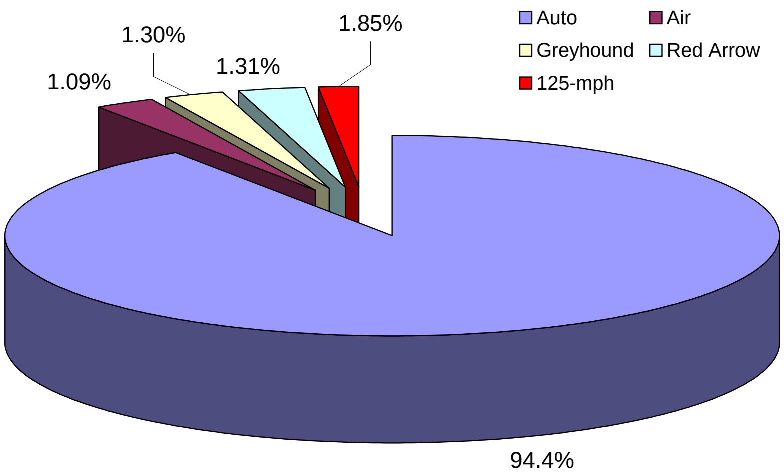
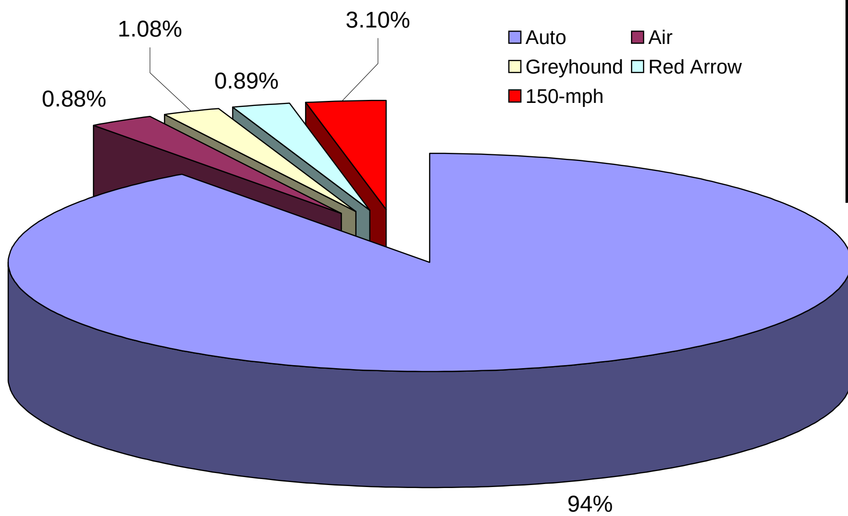



**Exhibit 6.9: Modal Market Share with 125 mph (2011, actual volumes in thousands)**



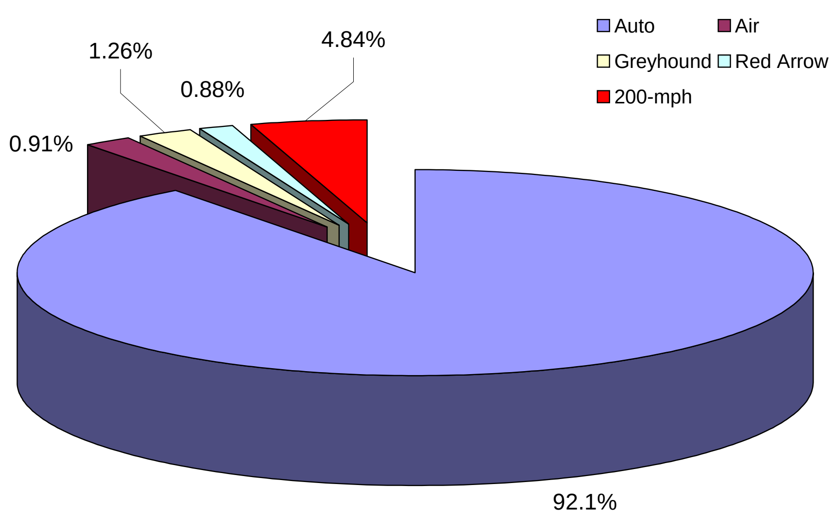

| | Actual | Percent |
|---|---|---|
| ***Auto*** | 58,301 | 94.4% |
| ***Air*** | 675 | 1.09% |
| ***Greyhound*** | 805 | 1.30% |
| ***Red Arrow*** | 811 | 1.31% |
| ***Rail*** | 1,142 | 1.85% |
| ***Total*** | **61,734** | **100%** |

**Exhibit 6.10: Modal Market Share with 150 mph (2011, actual volumes in thousands)**



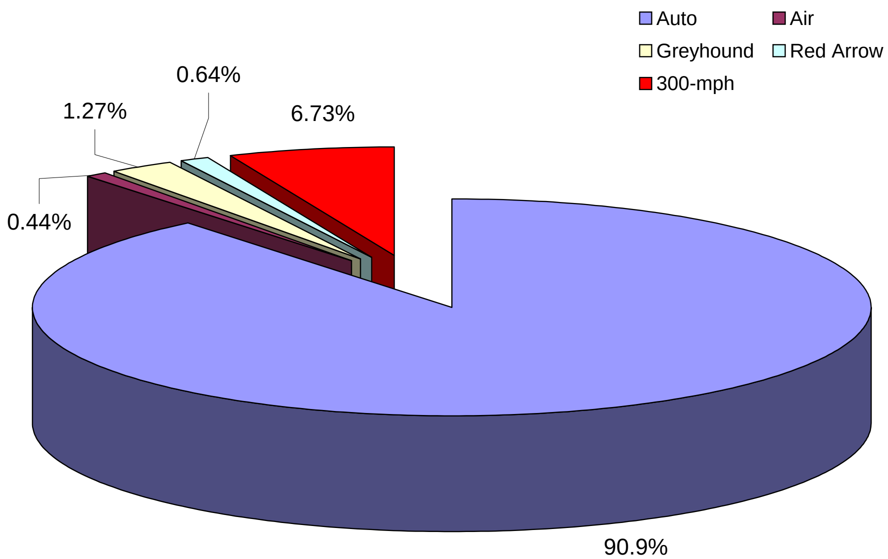

| | Actual | Percent |
|---|---|---|
| ***Auto*** | 58,092 | 94.0% |
| ***Air*** | 546 | 0.88% |
| ***Greyhound*** | 670 | 1.08% |
| ***Red Arrow*** | 552 | 0.89% |
| ***Rail*** | 1,917 | 3.10% |
| ***Total*** | **61,777** | **100%** |

**Exhibit 6.11: Modal Market Share with 200 mph (2011, actual volumes in thousands)**




| | Actual | Percent |
|---|---|---|
| ***Auto*** | 57,001 | 92.1% |
| ***Air*** | 565 | 0.91% |
| ***Greyhound*** | 782 | 1.26% |
| ***Red Arrow*** | 547 | 0.88% |
| ***Rail*** | 2,995 | 4.84% |
| ***Total*** | **61,890** | **100%** |

**Exhibit 6.12: Modal Market Share with 300 mph (2011, actual volumes in thousands)**



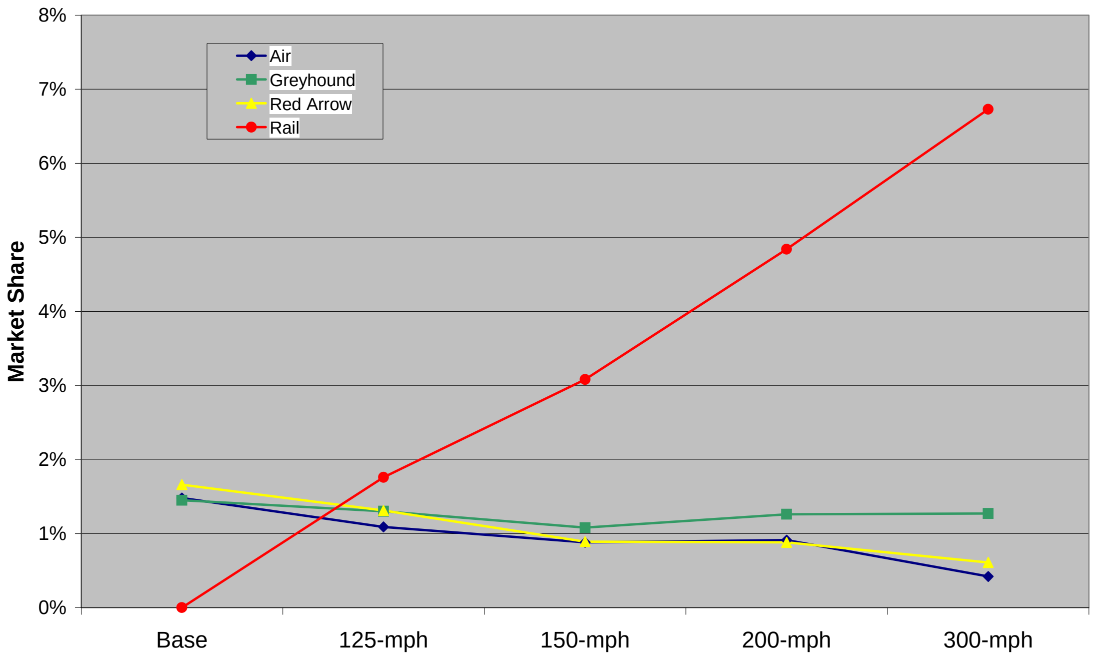

| | Actual | Percent |
|---|---|---|
| ***Auto*** | 56,890 | 90.9% |
| ***Air*** | 276 | 0.44% |
| ***Greyhound*** | 793 | 1.27% |
| ***Red Arrow*** | 401 | 0.64% |
| ***Rail*** | 4,212 | 6.73% |
| ***Total*** | **62,572** | **100%** |

Exhibits 6.8 through 6.12 show how market shares for other public modes fall as the speed of high-speed rail technology is raised. For example, shares for air travel fall from 1.49% in the Base year to 1.09% in 2011 in presence of a 125 mph technology, then to 0.88% in presence of a 150 mph technology, further to 0.91% in presence of a 200 mph technology and down to 0.44% in presence of the 300 mph technology. It is also interesting to note that the total volume of trips in the potential catchment area of HSR increases with the technology speed, because the improvement in high-speed rail service allows rail trips whose origin and destination were more distant to use the HSR mode.

The improvement in HSR technology leads to a higher market share for rail. Specifically, 125 mph is forecasted to have a market share of 1.85%, 150 mph of 3.10%, 200 mph of 4.84% and 300 mph of 6.73%. The growth of rail traffic is at the expense of auto, Red Arrow and Air, while the Greyhound market is rather stable given the different character of its role in the corridor, and the different nature of its market (*i.e.*, catering to low-VOT travellers). This scenario is charted in Exhibit 6.13, where the market shares of the various public modes are shown as a function of the rail technology.

The market shares are consistent through the time horizon. For instance, in the year 2031 with 125 mph, Auto has a share of 94.42%, Air of 1.16%, Greyhound of 1.27%, Red Arrow of 1.29% and Rail of 1.86%.

**Exhibit 6.13: 2011 Estimated Market Shares: Public Modes/HSR**




### 6.3.3 Impact on Traffic Volumes

Translating the market shares in actual volume figures, we have that in the base year (2006), Air has 744,000 trips, Greyhound has 729,000 trips, and Red Arrow has 835,000 trips. In 2011, 125 mph captures 1.8% of all trips, mostly through diversion from Auto and the public modes. As shown in Exhibit 6.9, in 2011 Air, Greyhound and Red Arrow will drop their market shares to 1.1%, 1.3%, and 1.3%, with diverted trips to HSR complemented by natural growth in the corridor. As a result, in actual trips, in 2011 Air has 675,000 trips, Greyhound 805,000 trips, and Red Arrow 811,000 trips. Therefore, despite the presence of 125 mph as a new mode, in actual ridership in the period 2006-2011, Air traffic decreased ten percent, Greyhound traffic increased ten percent and Red Arrow traffic dropped three percent. If 150 mph is the new HSR mode, actual ridership in the period 2006 through 2011 for Air decreases four percent; Greyhound increases one percent and Red Arrow drops 14%. For the faster HSR modes, Air & Red Arrow change in ridership is more substantial, while Greyhound maintains high market shares. In the case of Auto volumes, the impact of introducing HSR is to reduce Auto volumes by 606,000 passenger trips with 125 mph, by 1,010,000 passenger trips with 150 mph, by 1,518,000 passenger trips with 200 mph, and by 2,039,000 passenger trips with 300 mph, in 2011. A summary of these results is shown in the table in Exhibit 6.14.

**Exhibit 6.14: Change in Actual Ridership in the Period 2006-2011.**
**Actual volumes are in thousands with the percent change in brackets.**

| | Greyhound | Red Arrow | Air | Auto |
|---|---|---|---|---|
| Base | 729 | 835 | 744 | 47,545 |
| 125 mph | 805 (+10%) | 811 (-3%) | 675 (-9%) | 58,301 (+22%) |
| 150 mph | 670 (-8%) | 552 (-34%) | 546 (-27%) | 58,092 (+22%) |
| 200 mph | 782 (+7%) | 547 (-34%) | 565 (-24%) | 57,001 (+20%) |
| 300 mph | 793 (+9%) | 401 (-52%) | 276 (-63%) | 56,890 (+20%) |

### 6.3.4 Composition of Demand

Demand for HSR is broken up in three components:

- **Natural demand** – the part of demand that is *generated* by demographic increase. In other words, as cities and villages grow, so does the demand for travel.

- **Diverted demand** – the part of demand that is *transferred* from one mode to another as service level changes. In this case, where HSR is not present in the base case, diversion is the main ingredient of HSR demand.

- **Induced demand** – the part of demand that is *generated* because of improvement in the utility of travel, but that is not diverted from any other mode. For example, better highways reduce the cost of traveling longer distances; hence these extra trips are induced by the improvement of utility.

Each scenario with a different HSR technology will show different breakdowns of the demand across the components quoted above. Natural demand will remain the same, since there is no demographic change across the technologies, but its share appears diminishing because the overall traffic is higher when moving from a slow to a fast technology. The breakdown of demand is shown in Exhibits 6.15 through 6.18.

**Exhibit 6.15: Demand Breakdown for 125 mph (2011, actual volumes in thousands)**

| | Actual | Percent |
|---|---|---|
| ***Natural*** | 68 | 6.0% |
| ***Induced*** | 64 | 5.6% |
| ***Diverted*** | 1,010 | 88.4% |
| ***Total*** | **1,142** | **100%** |

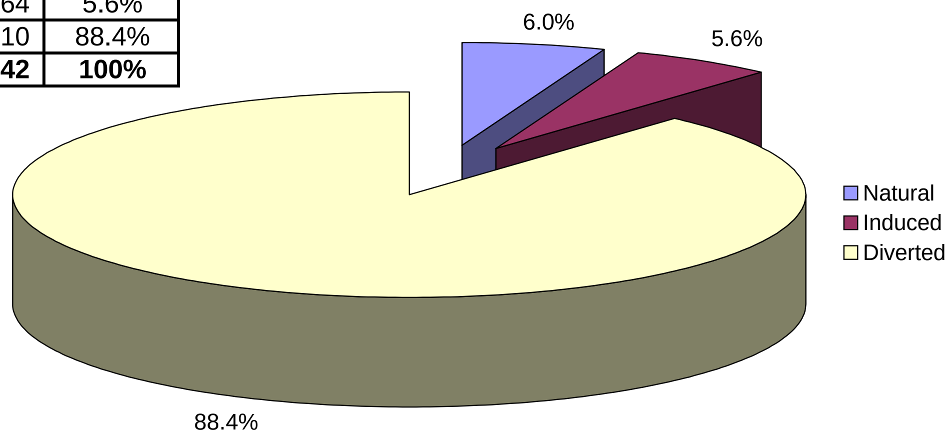



**Exhibit 6.16: Demand Breakdown for 150 mph (2011, actual volumes in thousands)**

| | Actual | Percent |
|---|---|---|
| ***Natural*** | 68 | 3.5% |
| ***Induced*** | 109 | 5.7% |
| ***Diverted*** | 1,741 | 90.8% |
| ***Total*** | **1,917** | **100%** |

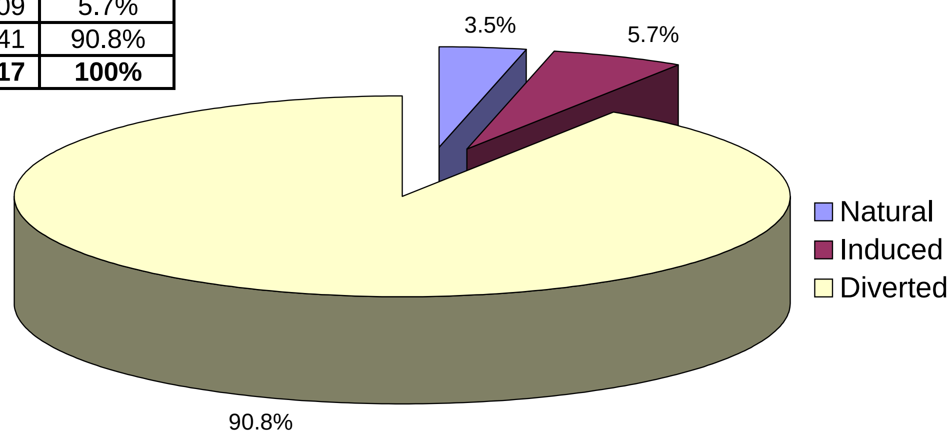


**Exhibit 6.17: Demand Breakdown for 200 mph (2011, actual volumes in thousands)**

| | Actual | Percent |
|---|---|---|
| ***Natural*** | 68 | 2.3% |
| ***Induced*** | 216 | 7.2% |
| ***Diverted*** | 2,710 | 90.5% |
| ***Total*** | **2,995** | **100%** |

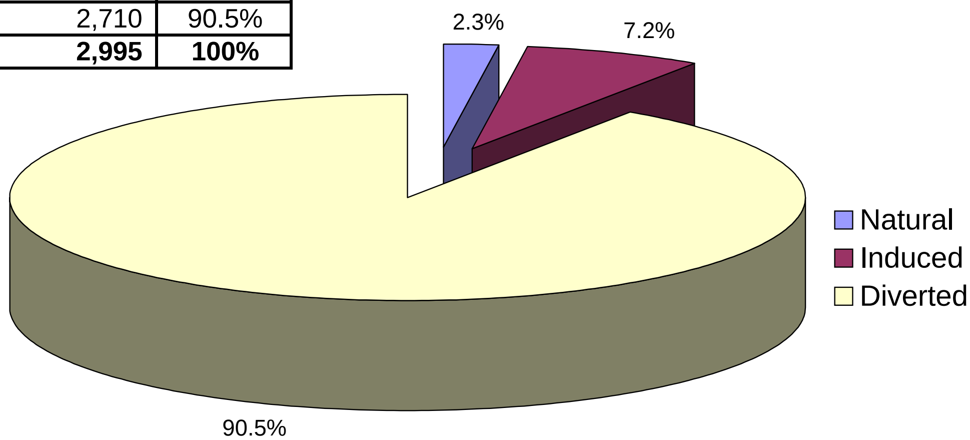
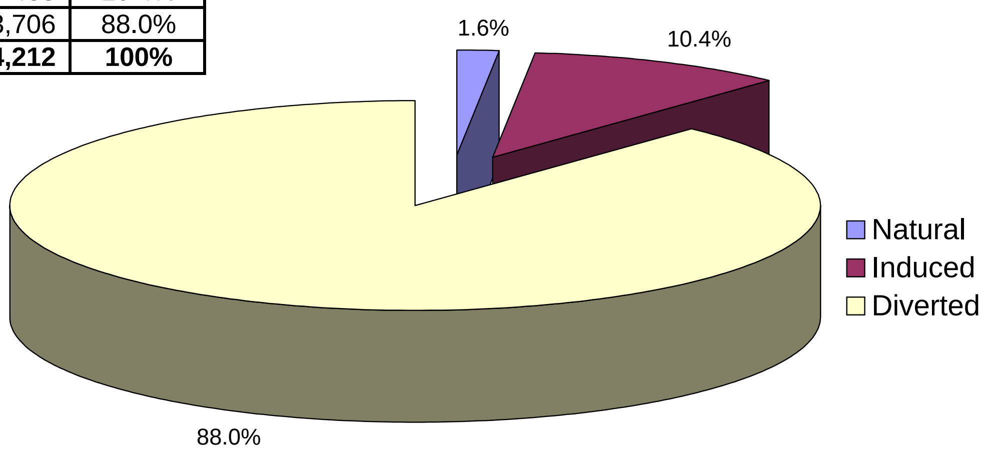



**Exhibit 6.18: Demand Breakdown for 300 mph (2011, actual volumes in thousands)**

| | Actual | Percent |
|---|---|---|
| ***Natural*** | 68 | 1.6% |
| ***Induced*** | 438 | 10.4% |
| ***Diverted*** | 3,706 | 88.0% |
| ***Total*** | **4,212** | **100%** |




As might be expected, diversion from other modes of travel is the largest contributing factor to rail ridership. From these charts it is possible to see that the level of induced demand almost doubles between 125 mph and 300 mph, rising from 5.6% for the 125 mph option to 10.4% for the 300 mph option. This reflects the increasing benefit of higher speed options. The "Natural" demand (i.e., demand generated by demographic growth is fixed for all technologies, but it is a gradually lower portion of the total demand.

The diversion from competitive modes to high speed rail is shown in Exhibit 6.19. The exhibit shows the volume of traffic and the percentage diversion from each mode to high speed rail. For example, the 125 mph rail mode attracts 167,000 Air trips, which represent 17% of all Air trips. It should be noted that the diversion is largely from the growth of new traffic, which will expand by 46 percent by 2016. The percentage diversion from competitive modes remains largely constant over time, up to 2050.

**Exhibit 6.19: Makeup of High-Speed Rail traffic from competitive modes (actual volumes in thousands)**

| | | 125 mph | | 150 mph | | 200 mph | | 300 mph | |
|---|---|---|---|---|---|---|---|---|---|
| **2016** | Air | 167 | 17% | 283 | 31% | 583 | 46% | 931 | 74% |
| | Bus | 311 | 14% | 546 | 28% | 843 | 35% | 1,019 | 42% |
| | Auto | 718 | 1% | 1,172 | 2% | 1,815 | 3% | 2,437 | 3% |
| **2031** | Air | 260 | 18% | 395 | 31% | 900 | 48% | 1,425 | 75% |
| | Bus | 433 | 14% | 790 | 29% | 1,279 | 36% | 1,554 | 43% |
| | Auto | 1,039 | 1% | 1,637 | 2% | 2,559 | 3% | 3,497 | 3% |
| **2051** | Air | 374 | 18% | 547 | 31% | 1,317 | 48% | 2,080 | 75% |
| | Bus | 623 | 14% | 1,093 | 29% | 1,871 | 36% | 2,269 | 43% |
| | Auto | 1,496 | 1% | 2,265 | 2% | 3,742 | 3% | 5,106 | 3% |

### 6.3.5 Passenger Revenue Forecasts

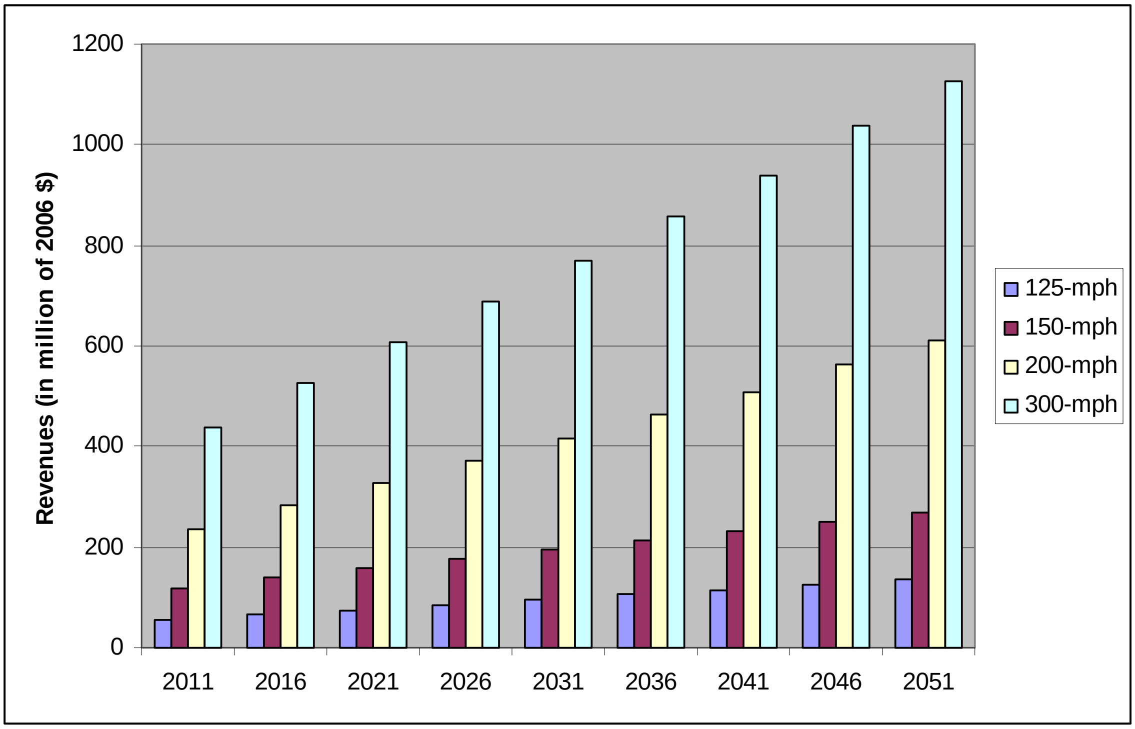
Revenue forecasts are derived considering the fare structure shown in Exhibit 6.4. To these costs, we have introduced a "premium" cost into the model to reflect the higher cost of travel in the short segments of the corridor (*i.e.*, an urban journey downtown-suburban station) in both urban centres. Specifically, a one-way journey for each one of the short segments $3 on 125 mph, $5 on 150 mph, $5 on 200 mph and $10 on 300 mph. The mix of long and short trips generates the revenues given in Exhibit 6.20.

The table in Exhibit 6.20 shows the forecasted HSR passenger revenues per year (in millions of 2006 $) for the four technologies considered. Exhibit 6.21 gives the same data in a chart. In these charts, the gap between the two "slow" technologies (125 mph and 150 mph) and the two "fast" technologies (200 mph and 300 mph is apparent).

**Exhibit 6.20: Passenger Revenues (in millions of 2006 $) for Years 2011 through 2051**

| Year | 125 mph | 150 mph | 200 mph | 300 mph |
|---|---|---|---|---|
| 2011 | 55.127 | 118.872 | 236.879 | 438.833 |
| 2016 | 65.459 | 138.420 | 284.024 | 526.069 |
| 2021 | 75.244 | 156.715 | 328.203 | 608.046 |
| 2026 | 84.940 | 174.931 | 371.730 | 688.427 |
| 2031 | 94.580 | 193.387 | 415.526 | 769.284 |
| 2036 | 105.242 | 213.544 | 464.508 | 858.959 |
| 2041 | 114.905 | 230.437 | 507.512 | 938.419 |
| 2046 | 126.510 | 250.631 | 561.834 | 1,038.695 |
| 2051 | 137.074 | 269.019 | 609.986 | 1,127.890 |

**Exhibit 6.21: Chart of Yearly Revenues (in millions of 2006 $) in the Time Span 2011 through 2051**




### 6.3.6 Base Case Comparison with Van Horne Report

In this section we draw a comparison of ridership and revenues between the current study and that of the Van Horne Institute [Van Horne, 2004]. The two studies differ in a number of operational and modelling details:

- The suburban Edmonton station in [Van Horne, 2004] is planned either near the Edmonton Ring Road or in proximity to YEG; in this study this station is closer to downtown, north of the Edmonton Ring Road, near the old CPR line.
- Frequencies for the various technologies in the Van Horne Study, 2004 are fixed across technologies at an average of 10.5 roundtrips/day; in this study we adopt different frequencies according to the technology used.
- The cost of travel is the same on all technologies, $115 (business) and $97 (non-business), per roundtrip. A $100 per roundtrip equates to approximately 30 cents/mile in this study we adopted varying fare structure according to technology (see Exhibit 6.1).
- The Van Horne Study, 2004 publishes ridership and revenues in the base year 2003, while in this study the first forecast year is 2011.
- Current demographic forecasts for the province of Alberta are higher for population and employment, particularly in the Edmonton Region.

The technological alternatives used in the Van Horne Study, 2004 are a CPR Alternative (akin to 125 mph, used in this report), a Greenfield Non-Electric (akin to 150 mph, used in this report), and a Greenfield Electric (akin to 200 mph, used in this report). A short review of the Van Horne is also shown in Exhibit 5.1 when discussing the technological status of HSR travel.

The original 2004 Van Horne forecasts are shown in Exhibit 6.22. These are only provided for the base year 2003.

**Exhibit 6.22: Ridership and Revenues in the Van Horne Study (2004)**

| Year 2003 | Ridership (in 000's) | Revenues (in 000's) |
|---|---|---|
| CPR Alternative | 1,603 | $ 82,285 |
| Greenfield Non-Electric | 1,903 | $ 94,521 |
| Greenfield Electric | 2,031 | $101,397 |

Adopting the following steps made a direct comparison:

- Because the Van Horne estimates were for 2003, the estimates in the Van Horne study needed to be updated to 2011. To do this we applied a modest yearly growth factor of three percent to both ridership and revenues to account for this eight-year difference.
- TEMS' forecasts were adjusted to reflect the operational assumptions in the Van Horne study (with the exception of moving the location of the suburban Edmonton station). All technologies will be set to a frequency of 10.5 roundtrips/day and a fare of 30 cents/mile.
- Additionally, TEMS' forecasts are obtained using the latest demographic forecasts reflecting investments in the Edmonton Region that were not known in 2003 (see Chapter 4). Hence, we adjusted the Van Horne estimates to account for the improvement in the demographic profile of the province, using an elasticity for demographic growth of 0.7.

The table in Exhibit 6.23 shows an adjusted comparison for the results from TEMS and the results published in 2004 Van Horne Study.

**Exhibit 6.23: Comparison of 2011Ridership and Revenues (both in millions) between the Van Horne Study (2004) and the Results from TEMS' Forecasting Model**

| Adjusted comparison | TEMS | | Van Horne | |
|---|---|---|---|---|
| For year 2011 | Ridership | Revenues | Ridership | Revenues |
| CPR Alternative | 1.216 | 70.411 | 2.265 | 116.263 |
| Greenfield Non-Electric | 1.967 | 120.677 | 2.689 | 133.552 |
| Greenfield Electric | 2.722 | 169.058 | 2.870 | 145.267 |

It can be seen that for the 125 mph and 150 mph the TEMS ridership forecast are half and two thirds than those of Van Horne with revenues between 60% and 85% lower. There is better agreement for the 200 mph Greenfield Electric, with TEMS' ridership at 90% of those of Van Horne and revenues ten percent higher.

# 7

# Oliver Wyman Methodology and Forecasts

This section provides a high-level description of the methodology employed by Oliver Wyman to develop the ridership and revenue forecasts for the High Speed Rail (HSR) for the Calgary-Edmonton High speed rail corridor. The inclusion of an Oliver Wyman ridership and revenue forecast serves three primary purposes:

- Provide an independent assessment of the HSR appeal in the corridor. Oliver Wyman uses the same input data as TEMS for the modeling effort, however employs a different modeling methodology from that of TEMS regarding behavioural characteristics (such as value of time) as well as modeling approach to modal split.

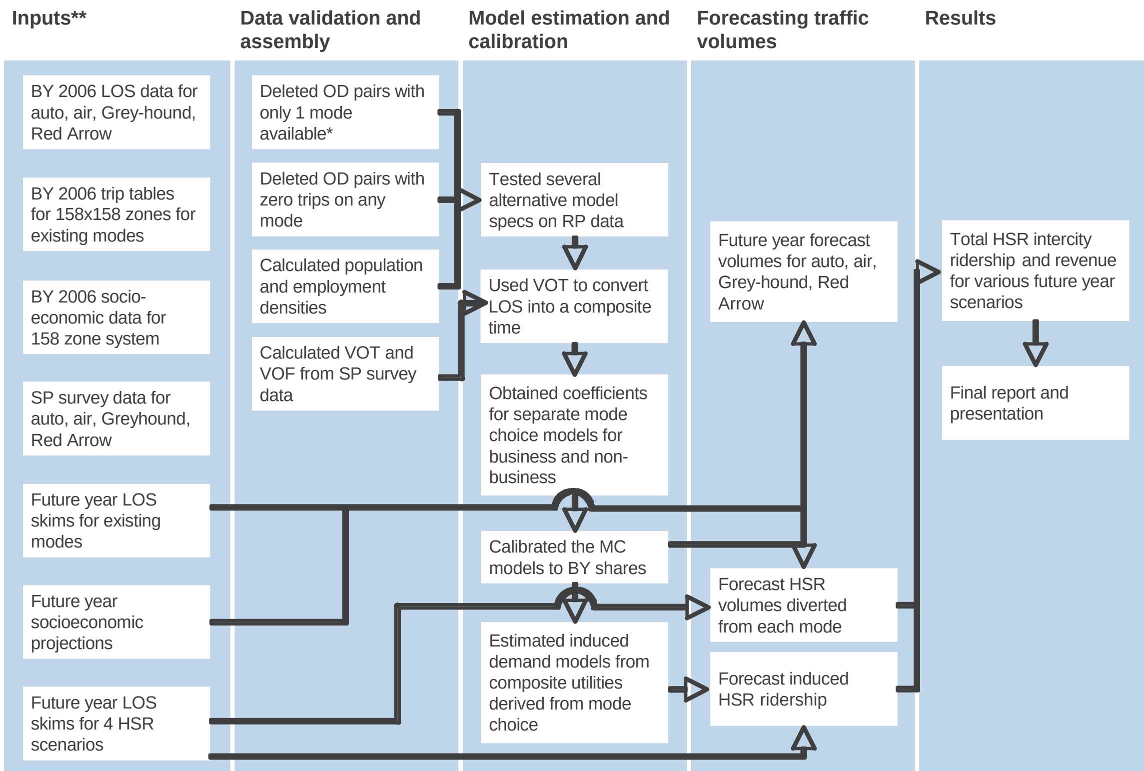
- Ensure robustness and reasonableness of the forecasts, by providing AIT with two model sources for the forecasts.

- Examine, validate and assess the appropriateness of socio-economic, modal service, and trips inputs that TEMS has prepared for use in the modeling effort.

## 7.1 High-Speed Rail Modeling Methodology

This section provides a brief overview of the modeling methodology employed by Oliver Wyman to develop the ridership and revenue forecasts. Exhibit 7.1 outlines the process and the various steps involved. A detailed description of the methodology including technical details is included in Appendix F.

**Exhibit 7.1 Flowchart of Intercity HSR Ridership and Passenger Revenue Forecasting Process**




*Availability of non-auto modes decided by frequency. A mode is not available between an OD pair if frequency of that mode is zero between the OD pair.
**Most of the input data, skims, total demand model outputs were obtained from TEMS.

### 7.1.1 Model Approach

As part of the model framework, three models were developed:

- Value-of-time (VOT) model. The VOT model deciphers the value of time travellers attach to their travel and is used to convert various components of travel service into a composite time or cost utility. VOT model is developed using the Stated Preference survey data collected by TEMS in 2006, which included a trade-off of travel options (within a single mode of Auto, Air, Greyhound, or Red Arrow) based on travel time and cost.

- Mode choice model. The mode choice model captures the trade-offs travellers make in the choice of modes, and is used to understand share shifts from introduction of new modes as well as sensitivity to mode shares from changes to levels of service. Model is developed using the observed travel patterns in Alberta in terms of the actual number of trips on the existing modes (Auto, Air, Greyhound, Red Arrow). The observed travel patterns are usually referred to as the Revealed Preference (RP) data. The Origin-Destination (OD) level trip tables developed by TEMS in collaboration with AIT were used as the basis for the RP behaviour.

- Induced demand model, using the same data as used for the mode choice model. The induced demand model represents the expected incremental trips in the system resulting from an improved transportation environment (addition of a new HSR service).

Significant effort was spent on data assembly and validation tasks in preparation for the model development, including merging disparate data sets together and checking the base year zonal socio-economic data, modal level of service data, and base year mode shares. Details of this process are included in Appendix F.

While Oliver Wyman uses the same input data for modeling as TEMS, key differences exist in terms of the modeling methodology, as explained in sections 7.1.2, 7.1.3, and 7.1.4 below.

### 7.1.2 Value-of-time (VOT) Models

As mentioned earlier, stated preference surveys conduced by TEMS required respondents to make trade-offs between two combinations of travel time and travel cost and two combinations of travel time and frequency in the case of public transit modes (Greyhound, Red Arrow and Air). This data collected for each existing mode was restructured and used for developing VOT estimates for that mode.

For example, a respondent in the mail-out car survey was given the choices of Alternative A – drive to their destination in 3 hours and spend $45 (including gasoline, parking and other costs) and Alternative B – drive in 2.5 hours and spend $51. The choice was captured in the form of a five-point scale ranging from "prefer Alternative A a lot," "prefer Alternative A a little," "Not sure," "prefer Alternative B a little," and "prefer Alternative B a lot." Each respondent was presented 4 or 5 such trade-off questions.

The key difference between TEMS and OW methodology was in the way the dependent variable for VOT analysis was created. OW translated the scaled choice into a binary choice variable (i.e. "Yes" or "No"). That is, if a respondent answered, "prefer Alternative A a little" or "prefer Alternative A a lot," then the response was assigned to be Alternative A. If a respondent answered, "prefer Alternative B a little" or "prefer Alternative B a lot," then the response was assigned to be Alternative B. TEMS uses the continuous scale response directly. In addition, OW methodology treats response from an individual somewhat independent of each other, while TEMS VOT estimates are calculated by examining all the responses for a respondent in combination, as detailed in section 3.7.

Another divergence in the TEMS and OW methodologies was that OW estimated VOT for Auto and Air separately for travel within the Calgary-Edmonton corridor and outside the corridor. This was done to account for any differences that may exist in how travellers value travel time within the key Calgary-Edmonton corridor as opposed to outside the corridor.

**Exhibit 7.2: VOT from SP Survey**

| Mode | Trip Purpose | Description | OW VOT ($/hour) | TEMS VOT ($/hour) |
|---|---|---|---|---|
| Auto | Business | Within corridor | 40.54 | 21.43 |
| | | Outside corridor | 30.00 | 21.43 |
| | Non-business | Within corridor | 16.00 | 16.81 |
| | | Outside corridor | 12.50 | 16.81 |
| Air | Business | Within corridor | 86.75 | 52.70 |
| | | Outside corridor | 66.56 | 52.70 |
| | Non-business | Within corridor | 53.00 | 34.41 |
| | | Outside corridor | 45.20 | 34.41 |
| Greyhound | Business | | 18.79 | 13.21 |
| | Non-business | | 15.12 | 9.16 |
| Red Arrow | Business | | 19.68 | 16.71 |
| | Non-business | | 18.03 | 14.61 |

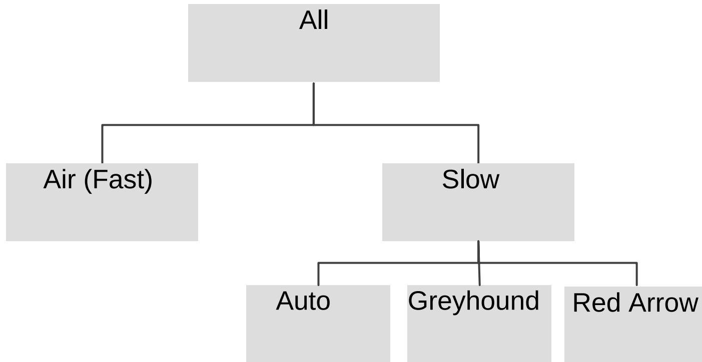
Overall, OW VOT estimates appear to be higher than those estimated by TEMS, but are well within the range of the values observed in other corridors, as detailed in Appendix G.

### 7.1.3 Mode Choice Models

The mode choice model captures the trade-offs travellers make in the choice of modes, and is used to understand share shifts from introduction of new modes as well as sensitivity to mode shares from changes to levels of service. Logit modeling techniques were used to estimate the mode choice model. The choice of mode was modeled as a hierarchy of decisions (a Nested model) that groups similar modes together while making choices.

A nested logit model structure was considered appropriate, particularly since it would provide the advantage of testing relative similarities of certain types of existing modes more than the others. In addition, it would provide the ability to fit high-speed rail into different nests or levels in the decision framework or hierarchy depending on the HSR scenario, speed and technology. After a number of iterations to understand the best-fit models, the decision hierarchy as presented in Exhibit 7.3 was selected as the model that best fits the observed travel behaviour.

**Exhibit 7.3: Nested Model Structure**




There exist some differences in OW and TEMS mode choice methodologies, which will result in slightly different sensitivities for travel time and cost. These include the following:

- Model variables: TEMS model uses a single variable as a driver that combines all time and cost information for a mode (e.g. access and egress time, in-vehicle trip time) into a composite time variable; whereas, OW models these variables independently. As a result, the OW model has separate parameters for in-vehicle and out-of-vehicle travel times for Greyhound and Red Arrow. In addition, the OW model has a separate coefficient to capture the impact of Frequency for transit modes, while TEMS incorporates Frequency into the composite time value using the Value-of-Frequency (VOF) model results. Also, the OW model captures the relative differences in modal preferences for travel to/from the downtowns of Calgary and Edmonton.

- The nested decision hierarchy: First, the OW model simultaneously models all choices, that is to say, all four existing modes are considered at the same time in structuring the decision hierarchy. So, a nest can have more than two modes underneath. Alternatively, TEMS models the decisions as a sequence of binary choices, which means that the mode selection is a sequence of decisions that involve a maximum of two modes at a time. Second, while TEMS has a different nesting structure for Business and Non-Business trips, the OW model has the same nesting structure for both trips, which was found to be the most relevant option for the OW model, given the other methodology choices made.

### 7.1.4 Induced Demand Model

It is reasonable to assume that improved mobility and access in the corridor due to the new high-speed rail line would lead to some new trips that would not have occurred otherwise. Typically, demand forecasting studies derive induced demand as an independent benefit arising out of improvements to overall level of service of all modes.

Induced demand was modeled separately for Business and Non-Business trip purposes, and as a function of the following:

- Zonal Socio-economic characteristics such as population, employment, and income.
- The composite utility of travel on any OD pair, as captured by the utility of travel by each mode in the mode choice model.
- Regional indicator variables to account for greater induced demand for trips ending in Calgary and Edmonton.

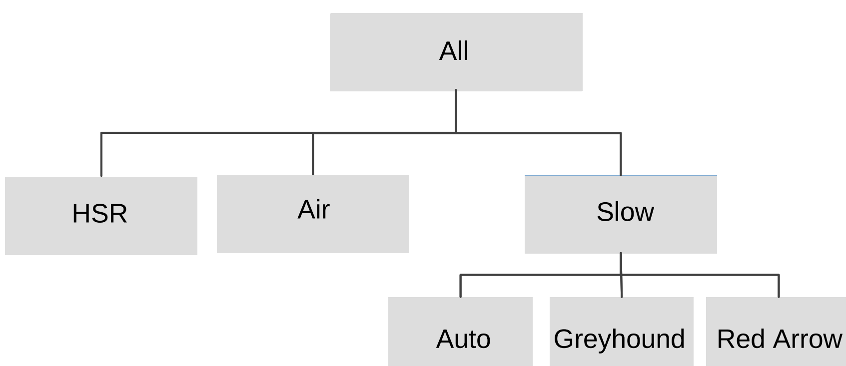
The methodology used by OW is similar to that used by TEMS for induced demand model, the main difference being in the formulation of the composite utility according to the mode choice hierarchical structure chosen.

### 7.1.5 Modeling High-Speed Rail Options

Different mode choice decision hierarchies were considered for the four alternative HSR options, with a structure that puts HSR parallel to Air chosen for implementation. Based on a comparison of in-vehicle travel time and travel costs between Calgary and Edmonton for existing modes and HSR modes, HSR was modeled to be behaviourally similar to and therefore parallel to Air. Our hypothesis and past research shows that HSR travellers have a much higher value of time than those using auto or slower public modes of transport, a hypothesis reinforced by TEMS' evaluation of VOT for HSR shown in Section 3.7.3.

Exhibit 7.4 below illustrates the model structure chosen for implementation.

**Exhibit 7.4: Nested Model Structure including High Speed Rail**




The choice of modal structure points to another difference between the approaches of TEMS and OW in modeling mode split. While TEMS adopted two different modal hierarchies (see Appendix A), one for 125 mph and 150 mph and another one for 200 mph and 300 mph, OW evaluation of an appropriate hierarchy led to a single one for all HSR technologies.

## 7.2 Ridership and Revenue Forecasts for the Base Case

This section provides an overview of the modeled scenarios and resulting forecasts of ridership and revenue for the proposed HSR options in Alberta. Ridership and revenue forecasts were developed for the following scenarios:

- Forecast years – 2021, 2031, 2051
- HSR technologies – Diesel (125 mph), Turbine Electric (150 mph), Electric (200 mph), Magnetic Levitation (300 mph)
- Socioeconomic growth – Central (normal), Low growth and High growth

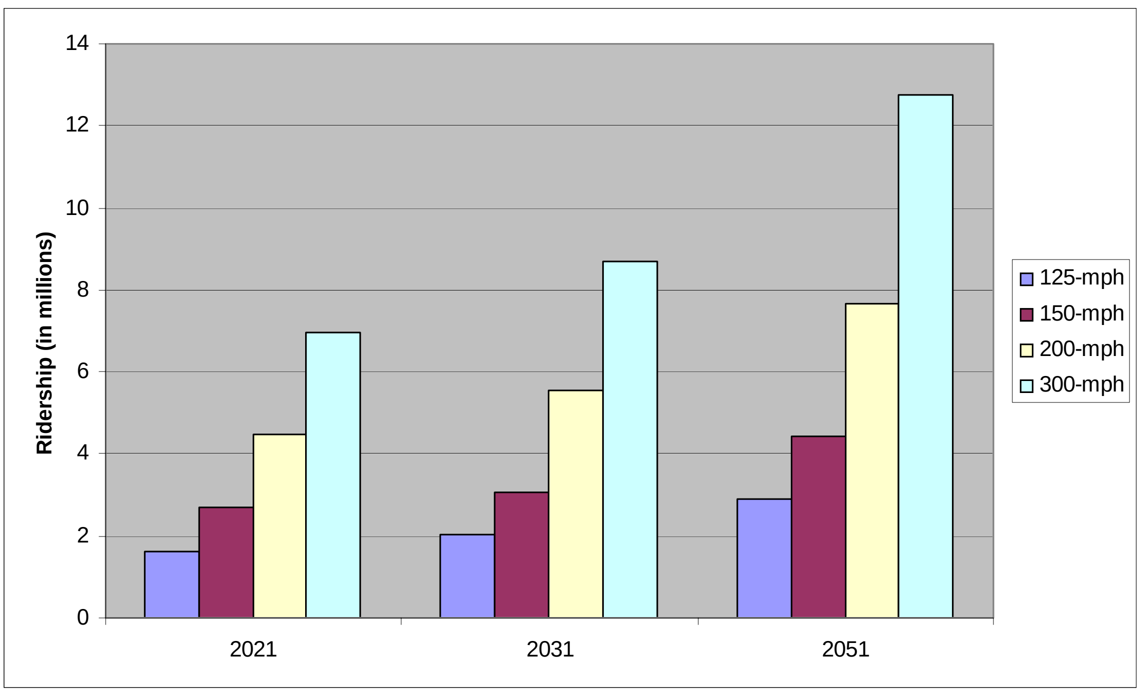
### 7.2.1 Ridership Forecasts

Exhibit 7.5 presents in table format the total annual ridership forecasts for the four HSR technologies for each of the three forecast years under the central socioeconomic growth case. Exhibit 7.6 presents the same information in a chart format. It can be noticed that the higher service levels associated with each faster HSR mode drive greater ridership levels. As a result, 150 mph Exhibits a ridership increase of 65% with respect to 125 mph in 2021, 200 mph of 67% (with respect to 150 mph) and 300 mph of 56% (with respect to 200 mph).

**Exhibit 7.5: Table of Annual Ridership Forecasts for Central Socioeconomic Case (in millions)**

| Year | 125 mph | 150 mph | 200 mph | 300 mph |
|---|---|---|---|---|
| 2021 | 1.620 | 2.678 | 4.473 | 6.978 |
| 2031 | 2.011 | 3.059 | 5.567 | 8.715 |
| 2051 | 2.916 | 4.451 | 7.654 | 12.768 |

**Exhibit 7.6: Chart of Annual Ridership Forecasts for Central Socioeconomic Case**



### 7.2.2 High-Speed Rail Market Shares

Exhibit 7.7 shows the mode share of the four HSR options for 2021 Central case. The share of 125 mph for both Business and Non-Business trips is almost the same. As the HSR options increase in speed, they become more attractive for both types of travellers, but much faster for Business travellers than for Non-Business travellers. This can be attributed to the higher VOT for Business travellers, and the corresponding higher time savings that faster HSR options provide.

**Exhibit 7.7: HSR Mode Shares in 2021 (for Central Case); actual volume in million**

| | 125 mph | | 150 mph | | 200 mph | | 300 mph | |
|---|---|---|---|---|---|---|---|---|
| Trip Purpose | actual | % | actual | % | actual | % | actual | % |
| Business | 0.514 | 1.7% | 1.087 | 3.5% | 2.335 | 6.9% | 4.215 | 12.2% |
| Non-Business | 1.106 | 1.7% | 1.591 | 2.4% | 2.138 | 3.2% | 2.763 | 4.1% |
| All Trips | 1.620 | 1.7% | 2.678 | 2.8% | 4.473 | 4.4% | 6.978 | 6.7% |

### 7.2.3 Business Share of High-Speed Rail Trips

Exhibit 7.8 presents the proportion of Business trips across the four options over the three forecast years. As expected, as the speed of the HSR option increases, which also correlates to higher travel costs, it becomes relatively more attractive for Business travellers. For any HSR type, across the forecast years, the Business share of total HSR trips remains almost the same.

**Exhibit 7.8: Business Share of Total HSR Trips (for Central Case); actual volume in million**

| | 125 mph | | 150 mph | | 200 mph | | 300 mph | |
|---|---|---|---|---|---|---|---|---|
| Year | actual | % | actual | % | actual | % | actual | % |
| 2021 | 0.514 | 31.7% | 1.087 | 40.6% | 2.335 | 52.2% | 4.215 | 60.4% |
| 2031 | 0.650 | 32.3% | 1.248 | 40.8% | 2.939 | 52.8% | 5.325 | 61.1% |
| 2051 | 0.959 | 32.9% | 1.847 | 41.5% | 4.110 | 53.7% | 7.840 | 61.4% |

### 7.2.4 Composition of Demand

These forecasts include both the trips diverted from current modes and induced trips from improved utility of travel in the corridor. The induced trips as a proportion of diverted trips are shown in Exhibit 7.9 below:

**Exhibit 7.9: HSR Induced Demand as a Portion of Total Trips (Central Case); actual volume in million**

| | 125 mph | | 150 mph | | 200 mph | | 300 mph | |
|---|---|---|---|---|---|---|---|---|
| Trip Purpose | actual | % | actual | % | actual | % | actual | % |
| Business | 0.017 | 3.4% | 0.082 | 7.5% | 0.350 | 15.0% | 0.784 | 18.6% |
| Non-Business | 0.064 | 5.8% | 0.151 | 9.5% | 0.233 | 10.9% | 0.376 | 13.6% |
| All Trips | 0.081 | 5.0% | 0.233 | 8.7% | 0.581 | 13.0% | 1.158 | 16.6% |

### 7.2.5 Revenue Forecasts

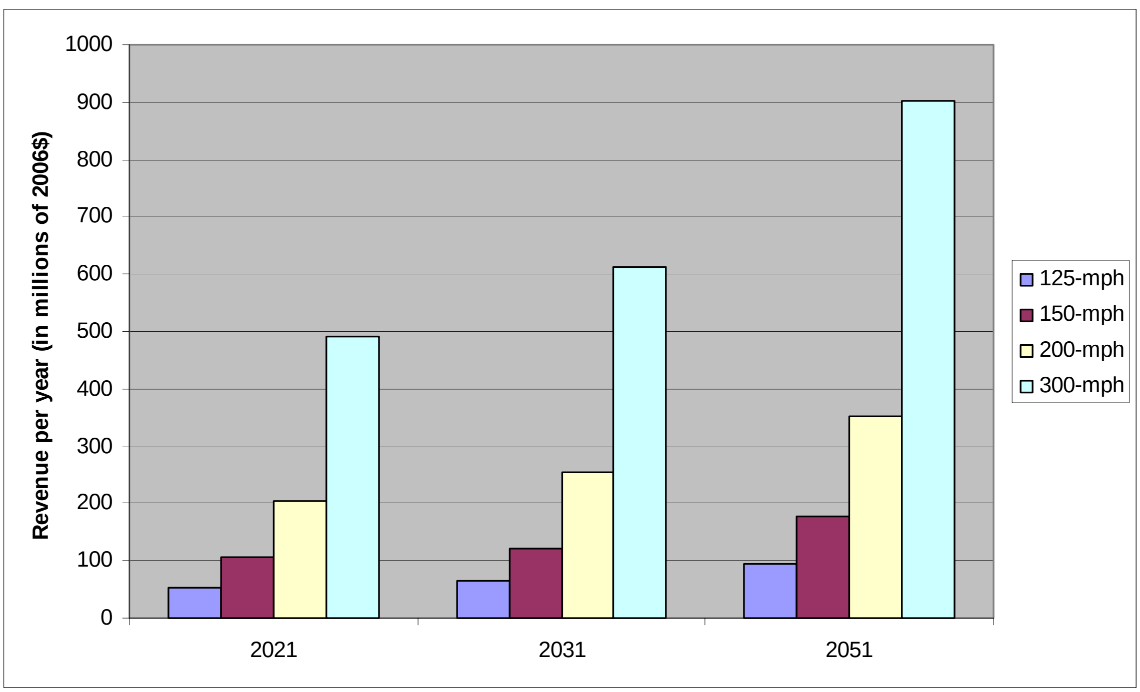
Revenue from HSR is calculated using the per mile fares on the OD pairs. To these costs, a "premium" cost was introduced into the model to reflect the higher cost per mile to travel in the short segments of the corridor (*i.e.*, an urban journey downtown-suburban station) in both urban centres. Specifically, a one-way journey for each one of the short segments $3 on 125 mph, $5 on 150 mph, $5 on 200 mph and $10 on 300 mph.

Total revenue forecasts – Exhibits 7.10 and 7.11 present the total revenue forecasts for the four HSR technologies for each of the three forecast years under the central socioeconomic growth scenarios in tabular and chart formats, respectively. These forecasts include both the trips diverted from current modes and induced trips from improved utility of travel in the corridor. It can be observed that the faster-speed HSR modes, and in particular the 300 mph, experience significant revenue gains relative to the slower HSR modes (125 mph and 150 mph). These revenues are represented in 2006 real dollars with no discount rate applied to account for current value of the revenues.

**Exhibit 7.10: Table of Annual Revenue Forecasts for Central Socioeconomic Case (in millions of 2006$)**

| Year | 125 mph | 150 mph | 200 mph | 300 mph |
|---|---|---|---|---|
| 2021 | $52.220 | $105.582 | $204.150 | $489.820 |
| 2031 | $64.722 | $121.285 | $254.321 | $612.326 |
| 2051 | $94.339 | $177.559 | $353.444 | $902.627 |

**Exhibit 7.11: Chart of Annual Revenue Forecasts for Central Socioeconomic Case (in 2006$)**

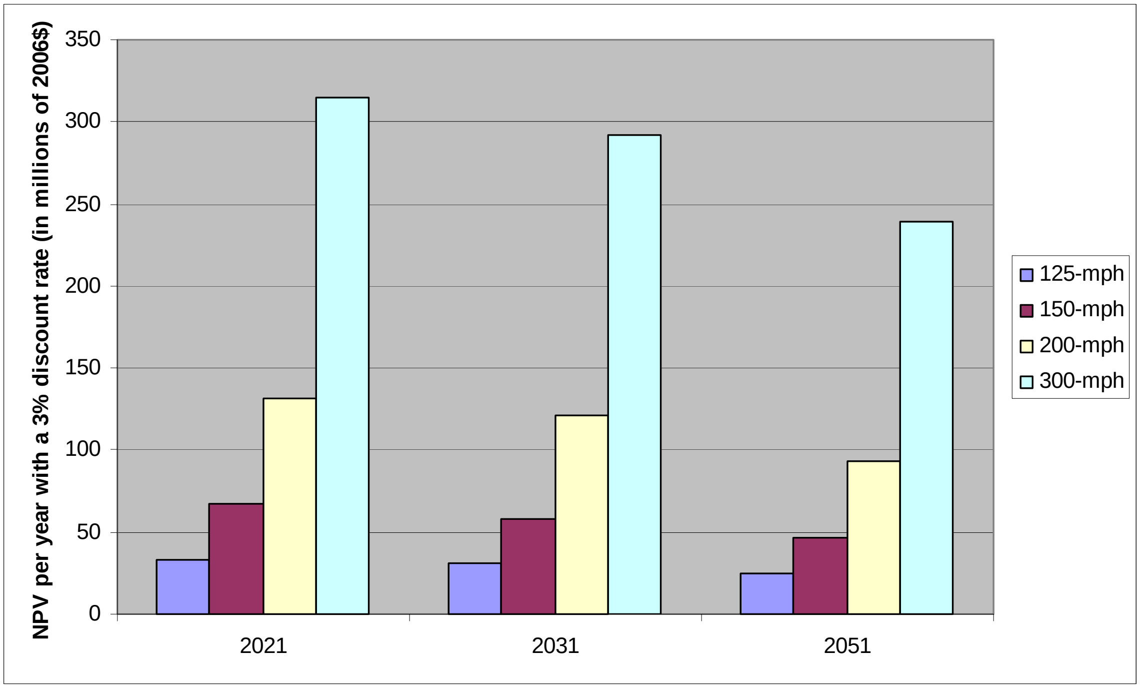



The present value of the forecasted cash flow of the project was also calculated, using a discount rate of 3%, as presented in Exhibits 7.12 and 7.13.

**Exhibit 7.12: Table of Discounted Annual Revenue Forecasts (NPV) for Central Socioeconomic Case (in millions of 2006$)**

| Year | 125 mph | 150 mph | 200 mph | 300 mph |
|---|---|---|---|---|
| 2021 | $33.518 | $67.769 | $131.036 | $314.396 |
| 2031 | $30.911 | $57.926 | $121.465 | $292.450 |
| 2051 | $24.946 | $46.953 | $ 93.464 | $238.689 |

**Exhibit 7.13: Chart of Discounted Annual Revenue Forecasts (NPV) for Central Socioeconomic Case (in 2006$)**




# 7.3 Sensitivity to Demographic Growth

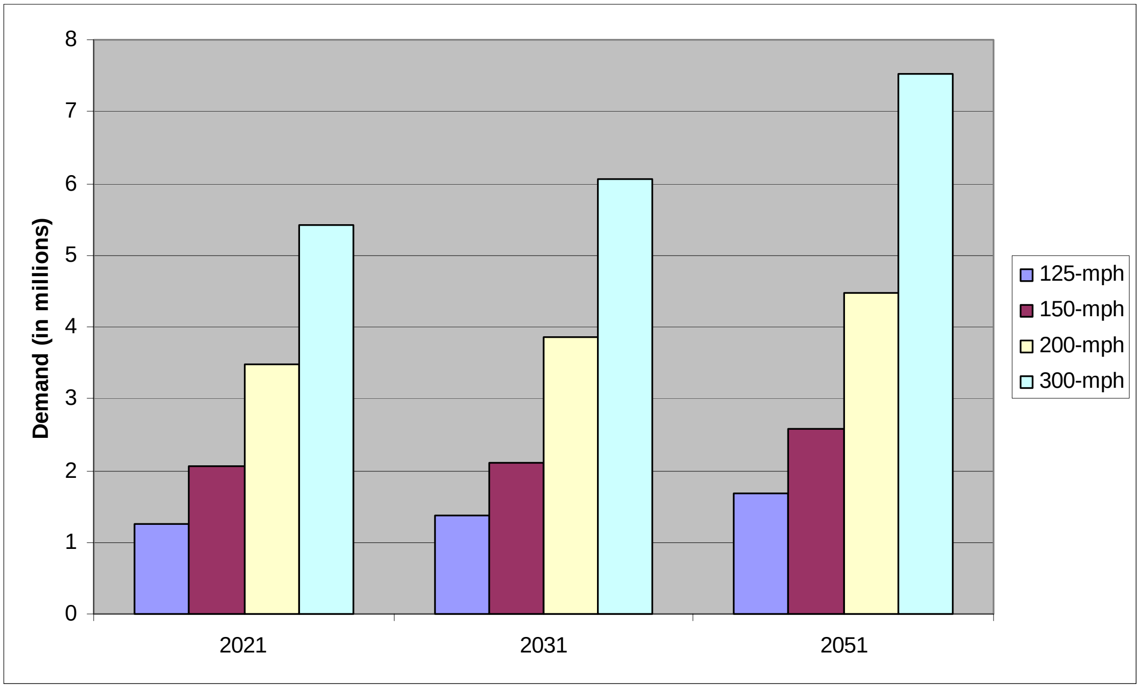
## 7.3.1 Low Demographic Scenario – All High-Speed Rail Technologies

Ridership forecasts for the four HSR options were also projected under a low socioeconomic growth scenario. Using 2031 as an example, 125 mph ridership under the low socioeconomic growth scenario is 1.375 million riders (see Exhibit 7.14) down from 2.011 million riders (see Exhibit 7.5) in the base case (or a 32% decrease). In general, ridership across all modes between the base case and low socioeconomic growth scenario differs by approximately 22 to 23% in 2021, 30 to 32% in 2031, and 41 to 42% in 2041.

**Exhibit 7.14: Table of Annual Ridership Forecasts for Low Growth Socioeconomic Case (in millions)**

| Year | 125 mph | 150 mph | 200 mph | 300 mph |
|---|---|---|---|---|
| 2021 | 1.243 | 2.064 | 3.467 | 5.427 |
| 2031 | 1.375 | 2.104 | 3.859 | 6.068 |
| 2051 | 1.671 | 2.575 | 4.482 | 7.523 |

**Exhibit 7.15: Chart of Annual Ridership Forecasts for Low Growth Socioeconomic Case**



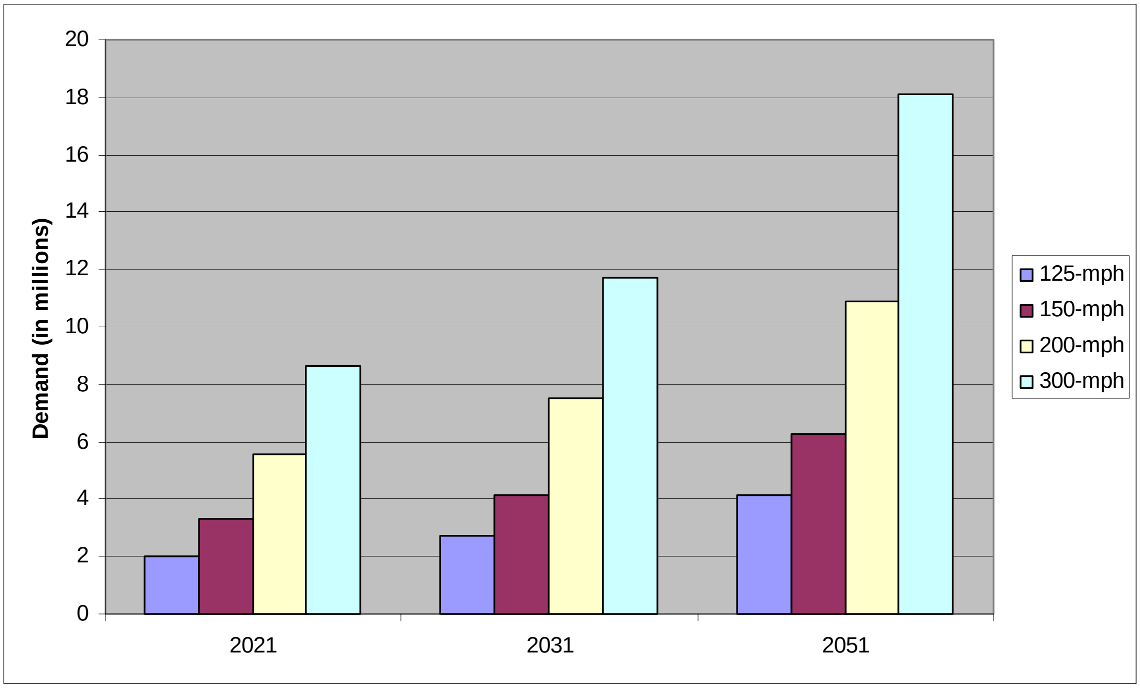

## 7.3.2 High Demographic Scenario – All High-Speed Rail Technologies

Ridership forecasts for the four HSR options were also projected under a high socioeconomic growth scenario. Using 2031 as an example, 200 mph ridership under the high socioeconomic growth scenario increases to 7.510 million riders (see Exhibit 7.16) from 5.567 million riders (see Exhibit 7.5) in the base case (or a 35% increase). In general, ridership across all modes grew between the base case and low socioeconomic growth scenario by approximately 24 to 25% in 2021, 35 to 36% in 2031, and 41 and 42% in 2041.

**Exhibit 7.16: Table of Annual Ridership Forecasts for High Growth Socioeconomic Case (in millions)**

| Year | 125 mph | 150 mph | 200 mph | 300 mph |
|---|---|---|---|---|
| 2021 | 2.021 | 3.331 | 5.544 | 8.630 |
| 2031 | 2.736 | 4.147 | 7.510 | 11.724 |
| 2051 | 4.133 | 6.285 | 10.892 | 18.090 |

**Exhibit 7.17: Chart of Annual Ridership Forecasts for High Growth Socioeconomic Case**




## 7.4 Base Case Comparison with TEMS forecasts

We can now carry out a comparison between the base case forecasts as reported in this and the previous chapter. Overall, the two sets of forecasts are very close in ridership, though some discrepancy is present in revenues. Ridership figures for the central case have been shown in Exhibit 6.2 by TEMS and Exhibit 7.5 by Oliver Wyman. The market shares for high-speed rail have been reported in Exhibits 6.6 through 6.9 by TEMS and in Exhibit 7.7 by Oliver Wyman. Revenue figures are shown in Exhibit 6.16 by TEMS and Exhibit 7.10 OW.

The comparison between the two sets of ridership forecasts is shown in Exhibit 7.18 below.

**Exhibit 7.18: Oliver Wyman Ridership Forecasts as a Proportion of TEMS Ridership Forecasts (actual volumes in million)**

| Year | 2021 | | | 2031 | | | 2051 | | |
|---|---|---|---|---|---|---|---|---|---|
| | OW | TEMS | % | OW | TEMS | % | OW | TEMS | % |
| 125 mph | 1.620 | 1.554 | 104% | 2.011 | 1.955 | 103% | 2.916 | 2.821 | 103% |
| 150 mph | 2.678 | 2.518 | 106% | 3.059 | 3.108 | 98% | 4.451 | 4.301 | 103% |
| 200 mph | 4.473 | 4.136 | 108% | 5.567 | 5.236 | 106% | 7.654 | 7.656 | 100% |
| 300 mph | 6.978 | 5.816 | 120% | 8.715 | 7.357 | 118% | 12.768 | 10.745 | 119% |

The agreement between the two sets of forecasts is very good for 125 mph. 150 mph and 200 mph, with an agreement between the two forecasts ranging between 98% and 108%. A small discrepancy exists between the ridership forecasts of the 300 mph magnetic levitation train, with Ol iver Wyman's forecasts consistently higher than TEMS' by at most 20%.

The Exhibit 7.19 shows a similar comparison between the market shares for HSR derived in the central case. Again, the comparison between the forecasts is given in OW's shares as a proportion of TEMS'.

**Exhibit 7.19: OW's HSR Market Shares as a Proportion of TEMS' HSR Market Shares (2021)**

| HSR Option | OW | TEMS | Ratio |
|---|---|---|---|
| 125 mph | 1.7% | 1.9% | 94% |
| 150 mph | 2.8% | 3.1% | 91% |
| 200 mph | 4.4% | 4.8% | 96% |
| 300 mph | 6.7% | 6.7% | 105% |

As in the case for ridership, the market shares evaluated by the two forecasting models are in good agreement between each other, with an agreement between 91% to 105%, reflecting that the definition of the HSR market is very close in both forecasts.

There is some discrepancy between the revenue figures of TEMS and OW. The comparison between them is shown in Exhibit 7.20 below.

**Exhibit 7.20: Oliver Wyman Revenue Forecasts as a Proportion of TEMS Revenue Forecasts (actual values is million of 2006 $)**

| Year | 2021 | | | 2031 | | | 2051 | | |
|---|---|---|---|---|---|---|---|---|---|
| | OW | TEMS | % | OW | TEMS | % | OW | TEMS | % |
| 125 mph | 52.220 | 75.244 | 69% | 64.722 | 94.580 | 68% | 94.339 | 137.074 | 69% |
| 150 mph | 105.582 | 156.715 | 67% | 121.285 | 193.387 | 63% | 177.559 | 269.019 | 66% |
| 200 mph | 204.150 | 328.203 | 62% | 254.321 | 415.526 | 61% | 353.444 | 609.986 | 58% |
| 300 mph | 489.820 | 608.046 | 81% | 612.326 | 769.284 | 80% | 902.627 | 1,127.890 | 80% |

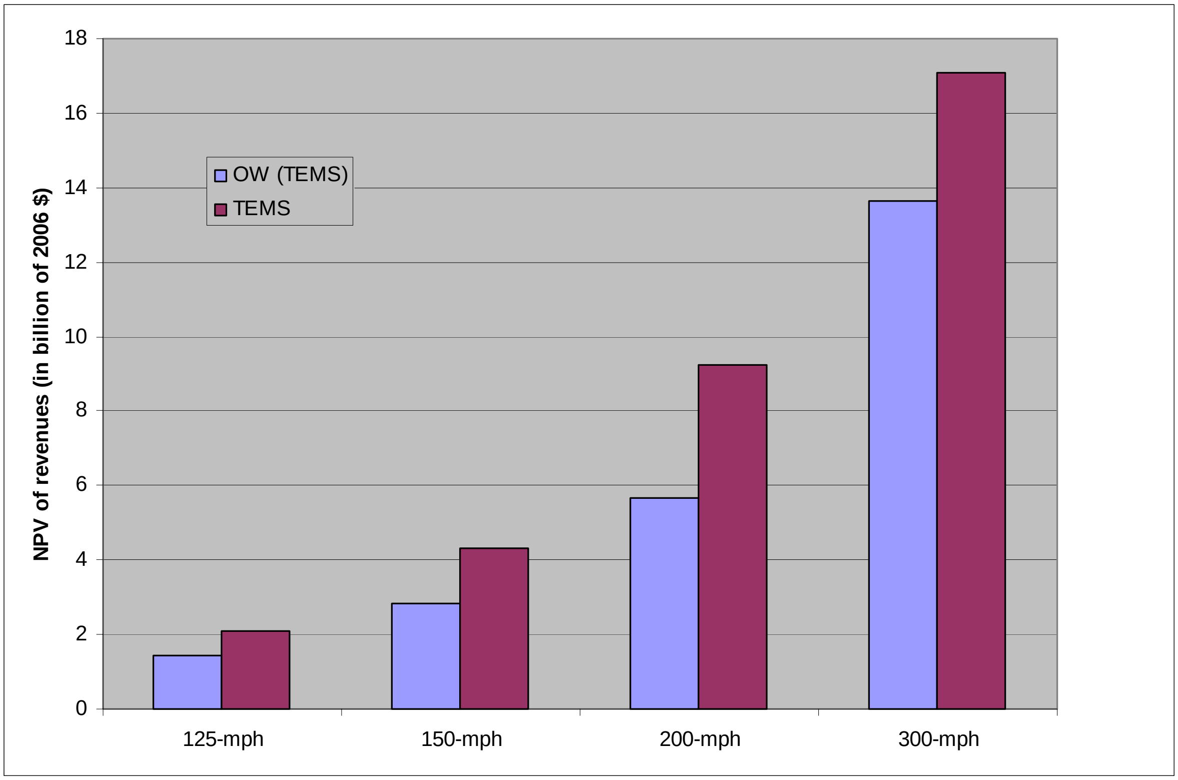
TEMS and OW have examined the possible causes of this difference, which can be explained by the difference in the modeling methodology. As one of the important aspects of the difference it was noticed that the trip length for HSR was shorter on average in the OW's set of forecasts, suggesting that TEMS' model is attracting a larger share of long-distance trips than OW's model.

TEMS extrapolated what difference in net-present value of the revenues is calculated when OW's revenue numbers are compounded, with a discount rate of three percent. TEMS' estimation of the NPV for the central case is shown in Exhibit 9.1. The two NPVs are given in Exhibit 7.21 below and in the chart in Exhibit 7.22.

**Exhibit 7.21: NPV of the Revenues Discounted at Three Percent for Both Forecasts (billions of 2006 $)**

| HSR Option | OW (TEMS) | TEMS |
|---|---|---|
| 125 mph | 1.444 | 2.100 |
| 150 mph | 2.812 | 4.306 |
| 200 mph | 5.645 | 9.205 |
| 300 mph | 13.635 | 17.039 |

**Exhibit 7.22: NPV of the Revenues Discounted at Three Percent for Both Forecasts (in billions of 2006 $)**




Over the life of the project (2011-2051), the net present value of the revenues ranges between 1.4 and 2.1 billion (of 2006 $) for the 125 mph technology, between 2.8 and 4.3 billion for the 150 mph technology, between 5.6 and 9.2 billion for the 200 mph technology, and between 14 and 17 billion for the 300 mph technology.

## 7.5 Comparison of Base Case Results between TEMS, Oliver Wyman, and Van Horne.

In the previous chapter we have presented a comparison for the year 2011 of the forecasts of ridership and revenues between TEMS' study and the Van Horne study (2004). In this section we extend the comparison to include OW's results outlined in this chapter, which are first derived for 2021. In order to produce this comparison we must, in order

- Extend Van Horne's results at year 2021. As done in the methodology outlined in the previous chapter, this is achieved by applying a growth rate of three percent to both ridership and revenues.
- Modify OW's results assuming elasticities similar to those derived for TEMS' model.

As mentioned in the previous chapter, the technological alternatives used in the Van Horne Study, 2004 are a CPR Alternative (akin to 125 mph, used in this report), a Greenfield Non-Electric (akin to 150 mph, used in this report), and a Greenfield Electric (akin to 200-125 mph, used in this report). The results of this comparison are shown in Exhibits 7.23, 7.24 (Ridership) and 7.25 (Revenues).

**Exhibit 7.23: Comparison of 2011 Ridership and Revenues (both in millions) between the Van Horne Study (2004) and the Results from TEMS' and OW's Forecasting Models**

| Adjusted Comparison | TEMS | | Van Horne | | OW | |
|---|---|---|---|---|---|---|
| Year 2021 | Ridership | Revenues | Ridership | Revenues | Ridership | Revenues |
| CPR Alternative (125 mph) | 1.654 | 96.105 | 3.044 | 156.248 | 1.723 | 66.672 |
| Greenfield Non-Electric (150 mph) | 2.584 | 159.095 | 3.614 | 179.482 | 2.748 | 107.185 |
| Greenfield Electric (200 mph) | 3.759 | 234.235 | 3.857 | 192.539 | 4.065 | 145.700 |

**Exhibit 7.24: Adjusted Comparison of TEMS', Van Horne's and OW's Ridership Forecasts for 2021**

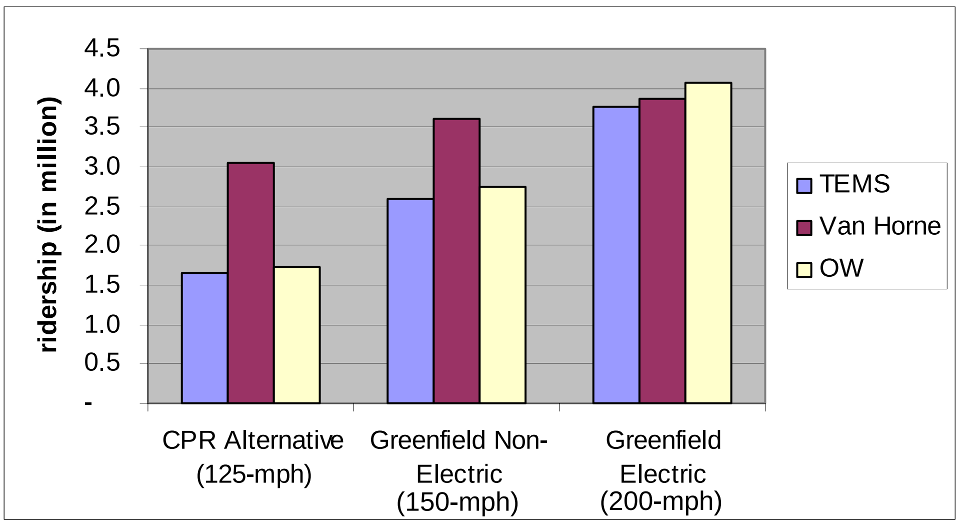
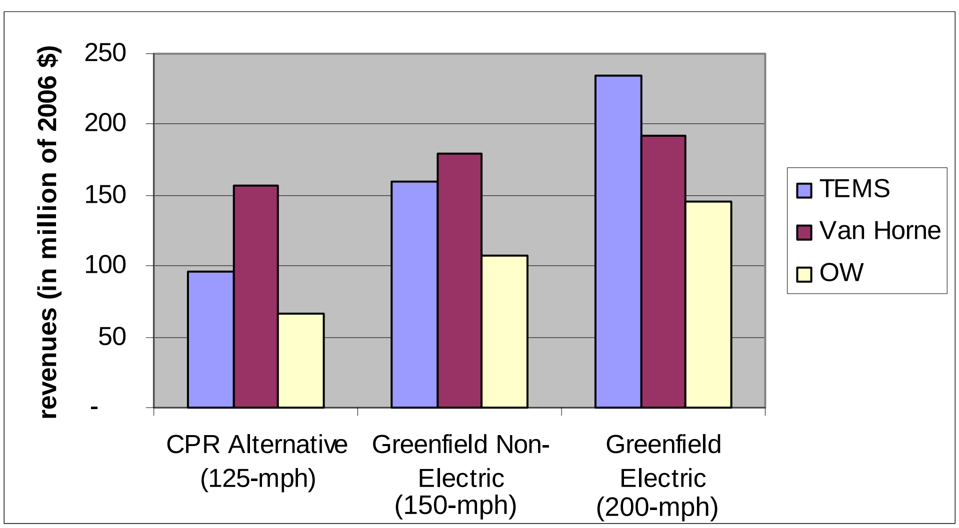



**Exhibit 7.25: Adjusted Comparison of TEMS', Van Horne's and OW's Revenue Forecasts for 2021**



# 8

# Sensitivity Analysis

The purpose of the sensitivity analysis is to quantify three sensitivity issues.

- The impact of uncertainty associated with three critical economic and strategy factors. These are demographic growth, highway congestion and oil prices.
- The potential competitive response of the other competitive modes
- The effect of frequency on rail ridership and revenue.

In developing the sensitivity analysis, TEMS base case ridership and revenue numbers have been used. In this Chapter we describe the sensitivity analysis as compared to the base results. The details of each economic scenario and strategy are provided in Chapter 4 and Chapter 5, respectively.

## 8.1 Sensitivity to Critical Economic Scenario and Transport Strategy Variables

**Economic Scenarios:** The effects of the uncertainty in the demographic forecasts of the province on the ridership and revenue forecasts for HSR have been captured in two scenarios that were described in Chapter 4. These consisted of both a low demographic growth scenario, as well as a high demographic growth scenario. The results for these two scenarios can be found in section 8.4.

**Level of Service for Auto and Bus Market:** The previous section addressed the effect of uncertainty in the demographic growth of the province of Alberta and its economic regions at the zone level, but the level of service for (mostly) Auto and Bus travel is an additional source of uncertainty that must be examined to gauge its effects on HSR ridership and revenue. Two important sources of the level of service of auto travel uncertainty are addressed in this section, namely, the effects of congestion level and gasoline price on HSR ridership and revenue.

The level of service assumptions used for the central case and various sensitivities have been outlined in Section 5.3. The central case included an increase of congestion in urban areas resulting in an increase in travel time in urban areas of half of a percent per year. Regarding oil price, the central case assumption is gasoline price at the pump of $1.05/liter.

It is clear that increasing urban congestion as well as increasing gasoline cost will favor HSR ridership for both factors make car travel more costly, in terms of either time or cost. These are factors that produce a *positive-HSR* effect, and this terminology will be used in the rest of this section. Conversely, it is clear that less urban congestion and lower price of gasoline tend to favor car travel. These factors produce a *negative-HSR* effect. To test these assumptions, in discussion with AIT, alternative scenarios were devised that vary both these level of service factors. The positive-HSR effects scenario includes a congestion rate increase of one percent per year, and a gasoline price at the pump of $1.5/liter. The negative-HSR effects scenario includes no change in congestion rate over time, and a gasoline price at the pump of $0.96/liter.

The results in Section 8.4 show that the congestion rate has a smaller effect than the price of gasoline in both ridership and revenues. This is because the expected percentage change in gasoline price is higher. It should be noted, however, that the combined effect of these two factors, together with an upper and lower demographic scenario, can change dramatically the level of ridership and revenues.

**The Combined Effect: A "Best" and "Worst" Case High-Speed Rail Scenario:** It is possible to combine all effects discussed until now, both demographic and related to the level of service to produce a "best" case scenario and a "worst" case scenario, in terms of HSR ridership and revenues. The "best" case HSR scenario consists of:

- high demographic growth;
- high congestion level (one percent longer travel time per year in urban areas); and
- high gasoline price (equivalent to $1.50/liter at the pump).

Conversely, the "worst" case HSR scenario consists of:

- low demographic growth;
- low congestion level (no yearly change in travel time in urban areas); and
- low gasoline price (equivalent to $0.96/liter at the pump).

These extreme scenarios provide the widest sensitivity interval for HSR ridership and revenues.

**Exhibit 8.1: "Best" and "Worst" Case Scenarios for 125 mph Ridership (in million)**

| | Worst Case | Central Case | Best Case |
|---|---|---|---|
| 2011 | 1.051 | 1.143 | 1.483 |
| 2016 | 1.166 | 1.353 | 1.841 |
| 2021 | 1.255 | 1.555 | 2.208 |
| 2026 | 1.323 | 1.756 | 2.601 |
| 2031 | 1.456 | 1.956 | 2.952 |
| 2036 | 1.559 | 2.176 | 3.373 |
| 2041 | 1.652 | 2.372 | 3.745 |
| 2046 | 1.766 | 2.606 | 4.193 |
| 2051 | 1.861 | 2.821 | 4.619 |

**Exhibit 8.2: "Best" and "Worst" Case Scenarios for 125 mph Ridership**

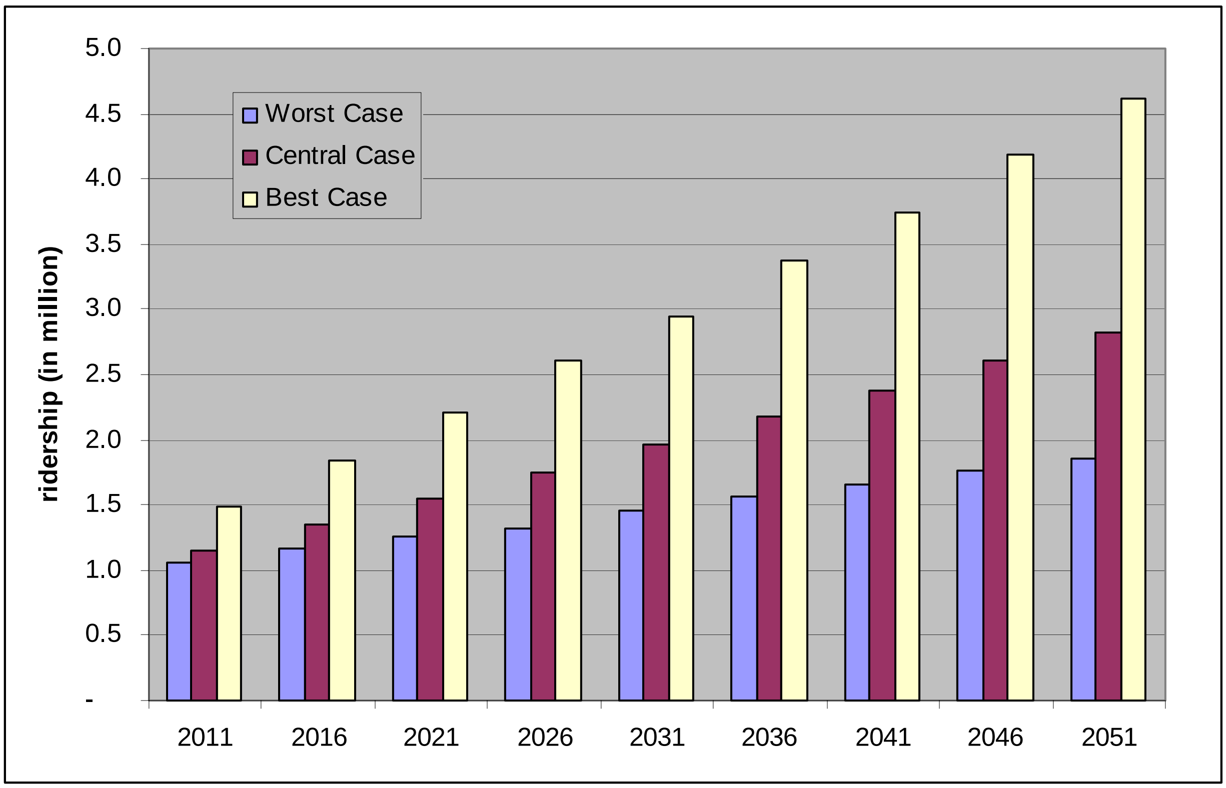


**Exhibit 8.3: "Best" and "Worst" Case Scenarios for 125 mph Revenues (in million of 2006 $)**

| | Worst Case | Central Case | Best Case |
|---|---|---|---|
| 2011 | 50.634 | 55.127 | 79.900 |
| 2016 | 56.333 | 65.459 | 99.404 |
| 2021 | 60.637 | 75.244 | 119.202 |
| 2026 | 63.925 | 84.940 | 140.246 |
| 2031 | 70.288 | 94.580 | 159.396 |
| 2036 | 75.266 | 105.242 | 182.296 |
| 2041 | 79.896 | 114.905 | 202.654 |
| 2046 | 85.530 | 126.510 | 227.065 |
| 2051 | 90.228 | 137.074 | 250.585 |

**Exhibit 8.4: "Best" and "Worst" Case Scenarios for 125 mph Revenues (in millions of 2006 $)**

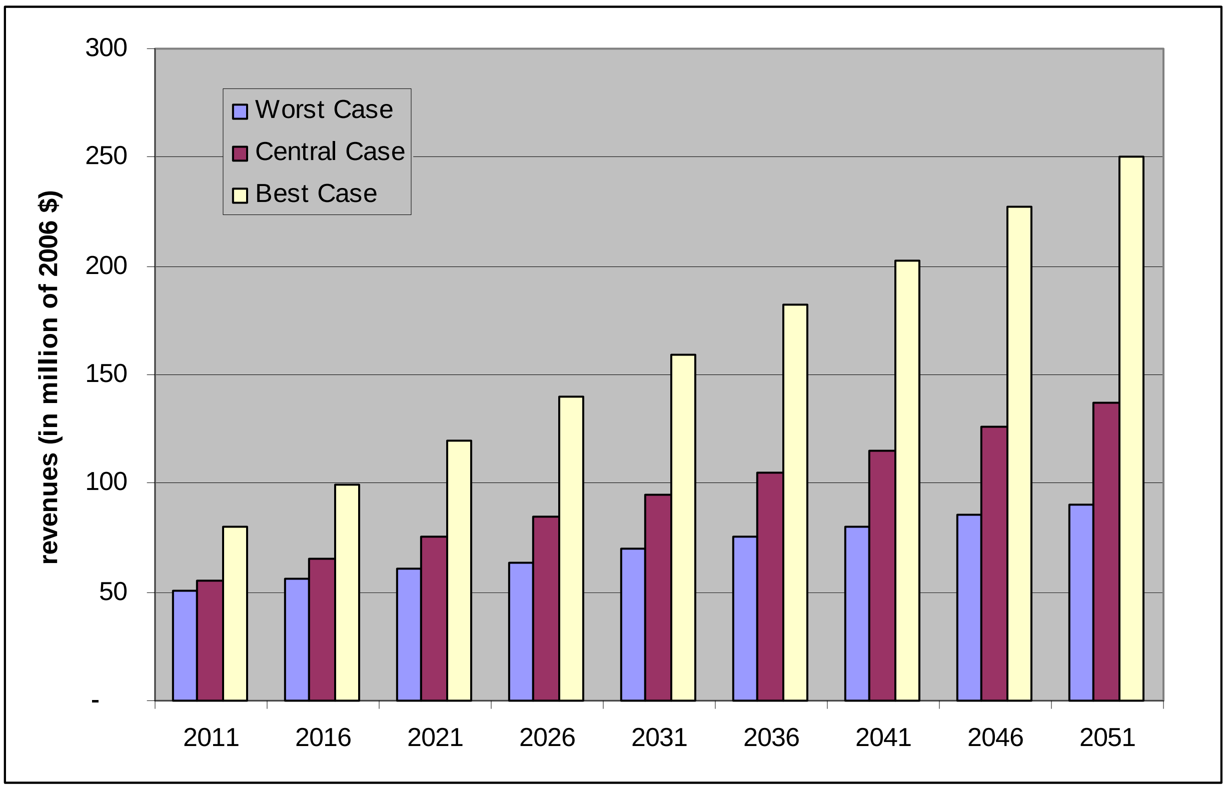


**Exhibit 8.5: "Best" and "Worst" Case Scenarios for 150 mph Ridership (in million)**

| | Worst Case | Central Case | Best Case |
|---|---|---|---|
| 2011 | 1.763 | 1.917 | 2.492 |
| 2016 | 1.920 | 2.226 | 3.025 |
| 2021 | 2.035 | 2.518 | 3.583 |
| 2026 | 2.119 | 2.811 | 4.119 |
| 2031 | 2.314 | 3.108 | 4.701 |
| 2036 | 2.458 | 3.431 | 5.306 |
| 2041 | 2.577 | 3.696 | 5.852 |
| 2046 | 2.718 | 4.011 | 6.469 |
| 2051 | 2.840 | 4.301 | 7.059 |

**Exhibit 8.6: "Best" and "Worst" Case Scenarios for 150 mph Ridership**

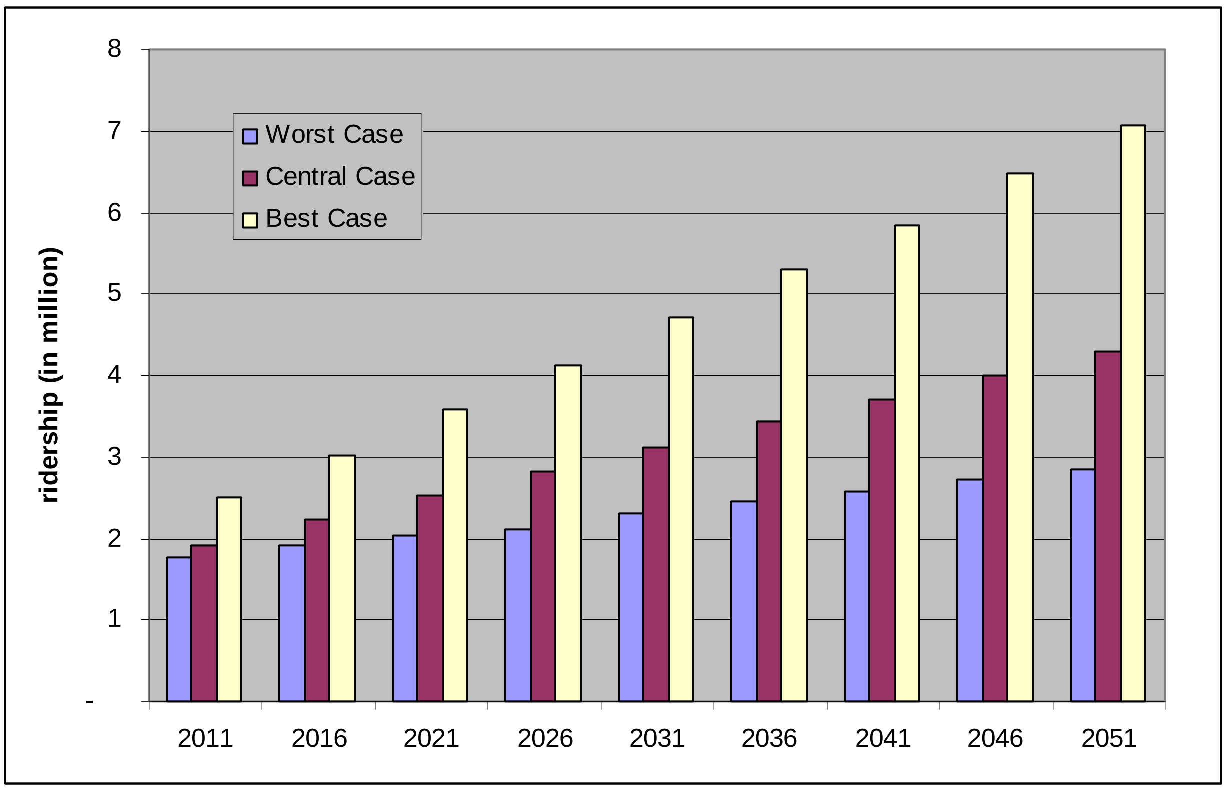


**Exhibit 8.7: "Best" and "Worst" Case Scenarios for 150 mph Revenues (in million of 2006 $)**

| | Worst Case | Central Case | Best Case |
|---|---|---|---|
| 2011 | 109.184 | 118.872 | 154.529 |
| 2016 | 119.122 | 138.420 | 187.813 |
| 2021 | 126.292 | 156.715 | 223.041 |
| 2026 | 131.651 | 174.931 | 256.218 |
| 2031 | 143.717 | 193.387 | 292.613 |
| 2036 | 152.720 | 213.544 | 330.189 |
| 2041 | 160.228 | 230.437 | 365.055 |
| 2046 | 169.445 | 250.631 | 404.292 |
| 2051 | 177.080 | 269.019 | 441.739 |

**Exhibit 8.8: "Best" and "Worst" Case Scenarios for 150 mph Revenues (in million of 2006 $)**

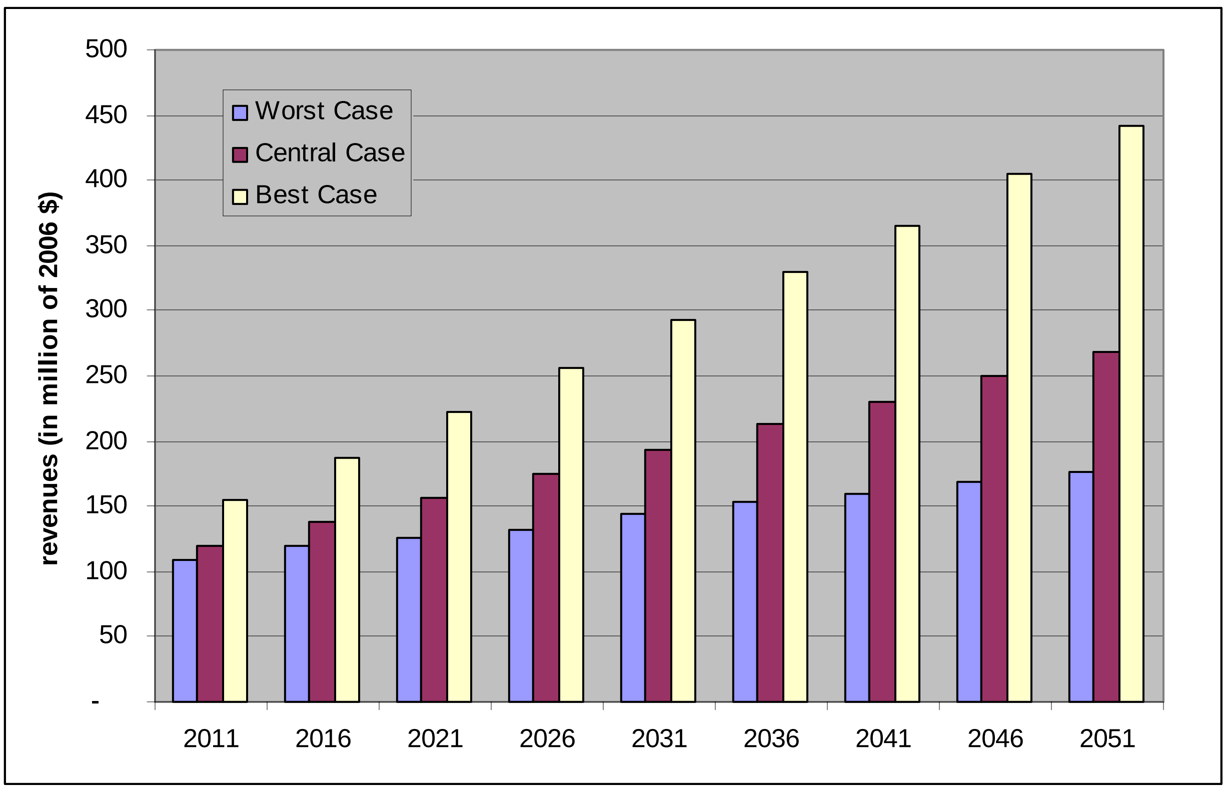


**Exhibit 8.9: "Best" and "Worst" Case Scenarios for 200 mph Ridership (in million)**

| | Worst Case | Central Case | Best Case |
|---|---|---|---|
| 2011 | 2.780 | 2.995 | 3.730 |
| 2016 | 3.111 | 3.582 | 4.672 |
| 2021 | 3.360 | 4.136 | 5.616 |
| 2026 | 3.549 | 4.685 | 6.630 |
| 2031 | 3.918 | 5.236 | 7.556 |
| 2036 | 4.212 | 5.851 | 8.646 |
| 2041 | 4.467 | 6.385 | 9.626 |
| 2046 | 4.800 | 7.058 | 10.809 |
| 2051 | 5.069 | 7.657 | 11.947 |

**Exhibit 8.10: "Best" and "Worst" Case Scenarios for 200 mph Ridership**

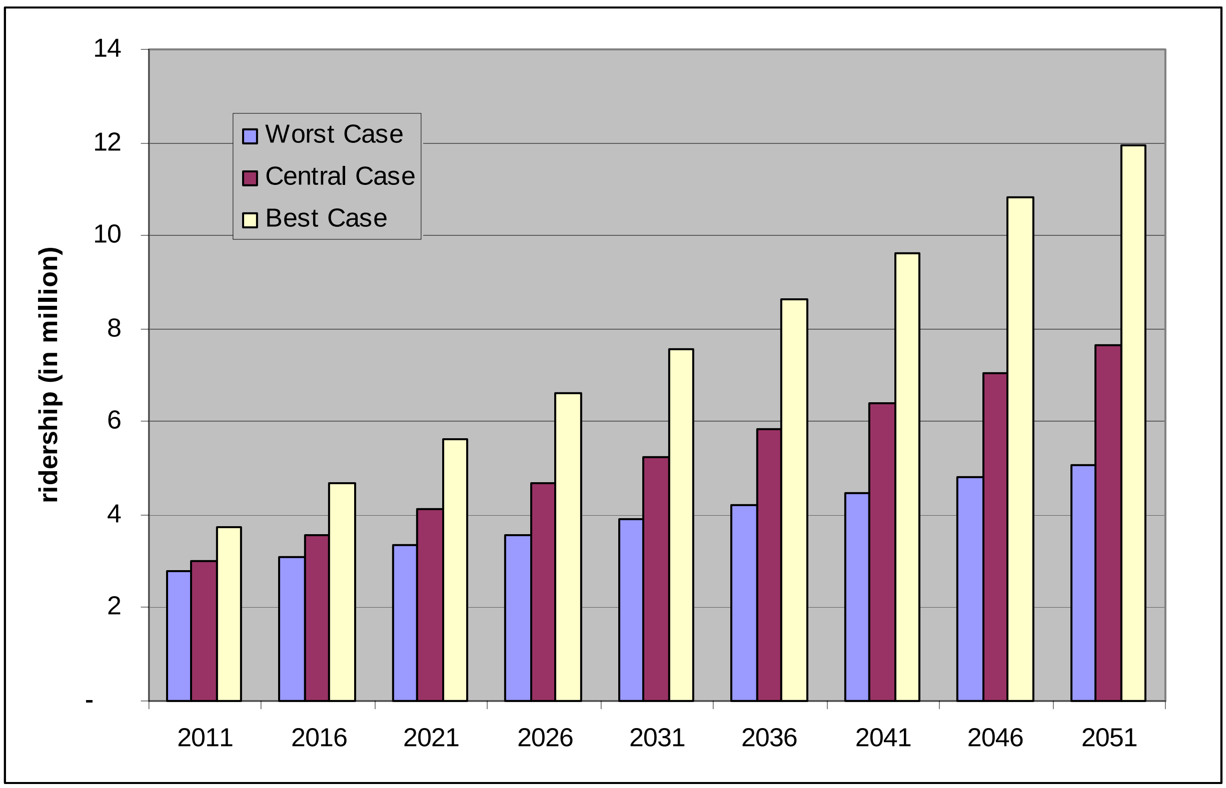


**Exhibit 8.11: "Best" and "Worst" Case Scenarios for 200 mph Revenues (in million of 2006 $)**

| | Worst Case | Central Case | Best Case |
|---|---|---|---|
| 2011 | 219.154 | 236.879 | 321.482 |
| 2016 | 245.878 | 284.024 | 402.775 |
| 2021 | 265.708 | 328.203 | 485.251 |
| 2026 | 280.500 | 371.730 | 572.664 |
| 2031 | 309.816 | 415.526 | 652.343 |
| 2036 | 333.191 | 464.508 | 747.619 |
| 2041 | 353.830 | 507.512 | 832.467 |
| 2046 | 380.695 | 561.834 | 935.944 |
| 2051 | 402.318 | 609.986 | 1,035.741 |

**Exhibit 8.12: "Best" and "Worst" Case Scenarios for 200 mph Revenues (in million of 2006 $)**

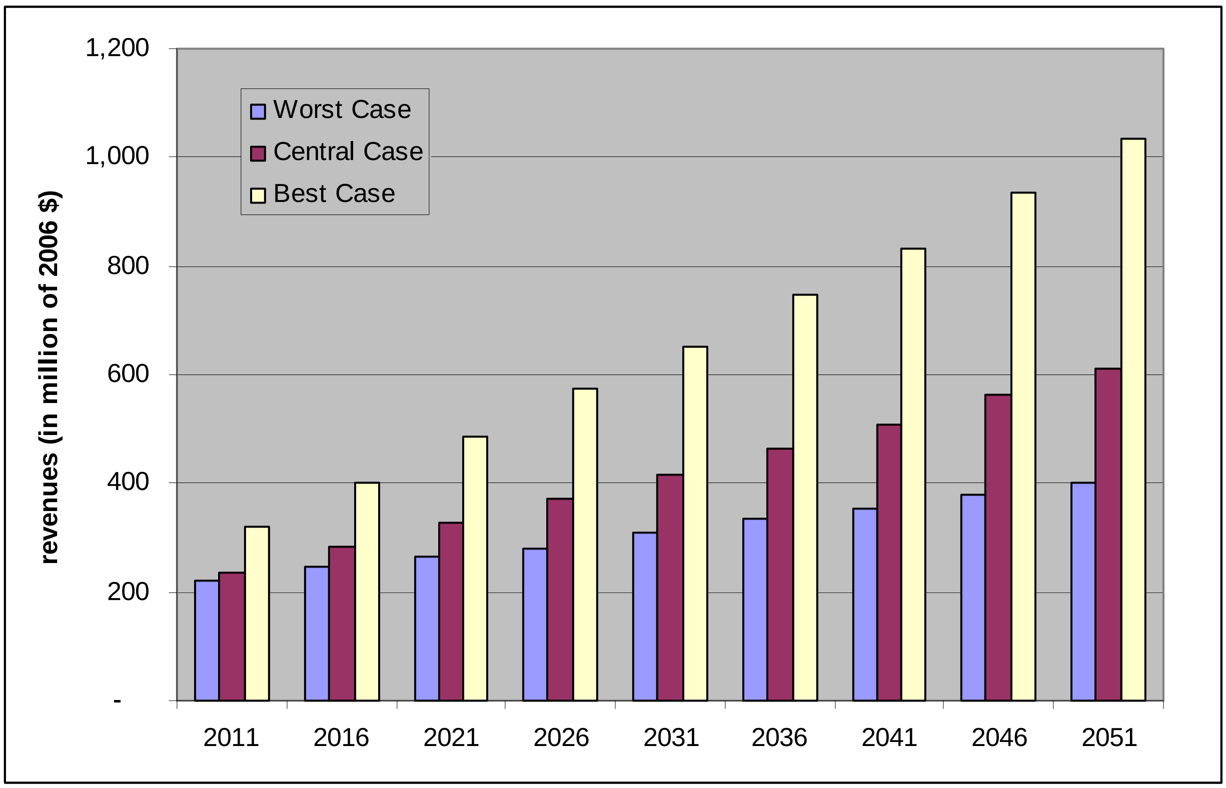


**Exhibit 8.13: "Best" and "Worst" Case Scenarios for 300 mph Ridership (in million)**

| | Worst Case | Central Case | Best Case |
|---|---|---|---|
| 2011 | 3.942 | 4.212 | 5.253 |
| 2016 | 4.412 | 5.037 | 6.580 |
| 2021 | 4.767 | 5.816 | 7.897 |
| 2026 | 5.034 | 6.586 | 9.319 |
| 2031 | 5.556 | 7.358 | 10,615 |
| 2036 | 5.966 | 8.212 | 12,134 |
| 2041 | 6.328 | 8.960 | 13,505 |
| 2046 | 6.798 | 9.903 | 15,160 |
| 2051 | 7.180 | 10,745 | 16,751 |

**Exhibit 8.14: "Best" and "Worst" Case Scenarios for 300 mph Ridership**

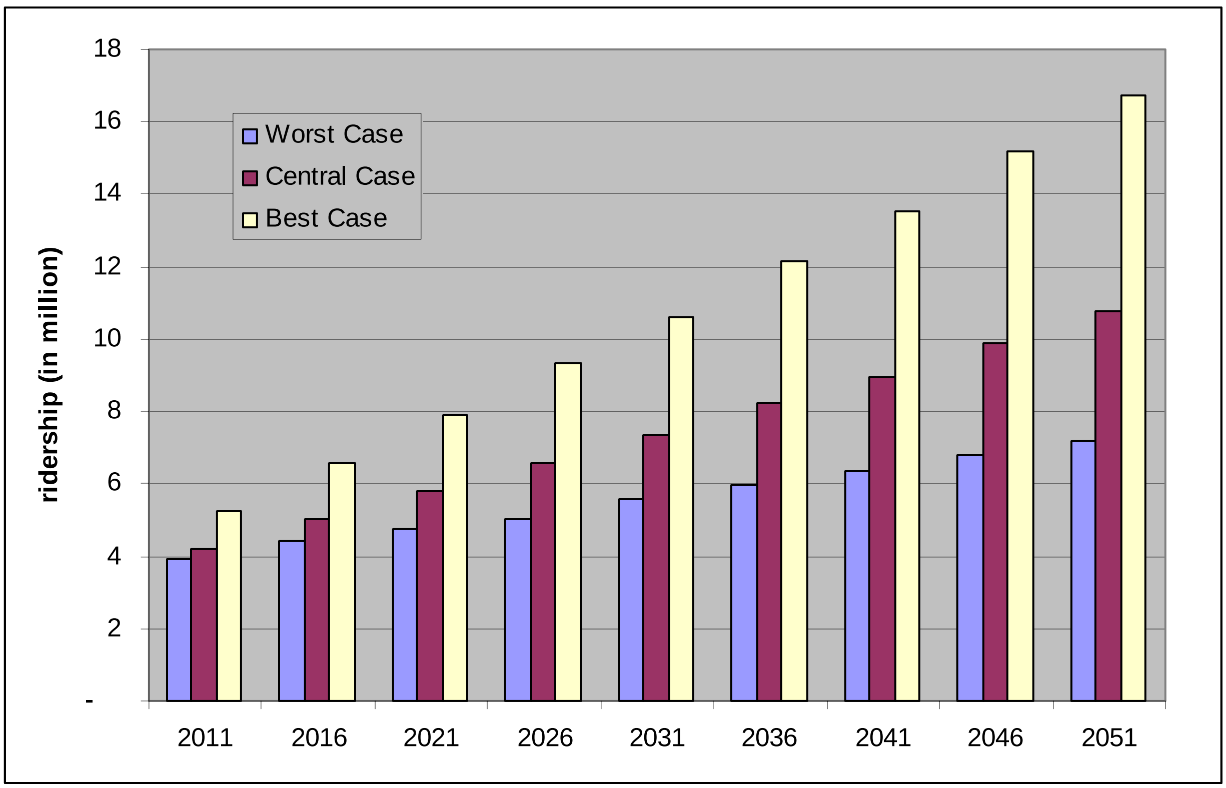
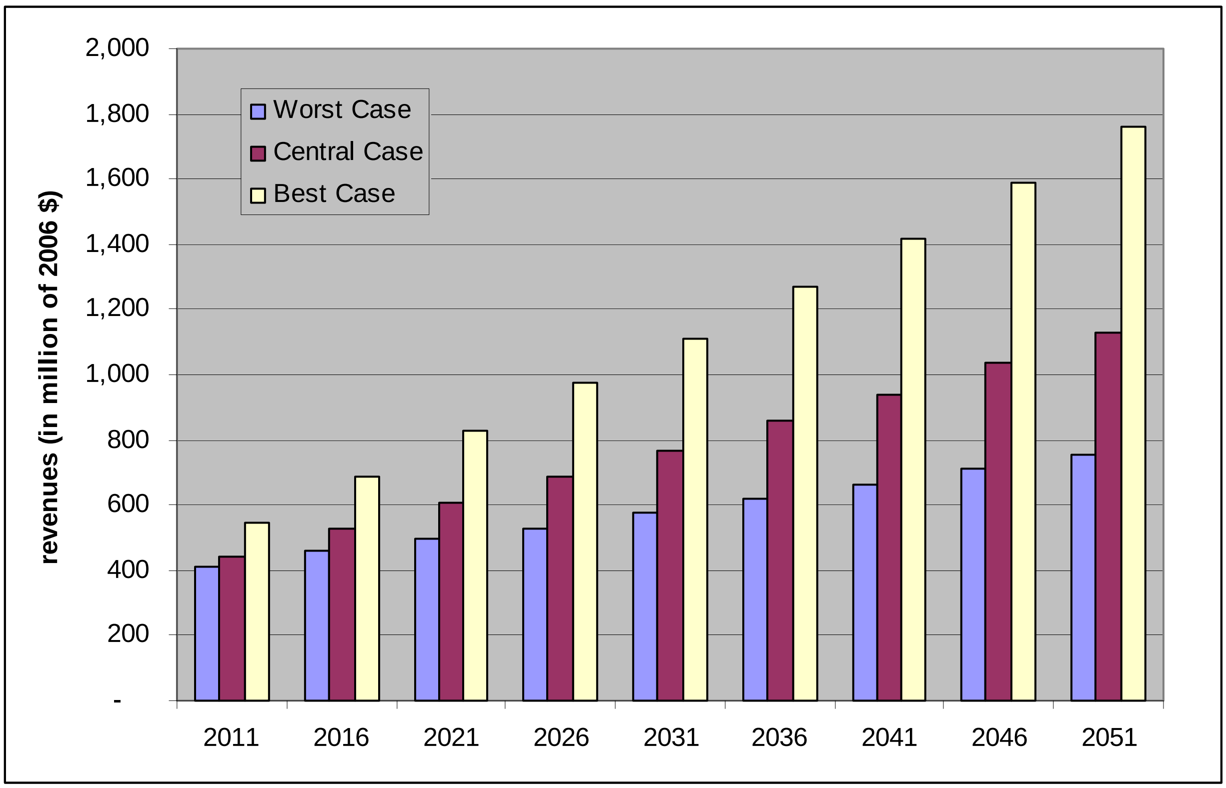


**Exhibit 8.15: "Best" and "Worst" Case Scenarios for 300 mph Revenues (in million of 2006 $)**

| | Worst Case | Central Case | Best Case |
|---|---|---|---|
| 2011 | 409.980 | 438.833 | 547.354 |
| 2016 | 459.941 | 526.069 | 687.373 |
| 2021 | 497.259 | 608.046 | 825.648 |
| 2026 | 524.993 | 688.427 | 974.149 |
| 2031 | 579.550 | 769.284 | 1,109.992 |
| 2036 | 622.648 | 858.959 | 1,269.505 |
| 2041 | 661.201 | 938.419 | 1,414.711 |
| 2046 | 711.290 | 1,038.695 | 1,590.388 |
| 2051 | 751.802 | 1,127.890 | 1,758.774 |

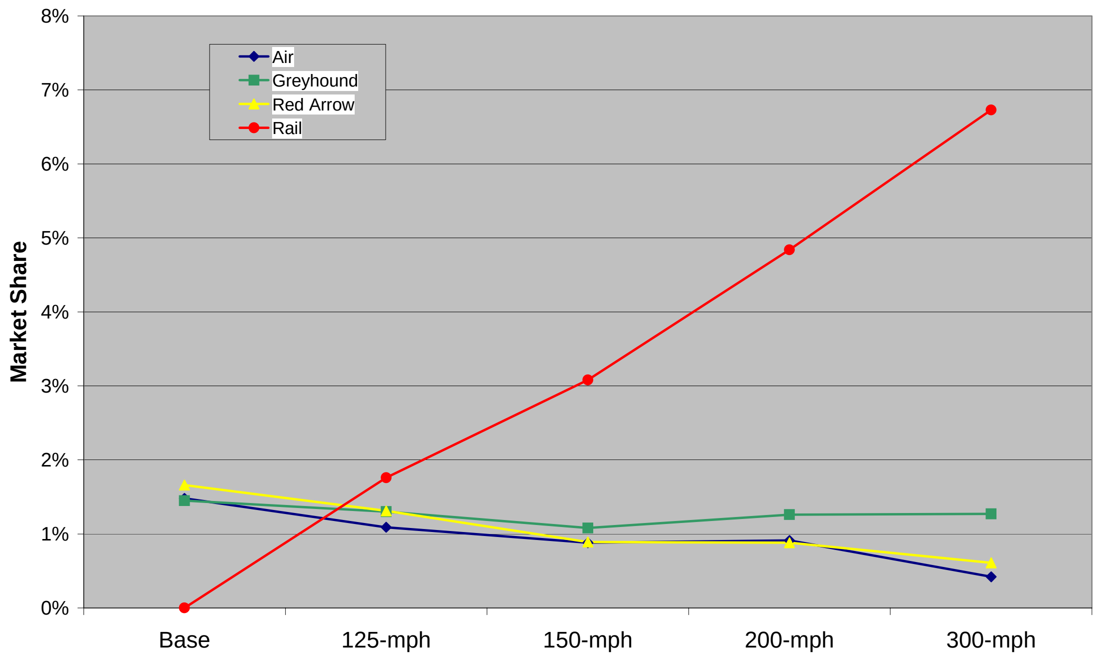
**Exhibit 8.16: "Best" and "Worst" Case Scenarios for 300 mph Revenues (in million of 2006 $)**




## 8.2 Competitive Response

An important sensitivity is the potential response of competitive carriers to the introduction of HSR. In the case of Red Arrow intercity Bus and Air the loss of market share is significant for the two very high-speed options, 200 mph and 300 mph, see Exhibit 8.17 (same as Exhibit 6.10).

**Exhibit 8.17: 2011 Estimated Market Shares: other Public Modes/HSR**




However, as shown in Exhibit 8.18 (same as Exhibit 6.11), the impact on Greyhound is quite small and in fact Greyhound trips actually increase in 2011 compared with 2006, due to demographic increase over this five-year period.

**Exhibit 8.18: Change in Actual Ridership in the Period 2006-2011.**
**Actual volumes are in thousands with the percent change in parentheses.**

| | Greyhound | Red Arrow | Air | Auto |
|---|---|---|---|---|
| Base | 729 | 835 | 744 | 47,545 |
| 125 mph | 805 (+10%) | 811 (-3%) | 675 (-9%) | 58,301 (+22%) |
| 150 mph | 670 (-8%) | 552 (-34%) | 546 (-27%) | 58,092 (+22%) |
| 200 mph | 782 (+7%) | 547 (-34%) | 565 (-24%) | 57,001 (+20%) |
| 300 mph | 793 (+9%) | 401 (-52%) | 276 (-63%) | 56,890 (+20%) |

To investigate the effect of a competitive response of Air and Red Arrow an analysis was made of lowering their fares by 20% at rail implementation (2011). The results of this simulation are shown in Exhibit 8.19 below.

**Exhibit 8.19: Market Shares (in thousand and percentage) as a Result of a Fare Reduction by Air and Red Arrow in 2011**

| | Auto | Air | Greyhound | Red Arrow | Rail |
|---|---|---|---|---|---|
| Base | 47,545 (95,37%) | 744 (1.49%) | 729 (1.46%) | 835 (1.66%) | 0 |
| 125 mph | 58,382 (94.56%) | 920 (1.50%) | 384 (0.62%) | 1,163 (1.88%) | 855 (1.35%) |
| 150 mph | 58,416 (94.56%) | 701 (1.13%) | 372 (0.60%) | 973 (1.57%) | 1,315 (2.11%) |
| 200 mph | 57,477 (92,87%) | 735 (1.19%) | 443 (0.72%) | 977 (1.58%) | 2,255 (3.64%) |
| 300 mph | 57,225 (91.45%) | 703 (1.12%) | 515 (0.82%) | 559 (0.89%) | 3,570 (5.71%) |

Comparing these charts with the market shares shown in Exhibits 6.6 through 6.9, the reduction in fares in both Air and Red Arrow has the twin effect of lessening the diversion to rail and generating diversion from Greyhound to Red Arrow. In this environment with both Red Arrow and Air maintaining 20 percent reductions in fares, the rail option loses 20 to 30 percent of its traffic.

## 8.3 Frequency Analysis

In addition to the sensitivities produced, TEMS ran a sensitivity analysis in which an “apples-to-apples” comparison of the technologies was made by setting them all at the common frequency of 14 roundtrips per day. The frequency sensitivity helps understanding the response of rail demand in changing operating frequency, a factor which is important especially when demand grows in the future, when additionally runs may be needed. Additionally, it is also important in order to judge the performance of each technology considered on a same frequency level. The results are detailed in the Exhibit 8.20 below:

**Exhibit 8.20: Frequency Sensitivity**

| Technology | Original Frequency (roundtrips/day) | Frequency Change (%) | Ridership | Revenue |
|---|---|---|---|---|
| 125 mph | 8 | +75% | 1,463K (+28%) | 71.665M (+30%) |
| 150 mph | 10 | +40% | 2,319K (+21%) | 140.269M (+18%) |
| 200 mph | 14 | 0 | 2,995K (0) | 236.879M (0) |
| 300 mph | 17 | -18% | 3,959K (-6%) | 416.891M (-5%) |

The 150 mph technology shows the most marked improvement in ridership and revenue relative to the percentage of frequency change, with an elasticity of demand of 0.52. In comparison, the 125 mph technology has an elasticity of demand of 0.37, and the 300 mph technology of 0.33.

## 8.4 Summary Table of Sensitivity Analysis

In this section a summary of all Sensitivity Analysis is presented. The ridership and revenue results are given for the years 2011, 2031, and 2051 for comparison.

**Exhibit 8.21: Summary of Ridership Sensitivity for 125 mph (in million)**

| 125 mph | 2011 | 2031 | 2051 |
|---|---|---|---|
| Central Case | 1.143 | 1,956 | 2,821 |
| Low Demographic | 1.091 | 1.511 | 1.931 |
| High Demographic | 1.217 | 2.418 | 3.778 |
| Low Gasoline | 1.101 | 1.884 | 2.719 |
| High Gasoline | 1.466 | 2.502 | 3.605 |
| Low Congestion | 1.142 | 1.953 | 2.817 |
| High Congestion | 1.213 | 2.075 | 2.993 |
| Worst Case | 1.051 | 1.456 | 1.861 |
| Best Case | 1.483 | 2.952 | 4.619 |

**Exhibit 8.22: Summary of Revenues Sensitivity for 125 mph (in million of 2006$)**

| 125 mph | 2011 | 2031 | 2051 |
|---|---|---|---|
| Central Case | 55.127 | 94.580 | 137.074 |
| Low Demographic | 52.613 | 73.011 | 93.698 |
| High Demographic | 58.683 | 116.982 | 183.642 |
| Low Gasoline | 53.053 | 91.049 | 131.990 |
| High Gasoline | 72.850 | 124.629 | 180.347 |
| Low Congestion | 55.051 | 94.451 | 136.865 |
| High Congestion | 58.797 | 100.888 | 146.217 |
| Worst Case | 50.634 | 70.288 | 90.228 |
| Best Case | 79.900 | 159.396 | 250.585 |

**Exhibit 8.23: Summary of Ridership Sensitivity for 150 mph (in million)**

| 150 mph | 2011 | 2031 | 2051 |
|---|---|---|---|
| Central Case | 1.917 | 3.108 | 4.301 |
| Low Demographic | 1.830 | 2.399 | 2.941 |
| High Demographic | 2.042 | 3.851 | 5.774 |
| Low Gasoline | 1.848 | 2.997 | 4.147 |
| High Gasoline | 2.298 | 3.882 | 5.535 |
| Low Congestion | 1.915 | 3.100 | 4.287 |
| High Congestion | 2.025 | 3.422 | 4.891 |
| Worst Case | 1.764 | 2.314 | 2.840 |
| Best Case | 2.492 | 4.701 | 7.059 |

**Exhibit 8.24: Summary of Revenues Sensitivity for 150 mph (in million of 2006$)**

| 150 mph | 2011 | 2031 | 2051 |
|---|---|---|---|
| Central Case | 118.872 | 193.387 | 269.019 |
| Low Demographic | 113.428 | 149.096 | 183.682 |
| High Demographic | 126.615 | 239.681 | 361.305 |
| Low Gasoline | 114.403 | 186.171 | 259.042 |
| High Gasoline | 152.993 | 259.663 | 372.560 |
| Low Congestion | 118.723 | 192.916 | 268.110 |
| High Congestion | 139.866 | 237.212 | 341.318 |
| Worst Case | 109.184 | 143.717 | 177.080 |
| Best Case | 154.529 | 292.613 | 441.739 |

**Exhibit 8.25: Summary of Ridership Sensitivity for 200 mph (in million)**

| 200 mph | 2011 | 2031 | 2051 |
|---|---|---|---|
| Central Case | 2.995 | 5.236 | 7.657 |
| Low Demographic | 2.859 | 4.039 | 5.231 |
| High Demographic | 3.191 | 6.488 | 10.279 |
| Low Gasoline | 2.912 | 5.079 | 7.418 |
| High Gasoline | 3.466 | 6.056 | 8.856 |
| Low Congestion | 2.992 | 5.230 | 7.647 |
| High Congestion | 3.118 | 5.489 | 8.057 |
| Worst Case | 2.780 | 3.918 | 5.069 |
| Best Case | 3.730 | 7.556 | 11.947 |

**Exhibit 8.26: Summary of Revenues Sensitivity for 200 mph (in million of 2006$)**

| 200 mph | 2011 | 2031 | 2051 |
|---|---|---|---|
| Central Case | 236.879 | 415.526 | 609.986 |
| Low Demographic | 226.093 | 320.364 | 416.501 |
| High Demographic | 252.404 | 514.984 | 819.137 |
| Low Gasoline | 229.610 | 401.837 | 589.176 |
| High Gasoline | 276.426 | 484.344 | 710.637 |
| Low Congestion | 236.651 | 415.038 | 609.199 |
| High Congestion | 247.736 | 437.708 | 644.895 |
| Worst Case | 219.154 | 309.816 | 402.318 |
| Best Case | 321.482 | 652.343 | 1,035.741 |

**Exhibit 8.27: Summary of Ridership Sensitivity for 300 mph (in million)**

| 300 mph | 2011 | 2031 | 2051 |
|---|---|---|---|
| Central Case | 4.212 | 7.358 | 10,745 |
| Low Demographic | 4.021 | 5.681 | 7.350 |
| High Demographic | 4.486 | 9.107 | 14,405 |
| Low Gasoline | 4.130 | 7.196 | 10,497 |
| High Gasoline | 4.703 | 8.245 | 12,060 |
| Low Congestion | 4.208 | 7.351 | 10,740 |
| High Congestion | 4.382 | 7.641 | 11,147 |
| Worst Case | 3.942 | 5.556 | 7.180 |
| Best Case | 5.253 | 10,615 | 16,751 |

**Exhibit 8.28: Summary of Revenues Sensitivity for 300 mph (in million of 2006$)**

| 300 mph | 2011 | 2031 | 2051 |
|---|---|---|---|
| Central Case | 438.833 | 769.284 | 1,127.890 |
| Low Demographic | 418.904 | 593.726 | 771.052 |
| High Demographic | 467.387 | 952.298 | 1,512.447 |
| Low Gasoline | 429.490 | 750.960 | 1,099.774 |
| High Gasoline | 494.631 | 869.944 | 1,277.121 |
| Low Congestion | 438.404 | 768.553 | 1,127.378 |
| High Congestion | 455.439 | 797.236 | 1,167.838 |
| Worst Case | 409.980 | 579.550 | 751.802 |
| Best Case | 547.354 | 1,109.992 | 1,758.774 |

# 9

# Financial Analysis

## 9.1 Project Revenues

In order to give a long-term measure of the project revenues, the Net Present Value (NPV) method was used to rank the proposed technological options. This method of evaluating an infrastructure project allows for the consideration of the time value for money by estimating the Present Value (PV) in "2006 dollars" of the future cash flow of the project, *i.e.*, discounted cash flows. The discounted values for revenues were computed using the discounting formula:

$$NPV = \sum_{i=0}^{n} \frac{CF_i}{(1+r)^i}$$

where $CF_i$ is the cash flow at period $i$, $n$ is the number of periods, and $r$ is the discount rate, which in this study is set to three percent. Exhibit 9.1 shows yearly revenues, the PV of the revenues and the NPV for the four technology options considered for the Central Case scenario. Exhibits 9.2 and 9.3 repeat the analysis for the "Worst" and "Best" case scenarios discussed in the previous chapter. Detailed forecasts were produced on a five-year interval; hence, all intermediate points have been produced by interpolation.

The results for the Central Case show that the Revenue estimates increase significantly with speed. For 125 mph the revenue is nearly $2.1 billion, for 150 mph it is $4.3 billion, for 200 mph it is $9.2 billion and for 300 mph, it is $17 billion.

**Exhibit 9.1: 2011-2051 HSR Technology Passenger Revenues (Central Case) (in millions of 2006 $) Discounted at 3%**

| | 125 mph | | 150 mph | | 200 mph | | 300 mph | |
|---|---|---|---|---|---|---|---|---|
| Year | per year | PV | per year | PV | per year | PV | per year | PV |
| 2011 | 55.127 | 55.127 | 118.872 | 118.872 | 236.879 | 236.879 | 438.833 | 438.833 |
| 2012 | 57.139 | 55.474 | 122.656 | 119.084 | 246.011 | 238.846 | 455.754 | 442.480 |
| 2013 | 59.150 | 55.755 | 126.441 | 119.182 | 255.144 | 240.498 | 472.676 | 445.542 |
| 2014 | 61.162 | 55.972 | 130.225 | 119.174 | 264.276 | 241.850 | 489.597 | 448.051 |
| 2015 | 63.174 | 56.129 | 134.009 | 119.065 | 273.409 | 242.920 | 506.518 | 450.035 |
| 2016 | 65.186 | 56.230 | 137.794 | 118.862 | 282.541 | 243.722 | 523.440 | 451.524 |
| 2017 | 67.197 | 56.277 | 141.578 | 118.569 | 291.673 | 244.272 | 540.361 | 452.544 |
| 2018 | 69.209 | 56.273 | 145.362 | 118.193 | 300.806 | 244.583 | 557.282 | 453.121 |
| 2019 | 71.221 | 56.222 | 149.146 | 117.738 | 309.938 | 244.668 | 574.203 | 453.281 |
| 2020 | 73.232 | 56.126 | 152.931 | 117.209 | 319.071 | 244.541 | 591.125 | 453.048 |
| 2021 | 75.244 | 55.989 | 156.715 | 116.611 | 328.203 | 244.214 | 608.046 | 452.443 |
| 2022 | 77.178 | 55.755 | 160.382 | 115.864 | 336.935 | 243.409 | 624.170 | 450.914 |
| 2023 | 79.111 | 55.487 | 164.049 | 115.061 | 345.668 | 242.444 | 640.294 | 449.089 |
| 2024 | 81.045 | 55.188 | 167.717 | 114.207 | 354.400 | 241.329 | 656.417 | 446.988 |
| 2025 | 82.978 | 54.858 | 171.384 | 113.305 | 363.132 | 240.073 | 672.541 | 444.629 |
| 2026 | 84.912 | 54.502 | 175.051 | 112.359 | 371.865 | 238.686 | 688.665 | 442.028 |
| 2027 | 86.846 | 54.119 | 178.718 | 111.371 | 380.597 | 237.175 | 704.789 | 439.201 |
| 2028 | 88.779 | 53.713 | 182.385 | 110.346 | 389.329 | 235.551 | 720.913 | 436.164 |
| 2029 | 90.713 | 53.284 | 186.053 | 109.286 | 398.061 | 233.819 | 737.036 | 432.931 |
| 2030 | 92.646 | 52.835 | 189.720 | 108.195 | 406.794 | 231.989 | 753.160 | 429.517 |
| 2031 | 94.580 | 52.367 | 193.387 | 107.074 | 415.526 | 230.067 | 769.284 | 425.934 |
| 2032 | 96.613 | 51.934 | 197.092 | 105.947 | 424.725 | 228.310 | 786.198 | 422.620 |
| 2033 | 98.645 | 51.482 | 200.797 | 104.794 | 433.923 | 226.461 | 803.111 | 419.138 |
| 2034 | 100.678 | 51.012 | 204.502 | 103.619 | 443.122 | 224.526 | 820.025 | 415.500 |
| 2035 | 102.710 | 50.527 | 208.207 | 102.424 | 452.320 | 222.512 | 836.938 | 411.718 |
| 2036 | 104.743 | 50.026 | 211.912 | 101.210 | 461.519 | 220.424 | 853.852 | 407.804 |
| 2037 | 106.775 | 49.511 | 215.617 | 99.980 | 470.718 | 218.269 | 870.765 | 403.769 |
| 2038 | 108.808 | 48.984 | 219.322 | 98.736 | 479.916 | 216.053 | 887.679 | 399.623 |
| 2039 | 110.840 | 48.446 | 223.027 | 97.480 | 489.115 | 213.781 | 904.592 | 395.376 |
| 2040 | 112.873 | 47.897 | 226.732 | 96.213 | 498.313 | 211.457 | 921.506 | 391.038 |
| 2041 | 114.905 | 47.339 | 230.437 | 94.937 | 507.512 | 209.088 | 938.419 | 386.616 |
| 2042 | 117.122 | 46.847 | 234.295 | 93.715 | 517.759 | 207.097 | 957.366 | 382.934 |
| 2043 | 119.339 | 46.344 | 238.153 | 92.484 | 528.007 | 205.045 | 976.313 | 379.139 |
| 2044 | 121.556 | 45.830 | 242.012 | 91.245 | 538.254 | 202.936 | 995.260 | 375.239 |
| 2045 | 123.773 | 45.306 | 245.870 | 89.999 | 548.502 | 200.776 | 1,014.207 | 371.245 |
| 2046 | 125.990 | 44.775 | 249.728 | 88.749 | 558.749 | 198.570 | 1,033.155 | 367.166 |
| 2047 | 128.206 | 44.235 | 253.586 | 87.495 | 568.996 | 196.322 | 1,052.102 | 363.009 |
| 2048 | 130.423 | 43.690 | 257.444 | 86.239 | 579.244 | 194.037 | 1,071.049 | 358.783 |
| 2049 | 132.640 | 43.138 | 261.303 | 84.982 | 589.491 | 191.718 | 1,089.996 | 354.495 |
| 2050 | 134.857 | 42.582 | 265.161 | 83.725 | 599.739 | 189.370 | 1,108.943 | 350.153 |
| 2051 | 137.074 | 42.021 | 269.019 | 82.470 | 609.986 | 186.995 | 1,127.890 | 345.762 |
| **NPV** | | **2,099.61** | | **4,306.07** | | **9,205.28** | | **17,039.42** |

**Exhibit 9.2: 2011-2051 HSR Technology Passenger Revenues ("Worst Case") (in millions of 2006 $) Discounted at 3%**

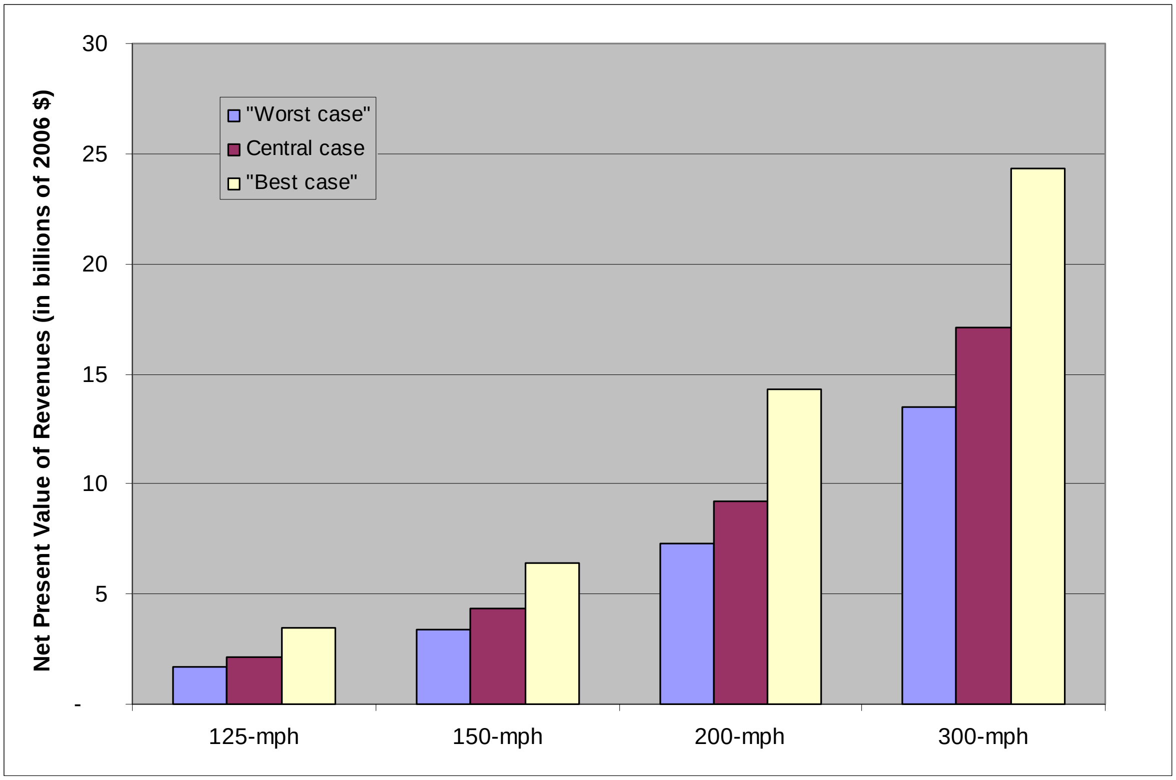
| | 125 mph | | 150 mph | | 200 mph | | 300 mph | |
|---|---|---|---|---|---|---|---|---|
| Year | per year | PV | per year | PV | per year | PV | per year | PV |
| 2011 | 52.613 | 52.613 | 113.428 | 113.428 | 226.093 | 226.093 | 418.904 | 418.904 |
| 2012 | 53.795 | 52.229 | 115.424 | 112.063 | 237.386 | 230.472 | 439.610 | 426.806 |
| 2013 | 54.978 | 51.822 | 117.421 | 110.680 | 241.517 | 227.653 | 447.321 | 421.643 |
| 2014 | 56.160 | 51.395 | 119.417 | 109.284 | 245.647 | 224.802 | 455.031 | 416.418 |
| 2015 | 57.343 | 50.948 | 121.414 | 107.874 | 249.778 | 221.925 | 462.742 | 411.140 |
| 2016 | 58.525 | 50.484 | 123.410 | 106.455 | 253.909 | 219.024 | 470.453 | 405.817 |
| 2017 | 59.417 | 49.761 | 124.951 | 104.644 | 258.040 | 216.104 | 478.164 | 400.455 |
| 2018 | 60.310 | 49.037 | 126.491 | 102.849 | 262.171 | 213.169 | 485.875 | 395.061 |
| 2019 | 61.202 | 48.314 | 128.032 | 101.069 | 266.301 | 210.221 | 493.585 | 389.641 |
| 2020 | 62.095 | 47.590 | 129.572 | 99.306 | 270.432 | 207.264 | 501.296 | 384.202 |
| 2021 | 62.987 | 46.868 | 131.113 | 97.560 | 274.563 | 204.301 | 509.007 | 378.749 |
| 2022 | 63.668 | 45.995 | 132.966 | 96.057 | 277.646 | 200.577 | 514.744 | 371.862 |
| 2023 | 64.350 | 45.134 | 134.818 | 94.559 | 280.728 | 196.897 | 520.481 | 365.055 |
| 2024 | 65.031 | 44.283 | 136.671 | 93.066 | 283.811 | 193.261 | 526.218 | 358.329 |
| 2025 | 65.713 | 43.444 | 138.523 | 91.580 | 286.893 | 189.670 | 531.955 | 351.685 |
| 2026 | 66.394 | 42.616 | 140.376 | 90.102 | 289.976 | 186.125 | 537.692 | 345.124 |
| 2027 | 67.717 | 42.199 | 142.120 | 88.564 | 296.054 | 184.491 | 548.899 | 342.056 |
| 2028 | 69.041 | 41.771 | 143.864 | 87.040 | 302.131 | 182.794 | 560.106 | 338.873 |
| 2029 | 70.364 | 41.332 | 145.608 | 85.529 | 308.209 | 181.040 | 571.312 | 335.586 |
| 2030 | 71.688 | 40.882 | 147.352 | 84.033 | 314.286 | 179.233 | 582.519 | 332.203 |
| 2031 | 73.011 | 40.424 | 149.096 | 82.551 | 320.364 | 177.378 | 593.726 | 328.732 |
| 2032 | 74.046 | 39.803 | 151.107 | 81.227 | 325.211 | 174.817 | 602.574 | 323.913 |
| 2033 | 75.081 | 39.184 | 153.117 | 79.911 | 330.058 | 172.255 | 611.422 | 319.097 |
| 2034 | 76.115 | 38.567 | 155.128 | 78.602 | 334.904 | 169.693 | 620.270 | 314.286 |
| 2035 | 77.150 | 37.953 | 157.138 | 77.302 | 339.751 | 167.135 | 629.118 | 309.484 |
| 2036 | 78.185 | 37.342 | 159.149 | 76.010 | 344.598 | 164.582 | 637.966 | 304.696 |
| 2037 | 79.144 | 36.699 | 160.559 | 74.450 | 348.888 | 161.778 | 645.901 | 299.501 |
| 2038 | 80.104 | 36.062 | 161.969 | 72.917 | 353.178 | 158.997 | 653.836 | 294.350 |
| 2039 | 81.063 | 35.431 | 163.379 | 71.409 | 357.469 | 156.241 | 661.771 | 289.245 |
| 2040 | 82.023 | 34.806 | 164.789 | 69.928 | 361.759 | 153.511 | 669.706 | 284.187 |
| 2041 | 82.982 | 34.187 | 166.199 | 68.472 | 366.049 | 150.807 | 677.641 | 279.179 |
| 2042 | 84.151 | 33.659 | 168.122 | 67.247 | 371.640 | 148.651 | 687.971 | 275.180 |
| 2043 | 85.320 | 33.133 | 170.045 | 66.035 | 377.232 | 146.493 | 698.301 | 271.176 |
| 2044 | 86.488 | 32.608 | 171.967 | 64.836 | 382.823 | 144.334 | 708.631 | 267.172 |
| 2045 | 87.657 | 32.086 | 173.890 | 63.652 | 388.415 | 142.177 | 718.961 | 263.172 |
| 2046 | 88.826 | 31.567 | 175.813 | 62.481 | 394.006 | 140.023 | 729.291 | 259.178 |
| 2047 | 89.800 | 30.984 | 177.387 | 61.204 | 398.505 | 137.497 | 737.643 | 254.511 |
| 2048 | 90.775 | 30.408 | 178.961 | 59.949 | 403.004 | 134.999 | 745.995 | 249.896 |
| 2049 | 91.749 | 29.839 | 180.534 | 58.715 | 407.503 | 132.531 | 754.348 | 245.334 |
| 2050 | 92.724 | 29.278 | 182.108 | 57.501 | 412.002 | 130.091 | 762.700 | 240.825 |
| 2051 | 93.698 | 28.724 | 183.682 | 56.309 | 416.501 | 127.681 | 771.052 | 236.371 |
| **NPV** | | **1,661.46** | | **3,426.45** | | **7,286.79** | | **13,499.09** |

**Exhibit 9.3: 2011-2051 HSR Technology Passenger Revenues ("Best Case") (in millions of 2006 $) Discounted at 3%**

| Year | 125 mph | | 150 mph | | 200 mph | | 300 mph | |
|---|---|---|---|---|---|---|---|---|
| | per year | PV | per year | PV | per year | PV | per year | PV |
| 2011 | 79.900 | 79.900 | 154.529 | 154.529 | 321.482 | 321.482 | 547.354 | 547.354 |
| 2012 | 83.801 | 81.360 | 161.186 | 156.491 | 336.794 | 326.985 | 576.753 | 559.954 |
| 2013 | 87.702 | 82.667 | 167.843 | 158.208 | 353.289 | 333.009 | 604.408 | 569.713 |
| 2014 | 91.602 | 83.829 | 174.499 | 159.692 | 369.785 | 338.405 | 632.063 | 578.427 |
| 2015 | 95.503 | 84.853 | 181.156 | 160.955 | 386.280 | 343.205 | 659.718 | 586.151 |
| 2016 | 99.404 | 85.747 | 187.813 | 162.009 | 402.775 | 347.437 | 687.373 | 592.934 |
| 2017 | 103.364 | 86.565 | 194.859 | 163.191 | 419.270 | 351.132 | 715.028 | 598.825 |
| 2018 | 107.323 | 87.264 | 201.904 | 164.167 | 435.765 | 354.317 | 742.683 | 603.869 |
| 2019 | 111.283 | 87.848 | 208.950 | 164.947 | 452.261 | 357.019 | 770.338 | 608.112 |
| 2020 | 115.242 | 88.324 | 215.995 | 165.542 | 468.756 | 359.262 | 797.993 | 611.595 |
| 2021 | 119.202 | 88.697 | 223.041 | 165.963 | 485.251 | 361.072 | 825.648 | 614.360 |
| 2022 | 123.411 | 89.155 | 229.676 | 165.923 | 502.734 | 363.185 | 855.348 | 617.922 |
| 2023 | 127.620 | 89.510 | 236.312 | 165.744 | 520.216 | 364.869 | 885.048 | 620.755 |
| 2024 | 131.828 | 89.769 | 242.947 | 165.435 | 537.699 | 366.147 | 914.749 | 622.899 |
| 2025 | 136.037 | 89.937 | 249.583 | 165.004 | 555.181 | 367.040 | 944.449 | 624.392 |
| 2026 | 140.246 | 90.019 | 256.218 | 164.457 | 572.664 | 367.571 | 974.149 | 625.269 |
| 2027 | 144.076 | 89.783 | 263.497 | 164.203 | 588.600 | 366.796 | 1,001.304 | 623.979 |
| 2028 | 147.906 | 89.486 | 270.776 | 163.824 | 604.536 | 365.754 | 1,028.458 | 622.234 |
| 2029 | 151.736 | 89.129 | 278.055 | 163.328 | 620.471 | 364.462 | 1,055.613 | 620.061 |
| 2030 | 155.566 | 88.717 | 285.334 | 162.722 | 636.407 | 362.934 | 1,082.767 | 617.487 |
| 2031 | 159.396 | 88.254 | 292.613 | 162.013 | 652.343 | 361.187 | 1,109.922 | 614.537 |
| 2032 | 163.976 | 88.145 | 300.128 | 161.334 | 671.398 | 360.910 | 1,141.839 | 613.795 |
| 2033 | 168.556 | 87.968 | 307.643 | 160.557 | 690.453 | 360.342 | 1,173.755 | 612.574 |
| 2034 | 173.136 | 87.727 | 315.159 | 159.688 | 709.509 | 359.502 | 1,205.672 | 610.904 |
| 2035 | 177.716 | 87.424 | 322.674 | 158.734 | 728.564 | 358.405 | 1,237.588 | 608.811 |
| 2036 | 182.296 | 87.066 | 330.189 | 157.700 | 747.619 | 357.067 | 1,269.505 | 606.323 |
| 2037 | 186.368 | 86.418 | 337.162 | 156.340 | 764.589 | 354.536 | 1,298.546 | 602.129 |
| 2038 | 190.439 | 85.734 | 344.135 | 154.926 | 781.558 | 351.849 | 1,327.587 | 597.665 |
| 2039 | 194.511 | 85.016 | 351.109 | 153.461 | 798.528 | 349.018 | 1,356.629 | 592.951 |
| 2040 | 198.582 | 84.268 | 358.082 | 151.951 | 815.497 | 346.053 | 1,385.670 | 588.004 |
| 2041 | 202.654 | 83.491 | 365.055 | 150.398 | 832.467 | 342.965 | 1,414.711 | 582.842 |
| 2042 | 207.536 | 83.012 | 372.902 | 149.156 | 853.162 | 341.254 | 1,449.846 | 579.920 |
| 2043 | 212.418 | 82.490 | 380.750 | 147.859 | 873.858 | 339.351 | 1,484.982 | 576.673 |
| 2044 | 217.301 | 81.928 | 388.597 | 146.511 | 894.553 | 337.270 | 1,520.117 | 573.124 |
| 2045 | 222.183 | 81.329 | 396.445 | 145.117 | 915.249 | 335.022 | 1,555.253 | 569.292 |
| 2046 | 227.065 | 80.695 | 404.292 | 143.679 | 935.944 | 332.619 | 1,590.388 | 565.197 |
| 2047 | 231.769 | 79.968 | 411.781 | 142.078 | 955.903 | 329.818 | 1,624.065 | 560.355 |
| 2048 | 236.473 | 79.214 | 419.271 | 140.449 | 975.863 | 326.897 | 1,657.742 | 555.315 |
| 2049 | 241.177 | 78.437 | 426.760 | 138.794 | 995.822 | 323.867 | 1,691.420 | 550.094 |
| 2050 | 245.881 | 77.638 | 434.250 | 137.116 | 1,015.782 | 320.737 | 1,725.097 | 544.705 |
| 2051 | 250.585 | 76.819 | 441.739 | 135.418 | 1,035.741 | 317.513 | 1,758.774 | 539.164 |
| **NPV** | | **3,495.60** | | **6,409.61** | | **14,288.27** | | **24,310.67** |

Summarizing the results detailed in Exhibits 9.1 through 9.3, the chart in Exhibit 9.4 shows the Net Present Value of the revenues for all technologies.

**Exhibit 9.4: Net Present Value 2011-2051 HSR Technology Passenger Revenues (in billions of 2006 $) Discounted at 3% real**




## 9.2 Revenue Yield Analysis

The pricing scheme used to produce the ridership and revenue forecasts is based on average fares charged for these technologies in different corridors. However, these fares can be adjusted to increase the revenue gains of the project. The table in Exhibit 9.5 shows the revenue gains and the corresponding Consumer Surplus for all four technologies for various fares (measured in cents/mile). Essentially, the Consumer Surplus is defined as the additional benefit consumers receive from the purchase of a service or commodity above the price actually paid. Consumer surpluses exist because there are always consumers who are willing to pay a higher price than that actually charged for the commodity or service, i.e., these consumers receive more benefit than is reflected by the system revenues alone.

The fares that correspond to the original fare and a revenue-maximizing fare are highlighted in orange and yellow, respectively. When increasing the fare in cents/mile of a factor of, say, 12% (from 40 to 45 cents/mile), the premium fares are increased by the same factor, as well.

**Exhibit 9.5: Revenue Yield and Consumer Surplus Matrices for all Four HSR Technologies. Cost is in cents/mile and all figures are in millions of 2006$ for the Forecast Year 2011**

| Cost | Revenues | | | | Consumer Surplus | | | |
|---|---|---|---|---|---|---|---|---|
| | 125 mph | 150 mph | 200 mph | 300 mph | 125 mph | 150 mph | 200 mph | 300 mph |
| 0 | 0 | 0 | 0 | 0 | 148 | 192 | 871 | 2188 |
| 5 | 30 | 31 | 88 | 121 | 100 | 159 | 623 | 1650 |
| 10 | 46 | 57 | 139 | 230 | 66 | 127 | 452 | 1290 |
| 15 | 54 | 78 | 174 | 300 | 42 | 98 | 340 | 1050 |
| 20 | 57 | 93 | 200 | 340 | 25 | 78 | 270 | 845 |
| 25 | 55 | 105 | 216 | 365 | 13 | 55 | 216 | 680 |
| 30 | 51 | 114 | 226 | 382 | 5 | 37 | 170 | 566 |
| 35 | | 119 | 233 | 400 | | 26 | 135 | 460 |
| 40 | | 121 | 237 | 410 | | 17 | 113 | 396 |
| 45 | | 121 | 243 | 420 | | 10 | 86 | 340 |
| 50 | | 119 | 247 | 428 | | 5 | 60 | 286 |
| 55 | | | 248 | 432 | | | 43 | 243 |
| 60 | | | 239 | 439 | | | 29 | 208 |
| 65 | | | 225 | 443 | | | 20 | 170 |
| 70 | | | | 446 | | | | 142 |
| 75 | | | | 448 | | | | 124 |
| 80 | | | | 448 | | | | 105 |
| 85 | | | | 445 | | | | 92 |

The orange cells represent the revenues for the base fare while the yellow cells represent the revenues for the revenue-maximizing fare. The two fares are shown together to highlight the relative gap between the two. The results of this analysis show that revenues are maximized for 125 mph with a price reduction of base fare from 25 cents/mile to 20 cents/mile. For 150 mph, revenues are maximized with a fare increase from 35 cents/mile to 45 cents/mile, from 40 cents/mile to 55 cents/mile for 200 mph and from 60 cents/mile to 75 cents/mile for 300 mph. These results are shown in the charts in subsequent Exhibits. The horizontal axis shows the fare in cents/mile while the vertical axis shows the corresponding revenues and consumer surplus. An arrow indicates the revenue maximizing point.

**Exhibit 9.6: Revenue Yield Chart for 125 mph**

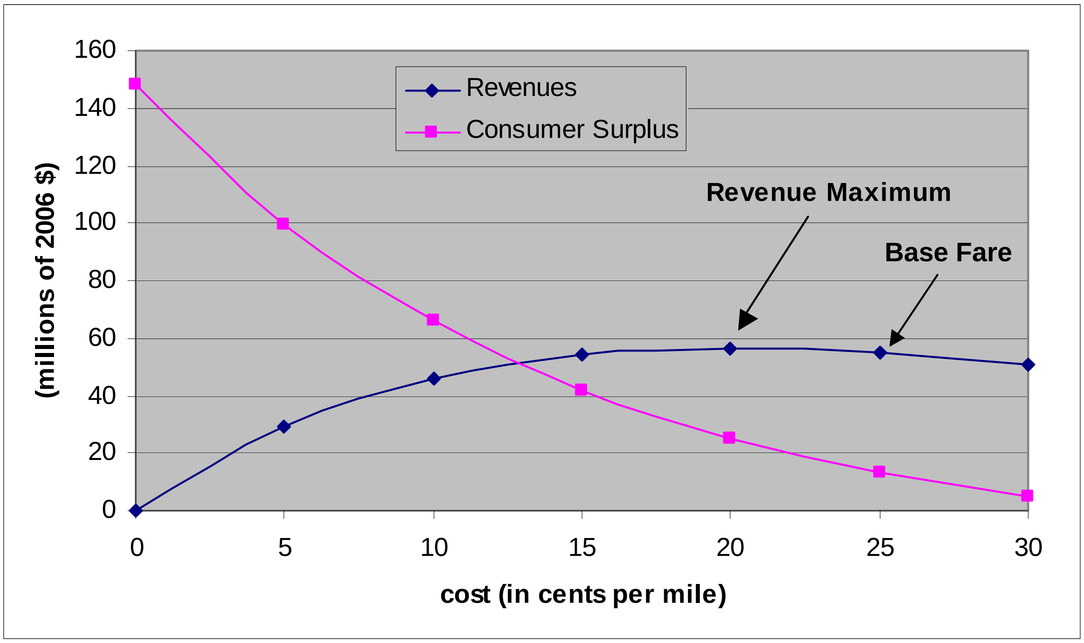



**Exhibit 9.7: Revenue Yield Chart for 150 mph**

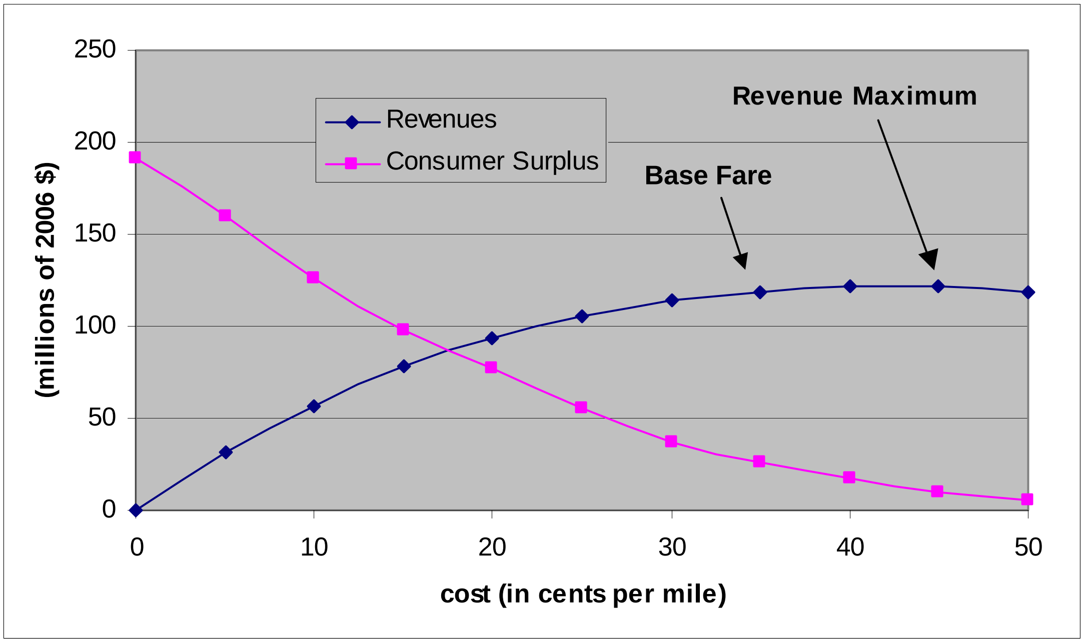


**Exhibit 9.8: Revenue Yield Chart for 200 mph**

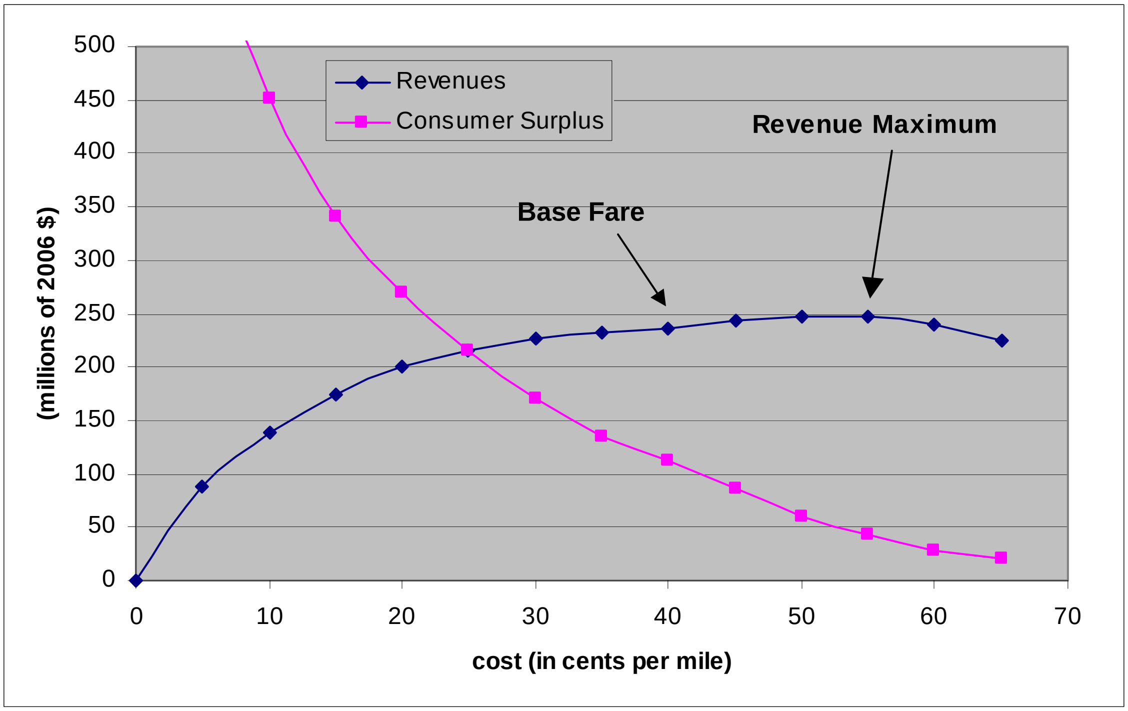
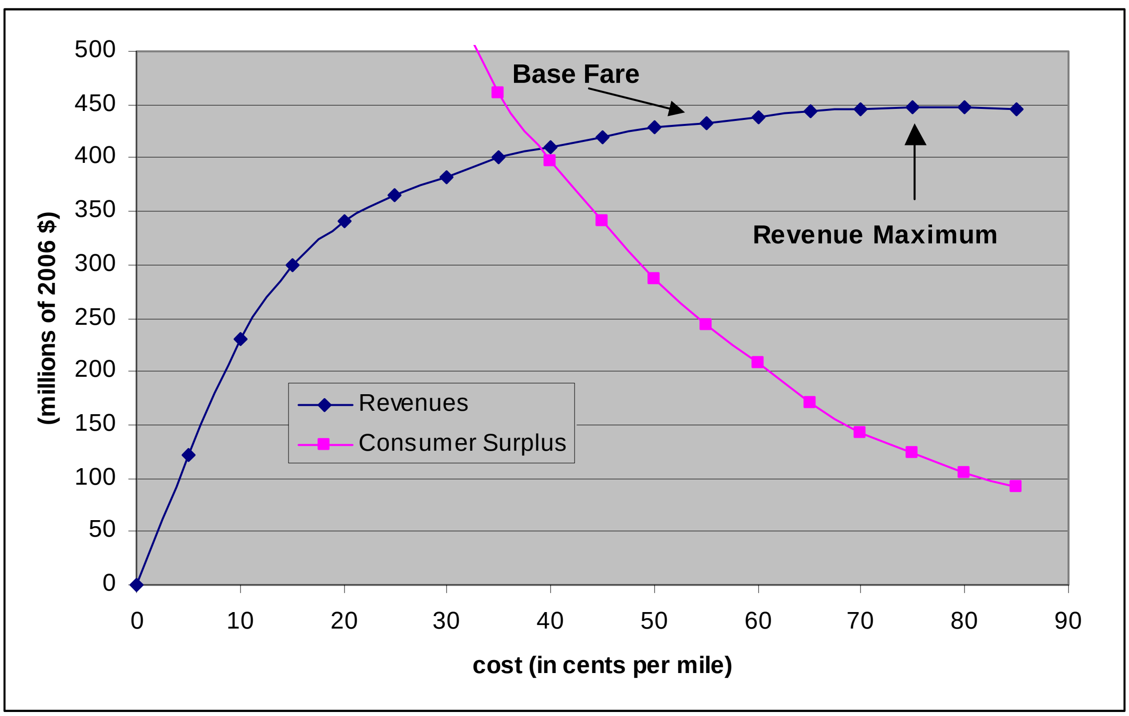



**Exhibit 9.9: Revenue Yield Chart for 300 mph**



In these Exhibits it is shown that each revenue curve is quite flat around its maximum, while the benefits to users (consumer surplus) falls in an almost exponential manner with the fare increase. This behavior is quite typical and it describes why it is common public sector practice to price a mode of travel slightly below the revenue maximizing point. The consumer surplus loss from optimizing fares is very large. Pricing below the maximum allows a good increase in Consumer Surplus with a relatively small loss in revenues. For example, pricing the 150 mph option at 80 percent of its optimum price 45 cents per mile, i.e., 25 cents per mile, increases consumer surplus to users from $10 million to $26 million, more than doubling user benefits.

Overall, the base case fares are found to be close to the overall revenue maximizing fare such that increasing (or decreasing) the fares will have little impact on revenue. The only exception to this finding is the 125-option for which fares might be lowered to as little at 15 cents per mile as this will maintain revenue and increase consumer surplus from $13 million to $42 million.

# 10

# Conclusions

This study has analyzed the possible demand for high-speed rail travel in the Edmonton-Calgary Corridor. Four different technologies were considered for analysis, as shown in the exhibit below:

**Exhibit 10.1: Technologies Considered for this Study**

| Technology | Speed |
|---|---|
| Diesel | 125 mph |
| Turbine Electric | 150 mph |
| Electric | 200 mph |
| Magnetic levitation | 300 mph |

In this analysis, service level fares for the four technologies have been computed based on the operating assumptions shown in Exhibit 10.2. Premium fares were charged to the short segments between suburban stops and city centers to reduce overloading and encourage long distance travellers.

**Exhibit 10.2: Technology Assumptions and Fare Structure for HSR**

| | 125 mph | 150 mph | 200 mph | 300 mph |
|---|---|---|---|---|
| Average travel time (h:min) | 2:00 | 1:45 | 1:35 | 1:00 |
| Frequency (roundtrips/day) | 8 | 10 | 14 | 17 |
| Fare (in cents/mile) | 25 | 35 | 40 | 60 |
| Maximum fare one-way Calgary-Edmonton | $56 | $80 | $90 | $120 |
| Maximum fare one-way from Red Deer | $28 | $40 | $45 | $60 |

The base case results for both ridership and revenues are shown below for the forecast years 2021, 2031, and 2051.

**Exhibit 10.3: Ridership for HSR technologies (in thousands)**

| Year | 125 mph | 150 mph | 200 mph | 300 mph |
|---|---|---|---|---|
| 2016 | 1,353 | 2,226 | 3,581 | 5,036 |
| 2021 | 1,554 | 2,518 | 4,136 | 5,816 |
| 2031 | 1,955 | 3,108 | 5,236 | 7,357 |
| 2051 | 2,821 | 4,301 | 7,656 | 10,745 |

The volumes of trips in Exhibit 10.3 increase between 31% and 38% in the 10-year period 2021-2031 and between 38% and 46% in the subsequent 20-year period 2031-2051.

As a proportion of total ridership in the Edmonton-Calgary corridor in 2011, high-speed rail trips are shown in the Table in Exhibit 10.4 below:

**Exhibit 10.4: Market shares for HSR technologies (2011)**

| Technology | 125 mph | 150 mph | 200 mph | 300 mph |
|---|---|---|---|---|
| Share | 1.85% | 3.10% | 4.84% | 6.73% |

These shares remain stable throughout the period considered (2011-2051), since no changes in the level of service are implemented in the Base Case forecasts. A table of revenues for 2021, 2031, and 2051 is shown in Exhibit 10.5. All figures are in 2006 dollars.

**Exhibit 10.5: Annual Revenues for HSR technologies (in million of 2006$)**

| Year | 125 mph | 150 mph | 200 mph | 300 mph |
|---|---|---|---|---|
| 2016 | 65 | 138 | 284 | 526 |
| 2021 | 75 | 157 | 328 | 608 |
| 2031 | 95 | 193 | 416 | 769 |
| 2051 | 137 | 269 | 610 | 1,128 |

Comparisons were made between the Van Horne, TEMS, and OW forecasts. This comparison is shown in Exhibits 10.6 and 10.7. It can be seen that all three forecasts are very close for the 200 mph option. There is greater disparity in the 125 mph and 150 mph options for the Van Horne forecasts. The OW forecasts produce consistently lower revenues, suggesting a much higher volume of short distance trip.

**Exhibit 10.6: Adjusted Comparison of TEMS', Van Horne's and OW's Ridership Forecasts for 2021**

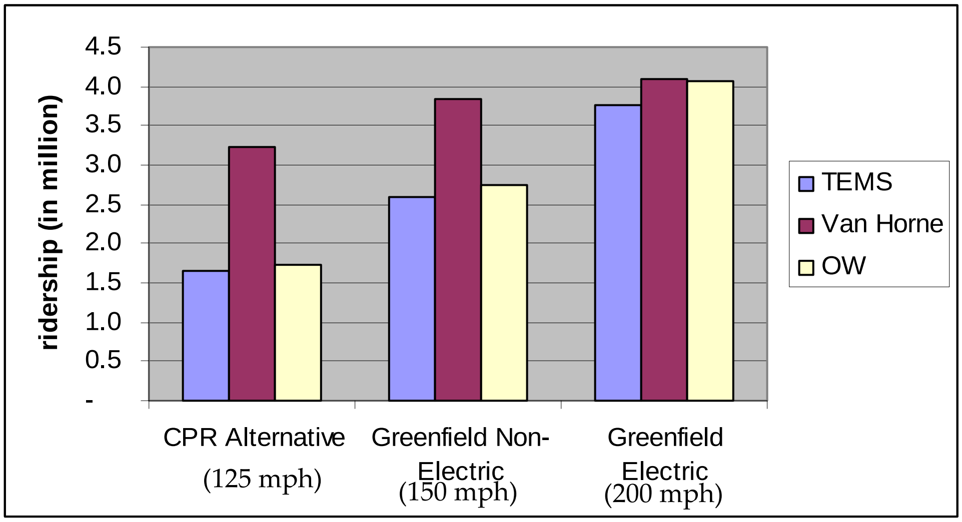
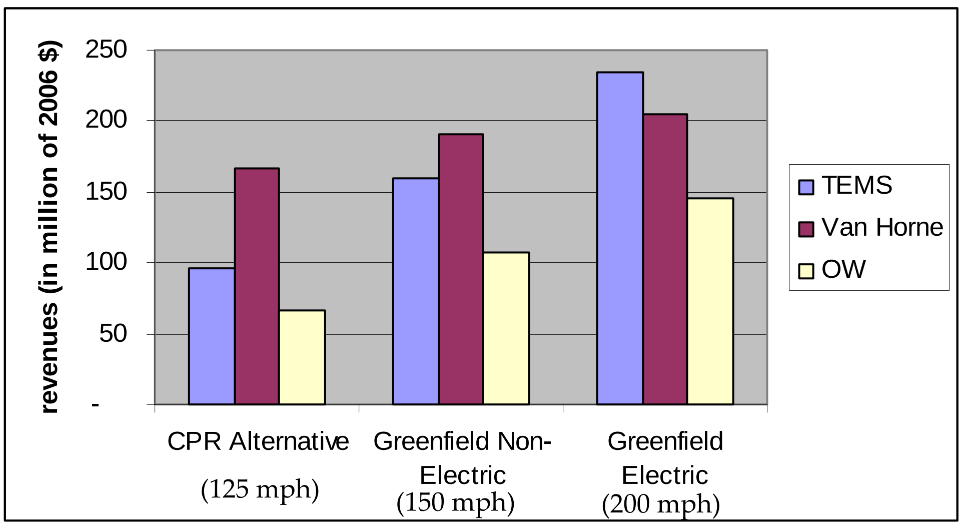



**Exhibit 10.7: Adjusted Comparison of TEMS', Van Horne's and OW's Revenue Forecasts for 2021**




Various sensitivities have been tested with values of ridership and revenues are expected to fall in the range shown in Exhibits 10.8 and 10.10.

**Exhibit 10.8: Range of Ridership (in million)**

| | 125 mph | | 150 mph | | 200 mph | | 300 mph | |
|---|---|---|---|---|---|---|---|---|
| Year | 2021 | 2051 | 2021 | 2051 | 2021 | 2051 | 2021 | 2051 |
| Worst Case | 1.254 | 1.860 | 2.034 | 2.839 | 3.359 | 5.068 | 4.766 | 7.180 |
| Base Case | 1.554 | 2.821 | 2.518 | 4.301 | 4.136 | 7.657 | 5.816 | 10.745 |
| Best Case | 2.207 | 4.618 | 3.583 | 7.058 | 5.615 | 11.947 | 7.897 | 16.751 |

**Exhibit 10.9: Range of Revenues (in million of 2006 $)**

| | 125 mph | | 150 mph | | 200 mph | | 300 mph | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **2021** | **2051** | **2021** | **2051** | **2021** | **2051** | **2021** | **2051** |
| Worst Case | 52 | 94 | 105 | 177 | 204 | 353 | 489 | 902 |
| Base Case | 75 | 137 | 157 | 269 | 328 | 610 | 608 | 1,128 |
| Best Case | 119 | 250 | 223 | 441 | 485 | 1035 | 825 | 1,758 |

The Net Present Value of the revenue streams increase significantly with speed. For 125 mph the NPV of the revenue in the period 2011 through 2051 is nearly $2.1 million, for 150 mph it is $4.3 million, for 200 mph it is $9.2 million and for 300 mph, it is $17 million. The various sensitivities tested have given a range of NPV of the revenues given in the table below (in million of 2006 $)

**Exhibit 10.10: Range of Net Present Value of Revenues (in million of 2006 $)**

| | 125 mph | 150 mph | 200 mph | 300 mph |
|---|---|---|---|---|
| Worst Case | 1.444 | 2.812 | 5.645 | 13.499 |
| Base Case | 2,100 | 4,306 | 9,205 | 17,039 |
| Best Case | 3,496 | 6,410 | 14,288 | 24,310 |

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# Disclaimer

## Report Qualifications, Assumptions & Limiting Conditions

This report sets forth the information required by the terms of the assignment and is prepared in the form expressly required thereby. This report is to be read and used as a whole and not in parts. The alteration of any section or page of this report or the removal of any section or page from the main body of this report invalidates that section or page, as well as this report in its entirety.

This report is for the use of our client to whom it is addressed and its professional advisers. The demand and revenue results presented in this report were produced for input to policy decision-making processes. The overall model error in the demand and revenue results is ± 20 percent at three standard deviations.

This report does not make any representation regarding the fairness of the opinions stated in this report to any and all parties. There are no third party beneficiaries with respect to this report, and the consultant team accepts no liability to any third party. The opinions expressed herein are valid only for the purpose stated herein and as of the date of this report.

Information furnished by others, upon which all or portions of this report are based, is believed to be reliable and every effort has been made by the consultant team to validate the information. However, no warranty is given as to the accuracy of such information. Specifically, public information and industry and statistical data including, without limitation, information and data from the following sources were deemed to be reliable and accepted in good faith.

- Alberta Infrastructure and Transportation
- Alberta Finance
- Alberta Human Resources and Employment
- Alberta First
- Alberta Municipal Affairs
- City of Calgary
- City of Edmonton
- City of Grand Prairie
- City of Lethbridge
- City of Medicine Hat
- City of Red Deer
- Statistics Canada
- Strathcona County
- Applications Management Consulting Ltd.
- Edmonton Economic Development Corporation

In preparing this report, the consultant team has also relied upon and assumed the accuracy of the economic scenarios and transport strategies developed jointly by the consultant team and the AIT Study Steering Committee. If any changes occur that would alter these scenarios or strategies, the demand and revenue results would have to be reviewed and recalculated. The consultant team assumes no responsibility for changes in market conditions or laws or regulations and is under no obligation to revise this report to reflect changes, events or conditions, which occur subsequent to the date of this report.