APPENDIX C-2

FUNCTIONAL ANALYSIS OF ROUTES 9, 11 AND 11A
LEVEL 2 ANALYSIS

PREPARED FOR

Northern Lights Express Alliance
Minnesota Department of Transportation
Wisconsin Department of Transportation

DRAFT

Northern Lights Express Technical Memorandum: Functional Analysis of Routes 9, 11 and 11A (Level 2 Analysis)

High-Speed Rail Environmental Assessment (Minneapolis – Duluth, Minnesota)

December 2010

PREPARED BY

Transportation Economics & Management Systems, Inc.
in cooperation with
SRF Consulting Group and Quandel Consultants, LLC

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1 OVERVIEW

1.1 INTRODUCTION

The purpose of this report is to provide additional information regarding capital cost estimates, ridership forecasts, operational costs, and resulting benefit-cost analysis for three routes (9, 11, and 11A, shown in Exhibit 1-1) that are currently under consideration for high speed passenger rail service between Minneapolis and Duluth, Minnesota. This information will be used to determine which of the three routes exhibit sufficient economic characteristics to be carried into detailed environmental analysis in the Environmental Assessment.

Exhibit 1-1: Minneapolis to Duluth - Routes under Consideration

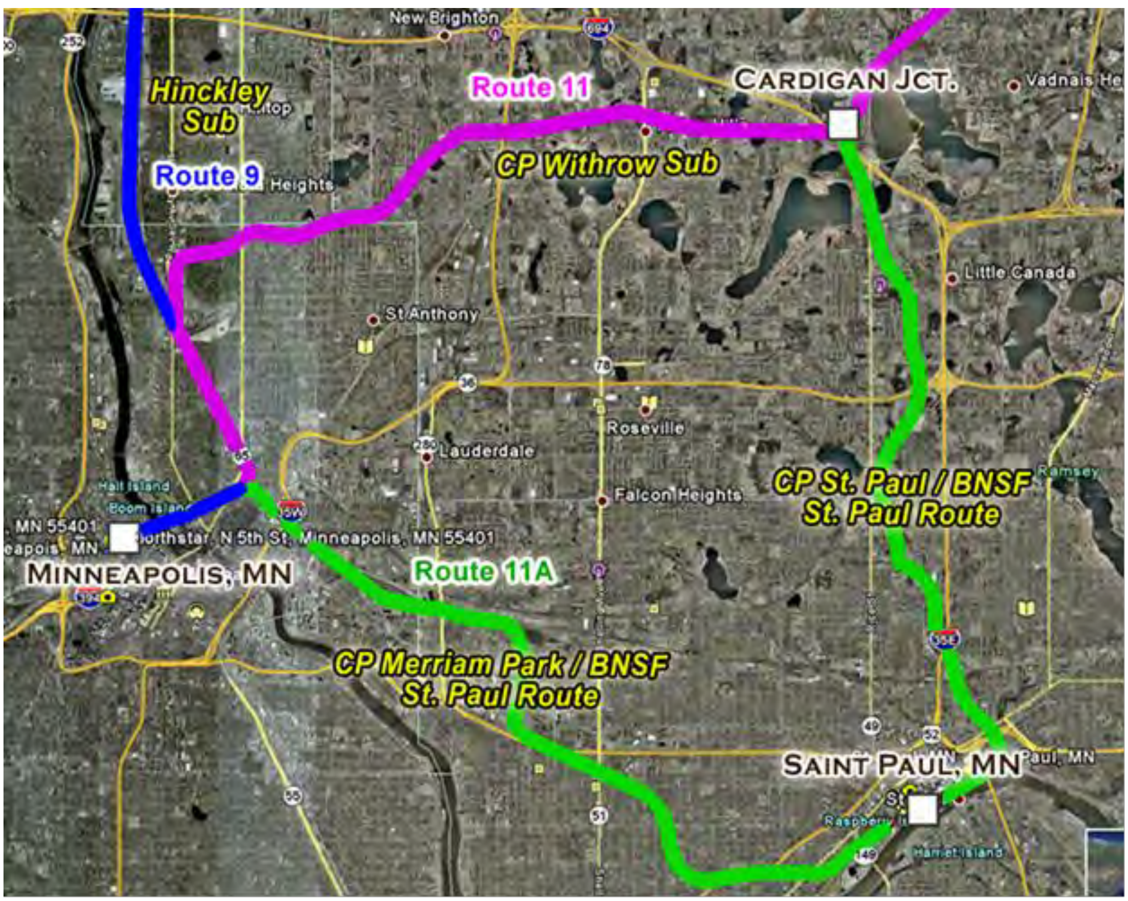
Route 9 shown in Exhibit 1-1 consists of the BNSF rail corridor that was evaluated in the original December 2007 feasibility study. The results of this study showed a strong potential for the Northern Lights Express (NLX) passenger rail service between Minneapolis and Duluth. Using the BNSF Hinckley Subdivision the line connects Minneapolis Northstar Station, with Foley Boulevard in Anoka County, Cambridge in Isanti County, Hinckley in Pine County, Superior in Douglas County (Wisconsin), and Duluth in St. Louis County.

In subsequent discussion with USDOT Federal Railroad Administration it was recommended that two additional routes utilizing the Rush Line, that parallels the Hinckley subdivision along a more easterly route, should also be assessed:

- **Route 11** – As shown in Exhibit 1-1, Route 11 begins in Duluth and follows the same BNSF route as far as Hinckley. South of Hinckley this route, as shown in Exhibit 1-2, uses the Rush Line as far as Cardigan Junction where it connects with the CP Withrow Subdivision. It links up with the BNSF route at University Avenue, from where it goes directly to Minneapolis along the Route 9 connections. As such, it goes directly to Minneapolis and does not go to St. Paul.
- **Route 11A** – As shown in Exhibit 1-1, this route follows Route 11 from Duluth to Hinckley to Cardigan Junction. At Cardigan Junction it continues south to St. Paul using the CP St. Paul subdivision (See Exhibit 1-2). From St. Paul it uses the CP Merriam Park/BNSF St. Paul Route to make the connection to Minneapolis.

  All options begin in Minneapolis; connect to Hinckley, and then Superior and Duluth. The different in the routes is how they connect from Hinckley south to Minneapolis, and the station connections they make in the exurban, suburban, and urban areas of Twin Cities.

Exhibit 1-2: Route 9, 11, and 11A within the Twin Cities



1.2 BACKGROUND

The NLX Passenger Rail Alliance was formed as a joint powers board to explore options for renewing passenger rail service in the 155-mile corridor between Duluth and Minneapolis. Members include the regional rail authorities of Hennepin, Anoka, Isanti, Pine, and St. Louis and Lake Counties in Minnesota, Douglas County (ex-officio) in Wisconsin, plus the Cities of Duluth and Minneapolis. A recent addition to the Alliance is the Mille Lacs Band of Ojibwe. The Alliance Board meets on a monthly basis, and is open to the public.

The Alliance commissioned Transportation Economics & Management Systems, Inc. (TEMS) in 2007 to examine the operational and fiscal feasibility of renewing this service.

The TEMS Feasibility Study, officially titled the 'Minneapolis-Duluth/Superior Restoration of Intercity Passenger Rail Service Comprehensive Feasibility Study and Business Plan, December 2007', investigated the implementation of service along the 155-mile Burlington Northern Santa Fe owned freight rail route between downtown Minneapolis and downtown Duluth. The TEMS study concluded that the implementation of a passenger rail system within the BNSF right of way would enhance mobility in the region, reduce auto congestion and emissions, and stimulate economic growth in towns along the corridor. It also concluded that intercity rail service would meet the need for a competitive alternative to automotive travel with respect to travel time, pricing, and travel experience.

Concept Engineering and Environmental Review
In 2009, the NLX Alliance, in consultation with the Minnesota and Wisconsin Departments of Transportation (Mn/DOT and WisDOT respectively), retained SRF Consulting Group, Inc., in association with Quandel Consultants, LLC and TEMS, to further project development by providing concept engineering and completing project-level environmental review for NLX service implementation under both the National Environmental Protection Act (NEPA) and Minnesota Environmental Policy Act (MEPA)/Minnesota Statutes 116D. In addition to NEPA and MEPA, this environmental documentation process will ensure compliance with other federal requirements including the National Historic Preservation Act (Section 106), and Transportation Act of 1966 (Section 4(f)) and the Clean Water Act (Section 404). Mn/DOT has agreed to take the lead role of the two state Departments of Transportation and accordingly has signed a Cooperative Agreement with Wis/DOT outlining each department's respective roles in the review process.

NLX Steering Committee
A Steering Committee comprised of staff from the NLX Alliance, Mn/DOT, WisDOT, Anoka County, Hennepin County and the Duluth -Superior Metropolitan Interstate Council (MPO) has been formed to guide consultant work and to provide technical assistance to the project development process. Participation in the Steering Committee is open to all NLX Alliance members. Members of the Steering Committee provide a vast knowledge of existing transportation services including roadway, trail, bus, Bus Rapid Transit (BRT), Light Rail Transit (LRT) and commuter rail services as well as other developing high speed rail routes.

Corridor Assessment
As described in the Northern Lights Express High Speed Rail Corridor Assessment Report: Level 1 Final Screening Report (December 29, 2009 and Revised June 2010), a three-level evaluation methodology is being utilized to conduct an alternative analysis of rail routes within the NLX corridor. Level 1 was an initial screening of rail alternatives comprised of an assessment of operation

characteristics (e.g. travel time and ridership), investment requirements, and environmental constraints at a broad conceptual level using a workshop approach. The Level 1 Screening resulted in one route scoring significantly higher than the others, leading to a local recommendation that only this route be carried forward into the environmental analysis. FRA review determined that the screening analysis was insufficiently robust to select a single alternative and requested a more detailed comparison of the top three scoring routes:

- **Route 9:** Minneapolis to Duluth via Coon Rapids, Cambridge, Hinckley and Superior
- **Route 11:** Minneapolis to Duluth via North Branch, Hinckley and Superior
- **Route 11A:** Minneapolis to Duluth via St. Paul, North Branch, Hinckley and Superior

The intent of this Level 2 analysis is to provide a more detailed examination of ridership and operations to determine if any of these routes should be eliminated before proceeding to Level 3. This additional level of functional analysis – including ridership modeling, development of revenue projections, assessment of operations and maintenance costs and the next level of capital costs culminating in a benefit-cost analysis – will be used to determine which of the alternatives are technically and financially feasible using FRA public-private partnership criteria.

1.3 STUDY APPROACH

For a "Level 2" analysis, the aim of the study is to subject each route 9, 11 and 11A to a full feasibility level financial and economic analysis, comparable to but updating the analysis that was earlier developed for Route 9 in the feasibility study "Restoration of Intercity Passenger Rail Service in the Minneapolis-Duluth/Superior Corridor" and subsequent updates and refinements. For conducting this analysis, it was essential to make sure each route was treated in exactly the same way in the evaluation process using the same underlying set of models, cost and operating assumptions, and that the same evaluation criteria and metrics were applied. Key steps for ensuring comparison of routes on an equitable basis included:

1. Identifying appropriate stations for Routes 11 and 11A
2. Ensuring that access and egress was treated equally for each route by developing an appropriate zone system, and transportation links and networks for modeling travel demand and forecasting ridership and revenue.
3. Application of consistent train performance criteria across all three routes to identify appropriate train times and schedules.
4. Application of a set of consistent engineering assumptions and unit costs to each route.
5. Application of the FRA Commercial Feasibility criteria[1] in the financial and economic evaluation framework used on all three routes.

This framework allows each route to be treated equally in a feasibility, Level 2 analysis.

The analysis will be updated to a 2010 base year for each route, and evaluate the routes finances and economics over 30 years from a proposed 2015 build out year. The cash flow of financial and economic benefit/revenues and costs will be discounted using U.S. Office of Management and Budget (OMB) 3 and 7 percent social discount rates.

[1] USDOT FRA, *High-Speed Ground Transportation for America*, September 1997

Capital Costs were assessed by segment and then as a summary cost. The Unit Capital Costs used have been peer reviewed and bench marked against other current studies.

Operating Costs are based on train miles, passenger miles, and fixed costs needed to operate the service on each route. The operating unit costs are benchmarked against current Amtrak Midwest costs.

Passenger ridership and revenue are derived from the COMPASS™ model that has been recalibrated using a 2010 database. This includes updated O/D data, new socioeconomic data, and the latest air, bus, and auto traffic volumes available from state and national sources.

Financial and economic evaluations are based on the FRA "public-private" partnership guidelines as defined in the 1997 *Commercial Feasibility Study* and OMB requirements[2], which provide guiding principles for conducting intercity passenger rail financial and economic studies. Key financial and economic criteria include –

- Operating Ratio: $\dfrac{\text{Present Value (PV) of Operating Cost}}{\text{Present Value (PV) of Revenues}}$

- Cost Benefit Ratio: $\dfrac{\text{Present Value (PV) of Revenue} + \text{Present Value (PV) of Benefits}}{\text{Present Value (PV) Operating Cost} + \text{Present Value (PV) Capital Cost}}$

1.4 REPORT STRUCTURE

This report is intended to provide a detailed review of the costs, benefits, and financial implications of Routes 9, 11 and 11A. The report is structured as follows –

Chapter 1 – Overview
Chapter 2 – Description of Routes Analyzed
Chapter 3 – Current Market
Chapter 4 – Ridership and Revenue
Chapter 5 – Capital Investment Needs
Chapter 6 – Operations
Chapter 7 – Operating Costs
Chapter 8 – Financial and Economic Viability
Chapter 9 – Conclusion

Appendices
Appendix A – Socioeconomic Data
Appendix B – COMPASS™ Model & Calibration

[2] OMB Circular A-4, see: http://www.whitehouse.gov/omb/circulars_a004_a-4/

2 DESCRIPTION OF ROUTES ANALYZED

2.1 STATION ANALYSIS

A critical issue for a feasibility analysis is the selection of stations. For Route 9, the original feasibility study assessed a number of station options but selected Minneapolis, Foley Boulevard, Cambridge, Hinckley, Superior, and Duluth as the best stations for the route. For Routes 11 and 11A, a careful assessment needed to be made for optimizing the selection of station locations. Exhibit 1-1 shows the list of candidate station locations that were considered. The Minneapolis, Hinckley, Superior and Duluth stations do not depend on the selection of the route and were considered fixed for all alternatives. Similarly, the St Paul Union Depot was specified for Route 11A so the location for a downtown St Paul station did not have to be assessed.

As a result, the assessment focused on the need to develop alternative Route 11 or 11A stations for replacing two intermediate Route 9 stations: Foley Boulevard and Cambridge. Three sites were considered as alternatives to Foley Boulevard and two sites as alternatives to Cambridge.

Alternative to Foley Boulevard Station: Foley Boulevard provides a very attractive suburban station location for Route 9. For Route 11 and 11A several alternatives can be considered. These include Cardigan Junction, White Bear Lake, and Forest Lake. In comparison with Foley Boulevard any selection would result in a smaller area
population, as the Northeast side of Twin Cities is far less populated than Northwest Twin Cities. For example, White Bear Lake has only 54 percent of the population within 15 minutes' drive time as Foley Boulevard and Forest Lake is even smaller. See Exhibits 2-1 and 2-2.

Exhibit 2-1: Foley Blvd. vs. White Bear Lake (15 minute drive time)

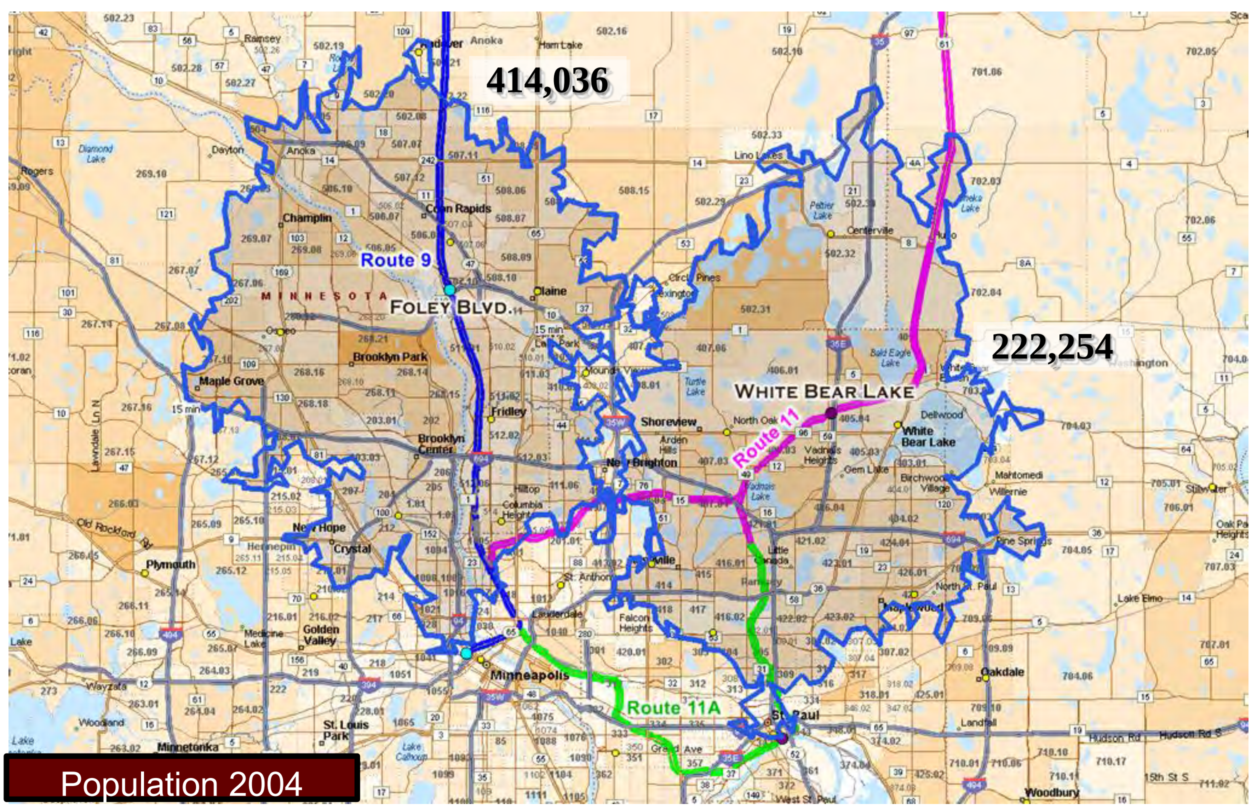


Exhibit 2-2: White Bear Lake vs. Forest Lake
(15 minute Drive-time)

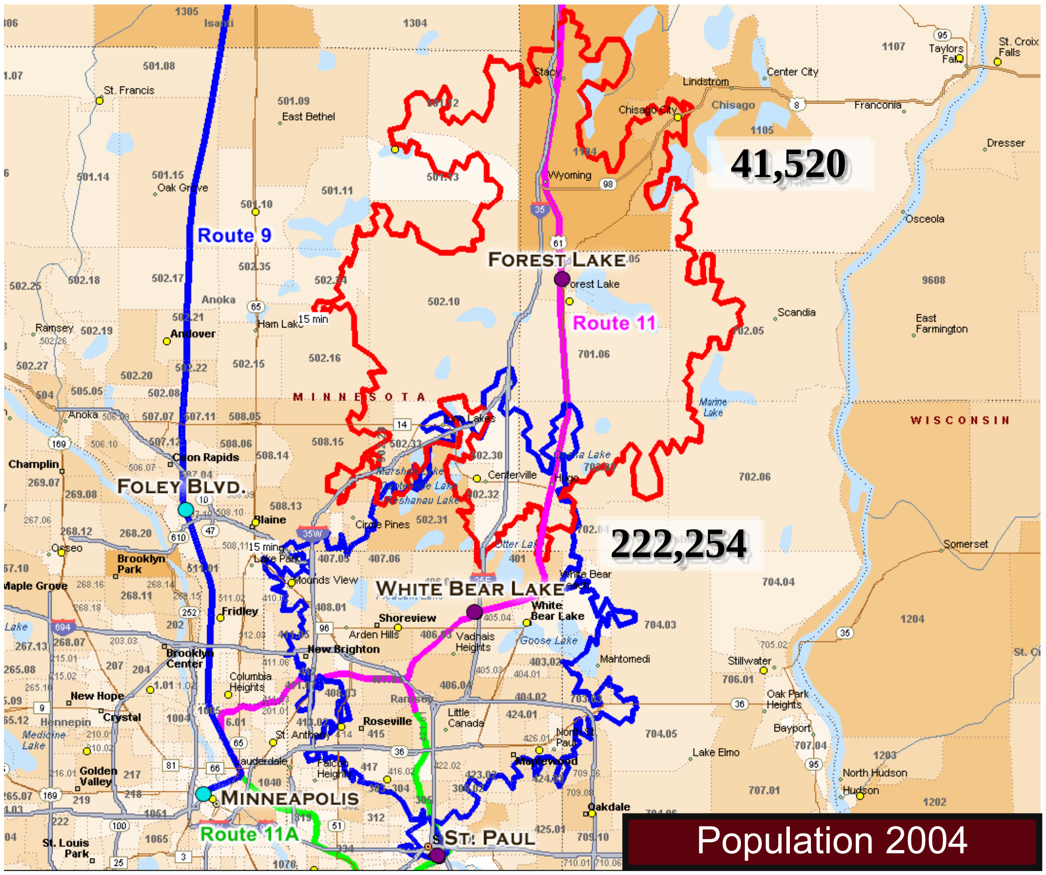
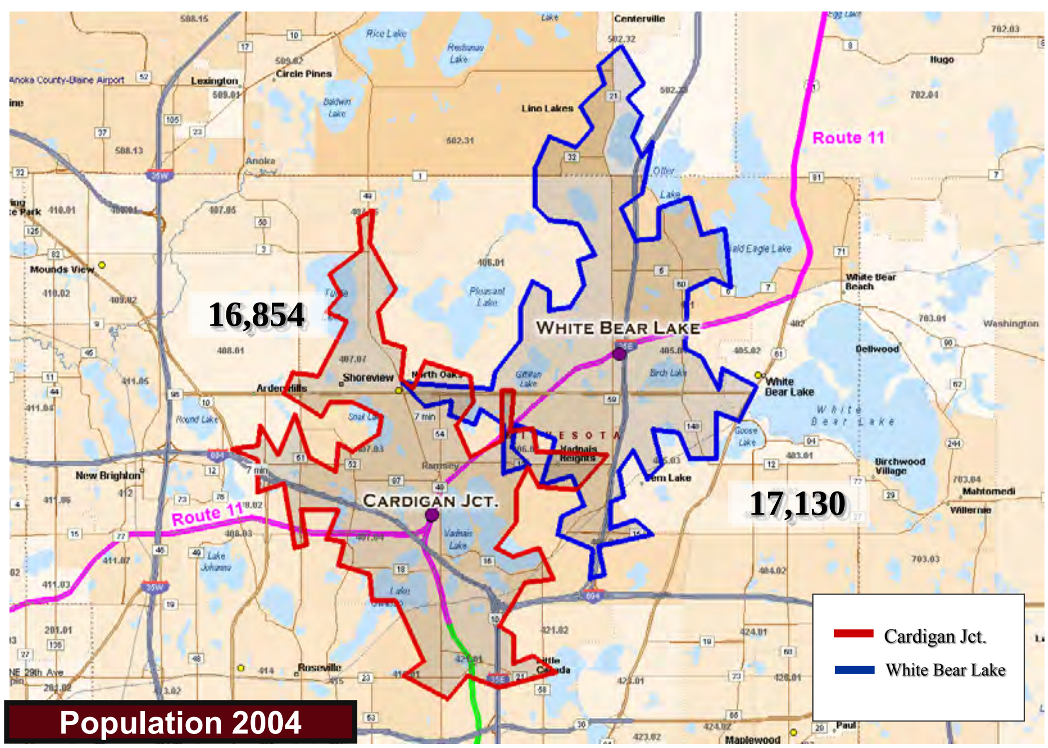


Exhibit 2-3: Cardigan Jct. vs. White Bear Lake
(7 minute Drive-time)



When comparing White Bear Lake to Forest Lake, White Bear Lake is bigger than Forest Lake in terms of station area population as seen in Exhibit 2-2 within 15 minutes' drive time. Either White Bear Lake or Forest Lake could provide good station sites with easy access to I-35. However, White Bear Lake was selected as it has a higher population than Forest Lake.

When comparing White Bear Lake to Cardigan Junction, they are very close to one another. In order to reduce the overlap between them, 7 minutes' drive time was selected. These produce approximately equivalent station area populations as seen in Exhibit 2-3. Cardigan Junction, however, suffers from being a poor location for a multimodal station due to the lack of sufficient land for a good station site near the railroad at that location, and difficult Interstate highway access. Therefore, White Bear Lake was selected over Cardigan Junction.

White Bear Lake is most similar to Foley Boulevard in terms of distance 15 miles compared to 12 miles to Twin Cities. *Thus, Foley Boulevard was selected for Route 9 and White Bear Lake for Routes 11 and 11A.*

Alternative to Cambridge Station: For Routes 11 and 11A, there are two possible alternatives to Route 9's Cambridge Station: North Branch and Rush City. As can be seen in Exhibits 2-4 and 2-5, North Branch has a bigger population than Rush City and is more comparable in terms of travel distance to the Twin Cities. Since the Hinckley Subdivision and Rush Line are beginning to converge the selection of North Branch would provide Cambridge inhabitants a 15 to 20 minute drive alternative. Rush City has no such comparable "Twin City". *As such, North Branch was selected as the best alternative to Cambridge.* Again, it has a smaller population than Cambridge.

Exhibit 2-4: Cambridge vs. North Branch (15 minute drive time)

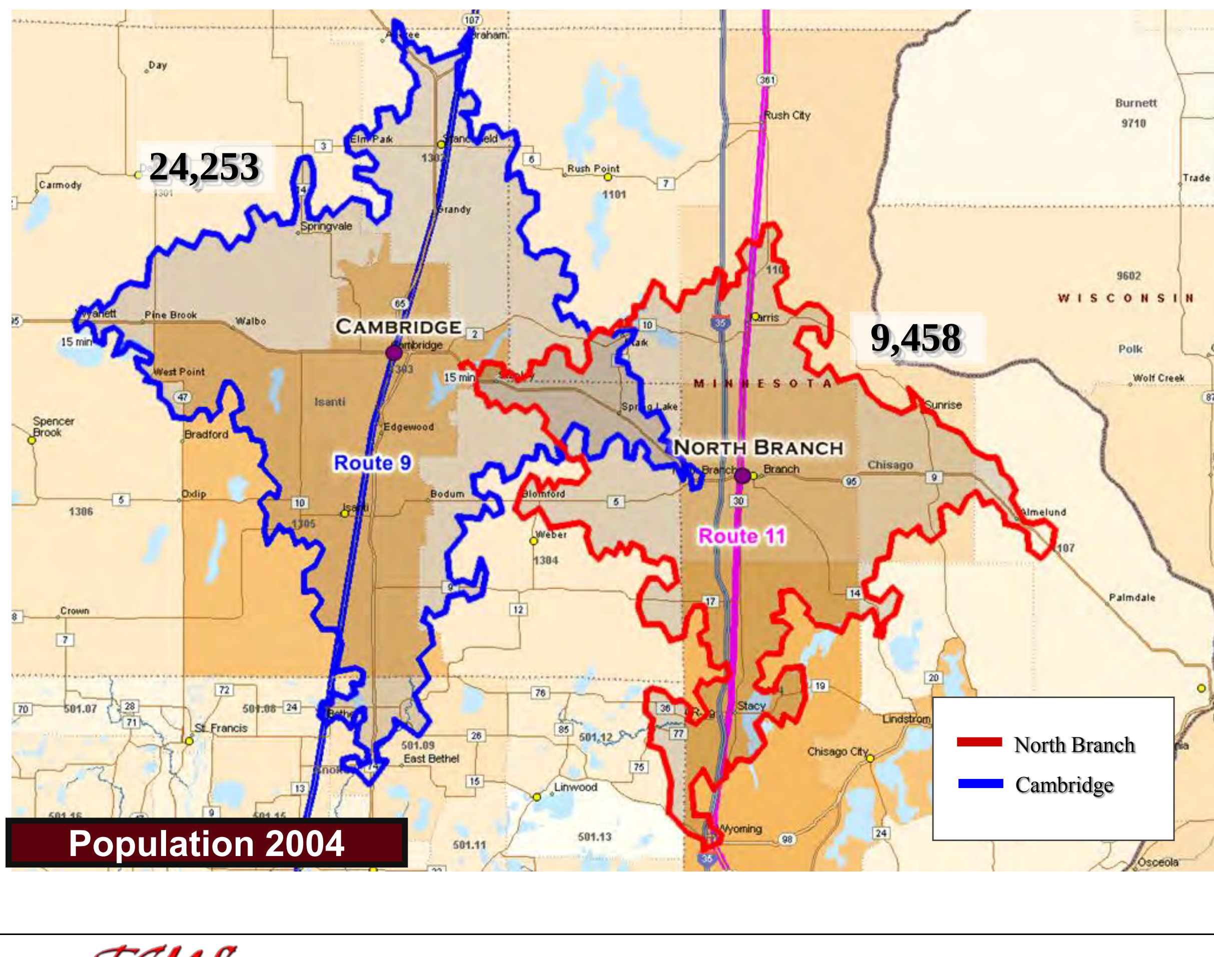
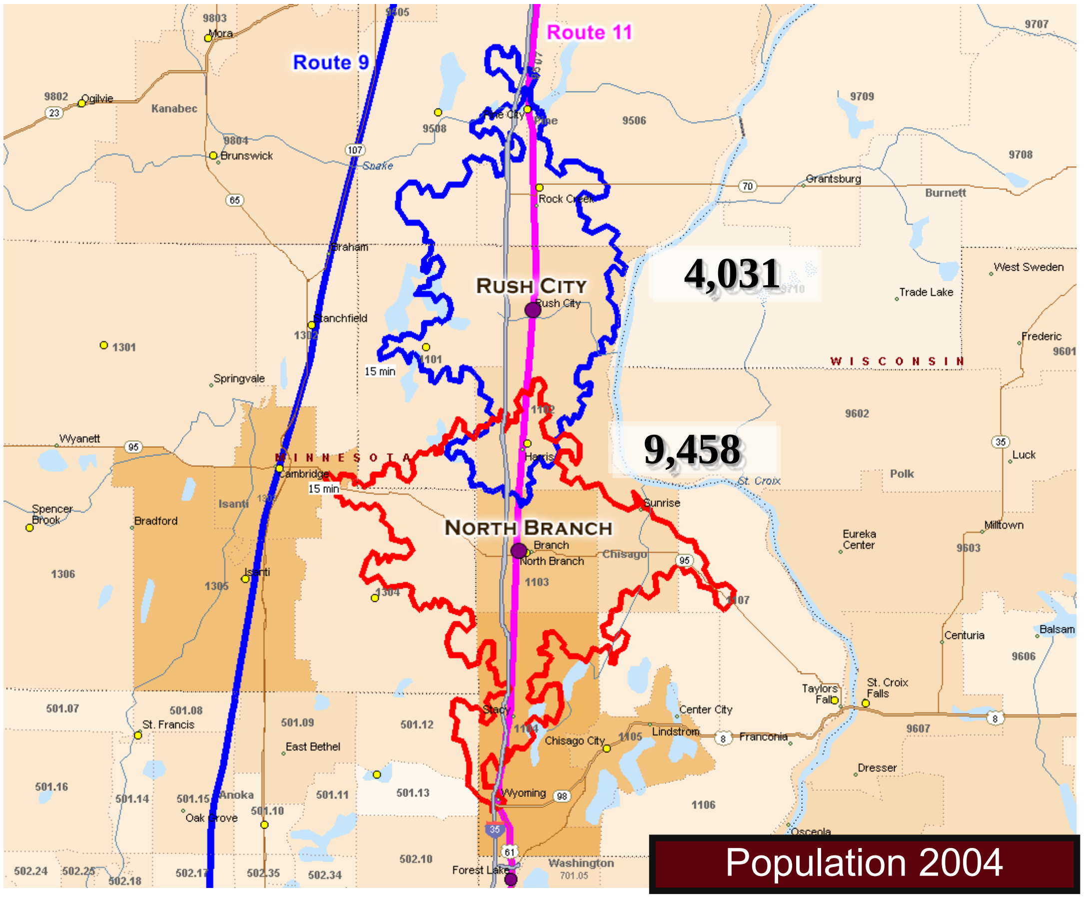


Exhibit 2-5: North Branch vs. Rush City (15 minute drive time)



Overall Comparison: The following table (Exhibit 2-6) shows the overall station area population of the routes based on 15 minute driving. It can be seen that Route 9 has a higher station area population based on 15 minutes driving time from stations, than Route 11. However, Route 11A serves the most people as it includes both the St. Paul and Minneapolis stations.

Exhibit 2-6: Overall Route Population Comparisons

Comparison of Station Area Populations Route 9 and Routes 11/11A (15 min drive time)					
Route 9		Route 11		Route 11A	
Minneapolis	677,005	Minneapolis	677,005	Minneapolis	677,005
Foley Blvd.	414,036	White Bear Lake	222,254	St. Paul	512,592
Cambridge	24,253	North Branch	9,458	White Bear Lake	222,254
–		–		North Branch	9,458
Totals	**1,115,294**		**908,717**		**1,421,309**

Exhibit 2-7 summarizes the analysis used to select Route 11 and 11A station locations.

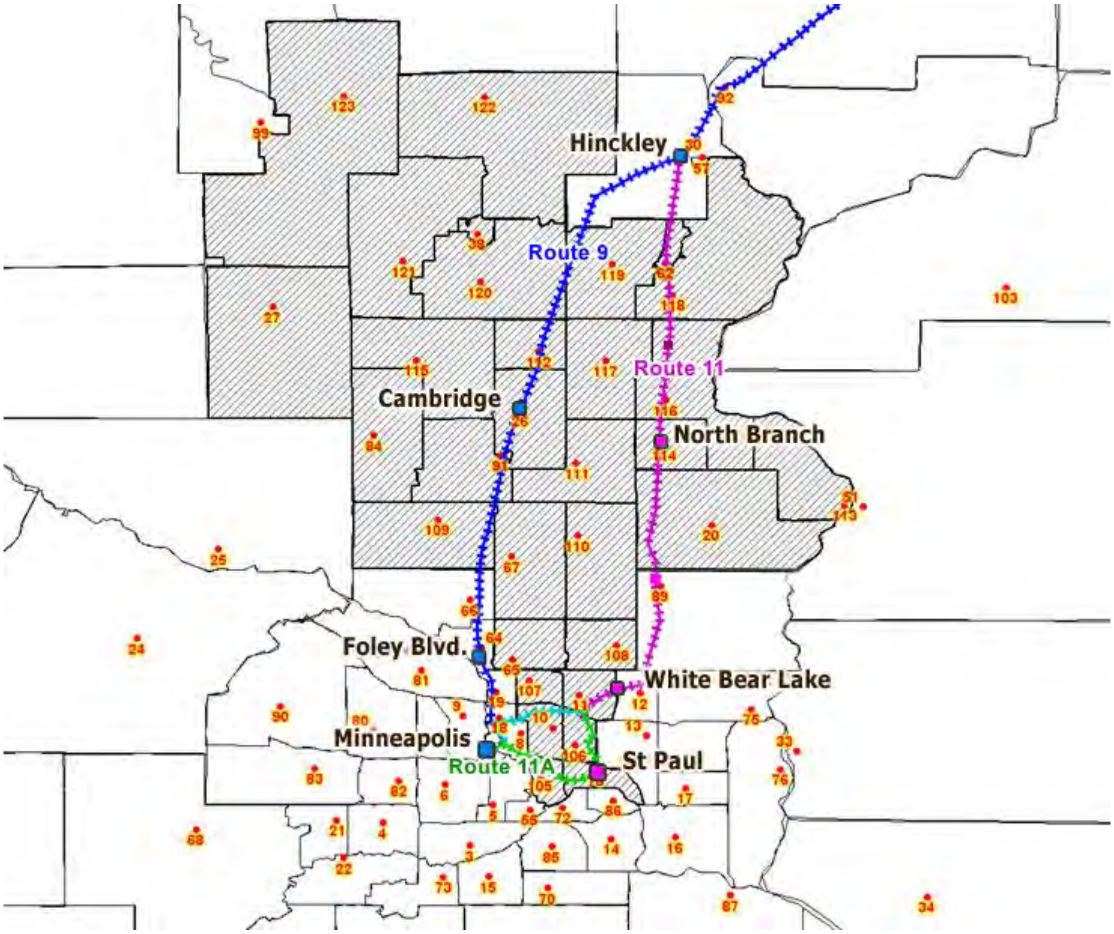
Exhibit 2-7: Routes and Stations
Discriminating Factors of Potential Station Sites

	White Bear Lake vs Cardigan Jct.	White Bear Lake vs Forest Lake	North Branch vs Rush City
Population	White Bear Lake is slightly larger within 7 minutes drive.	White Bear Lake is larger within 15 minutes drive.	North Branch larger within 15 minutes drive.
Trip Length to St. Paul or Minneapolis	White Bear Lake has longer Trip length.	Forest Lake has longer trip length but both more than 15 miles to St. Paul and White Bear Lake is similar to Foley Blvd which is 12 miles to Minneapolis.	Rush City has longer trip length but both more than 40 miles and North Branch is similar to Cambridge.
Quality of Station Site	Cardigan Jct. Problematic	Both have good potential	Both have good potential
Access to Highways	Both have Interstate Highway access. Cardigan Jct has east/west access in I 694, White Bear Lake has good north/south access in I 35E.	Both have good north/south Interstate Highway access - I 35. White Bear Lake also has good east/west access in Route 96 to West Ramsey County.	Both have good north/south Interstate Highway access - I 35. North Branch also has good east/west access in Route 95 to Cambridge.
Compatibility with Route 9 Option	Cardigan Jct only 8 miles from St. Paul, White Bear Lake is 12 miles from St. Paul & Foley Blvd. is 12 miles from Minneapolis.	Foley Blvd is 12 miles from Minneapolis which is comparable with White Bear Lake at 15 miles to St. Paul while Forest Lake is 26 miles.	Cambridge is 45 miles from Minneapolis which is comparable with North Branch at 42 miles from St. Paul while Rush City is 55 miles.
RECOMMENDATION	**Use White Bear Lake**	**Use White Bear Lake**	**Use North Branch**

2.2 ZONE SYSTEM

In the analysis of Routes 9, 11 and 11A, a critical element is the representation of travel between origins and destinations along the respective corridors. The original zone system for the Minneapolis- Duluth/Superior corridor was focused on Route 9 stations. To ensure a fair assessment of Route 11 and 11A, the zone system was revised. The revised zone system included a finer zone system along both the 11 and 11A corridors, and a finer accounting of access and egress to selected Route 11 and 11A stations. As a result, the original zone system was expanded from 100 internal zones to 123 internal zones, which together with 322 zones of the other MWRRI states makes up the basis for the analysis of the travel potential of the Route 9, 11, and 11A corridors. See Exhibit 2-8.

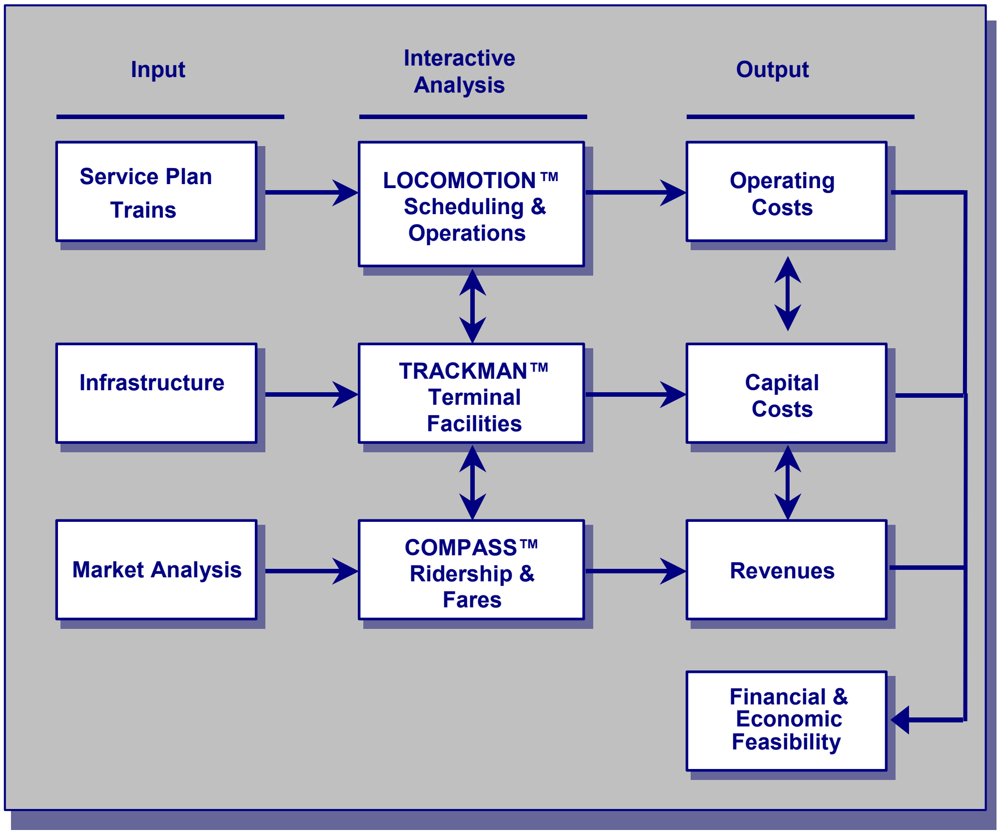
Exhibit 2-8: Modified Duluth Zone System



2.3 RAIL SERVICE ANALYSIS

The Rail Service Analysis for Routes 11 and 11A was completed using the same analysis process as used in the development of Route 9. An interactive analysis was used to compare train times, operating costs and capital costs for infrastructure. See Exhibit 2-9. For each Interactive Analysis assessed, which route infrastructure should be added given a recognition of the constraints of the corridor and the value of any speed improvement on Train Performance (i.e., train time saved per capital dollar expended).

Exhibit 2-9: Interactive Analysis



3 CURRENT MARKET

3.1 OVERVIEW

The Duluth-Minneapolis corridor is an important corridor of Minnesota, which serves the cities of Minneapolis and Duluth, and St. Louis, Hennepin, Anoka, Isanti, Pine, and Douglas counties. This corridor has a population of 3.7 million in 2010 which is about 70% of the total state population. The existing intercity transportation modes of this corridor include air, bus and auto. Today the corridor has 22 million intercity trips per year. The vast majority of travel in the corridor is by auto, which has about 95% of current market share.

To evaluate the potential for rail services in the Duluth-Minneapolis Corridor, it is important to assess the total travel market in the corridor under the study, and how well a new rail service might perform in that market. For the purpose of this study, this assessment was accomplished using the following process:

1. Gather information on the total market and travel patterns in the corridor for auto, air, bus and rail travel.
2. Identify and quantify factors that influence travel choices, including current and forecast socioeconomic characteristics and future gas price.
3. Build and calibrate a model to test different travel choice scenarios; in particular, identify the likely modal shares under each scenario.
4. Forecast travel, including total demand and modal shares.

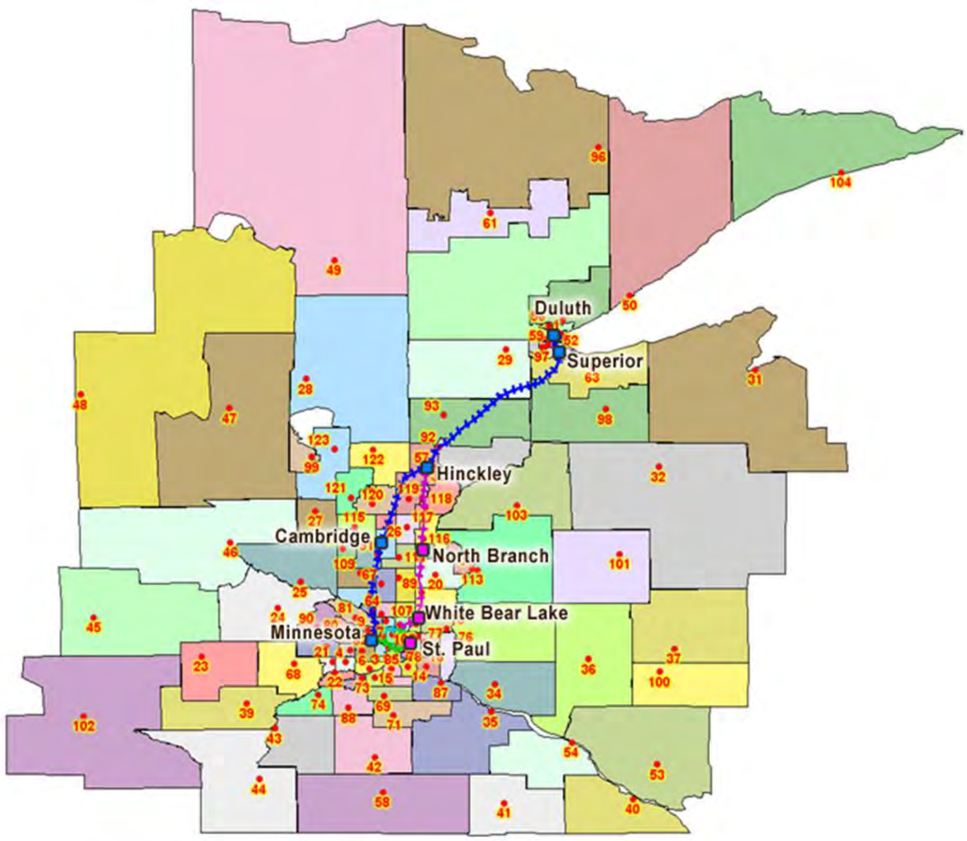
This chapter documents the analysis undertaken to establish the base year socioeconomic and travel market.

3.2 ZONE DEFINITION

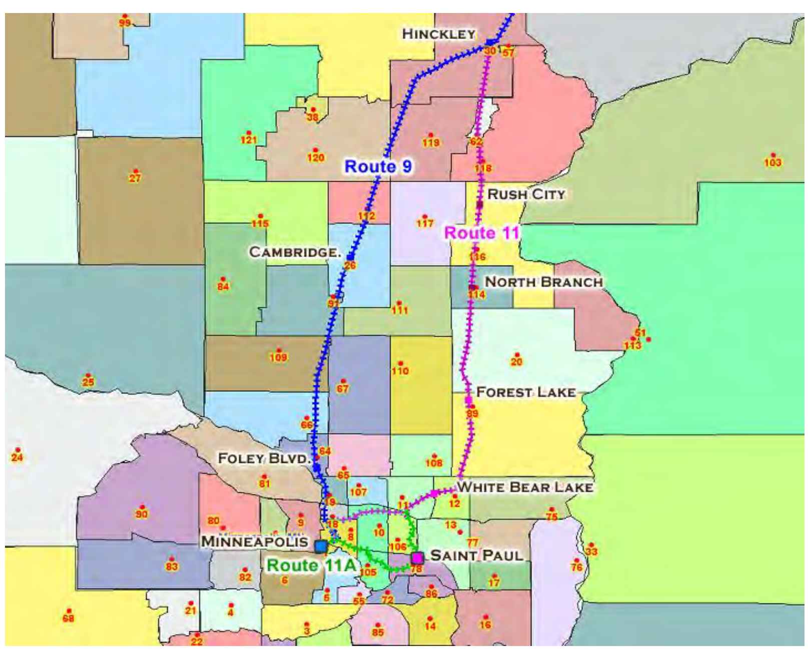
To develop a study database (network, socioeconomic and trip origin-destination), the fundamental unit of analysis, a zone system needs to be constructed. The zone system is predominately county-based in rural areas, and TAZ (traffic analysis zones) based in urban areas as shown in Exhibit 3-1. County-based zones are compatible with the socioeconomic baseline and forecast data derived from the Bureau of Economic Analysis (BEA), which are also county-based. Zones are defined relative to the proposed rail network. As zones move outward from stations, their size transitions from small to larger.

The networks and a zone system containing 123 zones developed for the Duluth - Minneapolis corridor are enhanced with finer zone detail in urban areas of Minneapolis and St. Paul. In order to evaluate the different route options, finer zones are added to the areas to be affected by Cambridge station, Foley Blvd. station, North Branch station, and White Bear Lake station as shown in the zoom-in map of the Exhibit 3-1. Some zones are based on TAZ, which has been developed by local urban planning agencies such as the Metropolitan Council, which is regional planning agency serving the Twin Cities seven-county metropolitan area.

Exhibit 3-1: Study Area Zone System



Routes 9, 11 and 11A Zoom-In



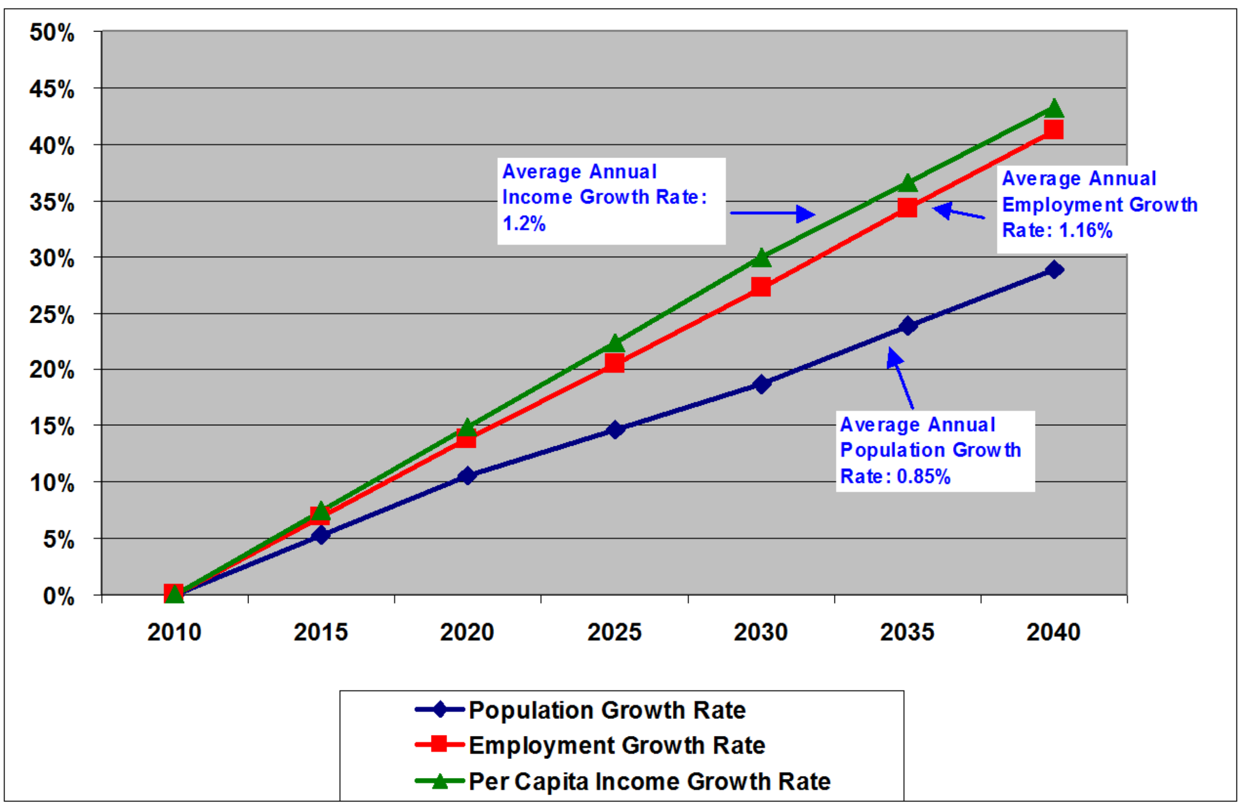
3.3 SOCIOECONOMIC BASELINE AND PROJECTIONS

For each zone in the study area, base year socioeconomic data and forecast growth rate percentages were derived from various sources, as follows:

- Metropolitan Council
- Minnesota Planning State Demographic Center
- Minnesota Department of Employment and Economic Development
- St. Louis County Planning Department
- Minneapolis-St. Paul International Airport
- Wisconsin Department of Administration
- Wisconsin Department of Workforce Development
- Bureau of Economic Analysis
- U.S. Census Bureau
- U.S. Department of Labor
- Woods & Poole Economics

Using these sources, each zone was treated as an independent unit in the income, population and employment forecast. In 2010, the total population in the corridor area is 3.7 million, the employment is 2.2 million, and the average per capita income is $49,169. From 2010 to 2040, the projected average annual growth rate of population is 0.85%, the annual growth rate of employment is 1.16%, and the average annual growth rate of per capita income is 1.2%. Exhibit 3-2 shows the population, employment, and per capita income central case growth projections from 2010 to 2040.

Exhibit 3-2: Study Area Socioeconomic Variables Growth Rates



The exhibit shows that there is higher growth of employment and per-capita income than population. However, travel increases are historically strongly correlated to increases in employment and per capita income, in addition to changes in population. Therefore, travel in the corridor is likely to continue to increase faster than the population growth rates, as changes in employment and per capita income outpace population growth, and stimulate more travel.

The exhibit shows the aggregate socioeconomic projection for the whole study area. It should be noted that in applying socioeconomic projections to the model, separate projections were made for each of the individual 123 zones using the data from the listed sources. Therefore, the socioeconomic projections for different zones are likely to be different and thus may lead to different future travel sub-market projections. A full description of socioeconomic data of each zone can be found in the Appendix B.

3.4 EXISTING TRAVEL MARKETS

In transportation analysis, travel desirability is measured in terms of cost and travel time. These variables are incorporated into the basic transportation network elements. Correct representation of the existing and proposed travel services is vital for accurate travel forecasting. Basic network elements are called nodes and links. Each travel mode consists of a database comprised of zones, stations or nodes, and existing connections or links between them in the study area. Each node and link is assigned a set of attributes. The network data assembled for the study included the following attributes for all the zone pairs.

For public travel modes (air, rail, bus):

- Access/egress times and costs (e.g., travel time to a station, time/cost of parking, time walking from a station, etc.)
- Waiting at terminal and delay times
- In-vehicle travel times
- Number of interchanges and connection times
- Fares
- On-time performance
- Frequency of service

For private mode (auto):

- Travel time, including rest time
- Travel cost (vehicle operating cost)
- Tolls
- Vehicle occupancy

The transportation service data of different modes available in the study corridor were obtained from a variety of sources and coded into the networks as inputs to the demand model.

3.4.1 HIGHWAY TRAVEL

The highway network was developed to reflect the major highway segments within the study area. The sources for building the highway networks in the study area include the Metropolitan Council, Minnesota Department of Transportation, and highway information from Microsoft MapPoint 2006. The Internal Revenue Service (IRS) Standard Mileage Rate was used to develop the auto network cost data. The values provided by the IRS consist of an average cost of 50 cents per mile for Business travel and 15 cents per mile for Other travelers. The Business figure reflects the IRS estimate of the full cost of operating a vehicle because a business is required to pay the full cost for the use of a vehicle. The covered routes include major Interstate such as I35 and I94 and some US routes such as US12 and US52.

3.4.2 AIR TRAVEL

Air network attributes contain a range of variables that include time and distance between airports, airfares, on-time performance measures and connection times. Travel times, frequencies and fares were derived from official airport websites and websites of the major airlines serving airports in the study area. For travel distances, the study team obtained the non-stop, shortest-path distance between airports. On-time performance measures were derived from the 2009 airport on-time performance statistics from the Bureau of Transportation Statistics (BTS) website.

Delta and Continental Airlines currently provide most of the passenger air travel service for Duluth International Airport. Delta Airlines travels to Minneapolis, MN and Detroit, MI. while Continental Airlines provides air travel to Chicago, IL. The Exhibit 3-3 shows the some flights connected with Duluth airport.

Exhibit 3-3: Average Annual Nonstop Air Travel Attributes Between Duluth and Other Airports 2010

From	To	Distance (miles)	Time (minutes)	Daily Frequency	Fare Cost ($)
Duluth(DLH)	Minneapolis (MSP)	144	60	7	224
Duluth (DLH)	Detroit (DTW)	542	111	2	625
Duluth (DLH)	Chicago (CHI)	402	87	2	150

3.4.3 RAIL TRAVEL

Amtrak has not provided passenger service between Minneapolis and Duluth/Superior since 1985.Therefore, the base-line forecast for the corridor was derived, based on a trip generation rates for Amtrak service in other corridors in the Midwest that have similar socioeconomic and trip-making characteristics. The base-line rail service assumed Amtrak 79-mph service with a frequency of 2 trains per day, a three hour running time from Minneapolis to Duluth, and 22 cents per mile fare. The base-line rail service is summarized in Exhibit 3-4.

Exhibit 3-4: Base Case Level of Rail Service

Train	Highest Speed (mph)	Frequency(train/day)	Time (minutes)	Fare Cost ($/mile)
Amtrak P42	79	2	170	0.22

3.4.4 BUS TRAVEL

Bus network attribute data, such as travel time, fares and frequencies, were obtained from official Internet websites (e.g., Greyhound) and 2008 Greyhound System Time Table. Fares were cross-referenced with fares obtained directly from Greyhound on selected routes within the study area.

Greyhound Lines Inc. and Jefferson Lines provide intercity bus services from Twin Cities to Duluth. Greyhound offers one express bus service daily, while Jefferson Lines offers three bus services daily, which stops at twelve intermediate stops. Additional buses might be put into use to accommodate passengers beyond the seating capacity of a single bus. The entire trip time for Greyhound bus is 2 hours 40 minutes, while the entire trip time for Jefferson Lines is 4 hours and 15 minutes. The fare for Greyhound bus is $18, while the fare for Jefferson Lines is $25.

3.5 ORIGIN-DESTINATION TRIP INFORMATION

TEMS extracted, aggregated and validated data from a number of sources in order to estimate base travel between origin-destination pairs in the study area. The travel demand forecast model requires the base trip information for all modes between each zone pair, in some cases this can be achieved directly from the data sources, while in other cases, the data providers only have origin-destination trip information of more aggregate level (e.g., station-to-station trip volume), if that is the case, a data enhancement process of trip simulation and access/egress simulation need to be conducted to estimate the zone-to-zone trip volume. The data sources and data enhancement requirements for each travel mode available in the study area are shown in Exhibit 3-5.

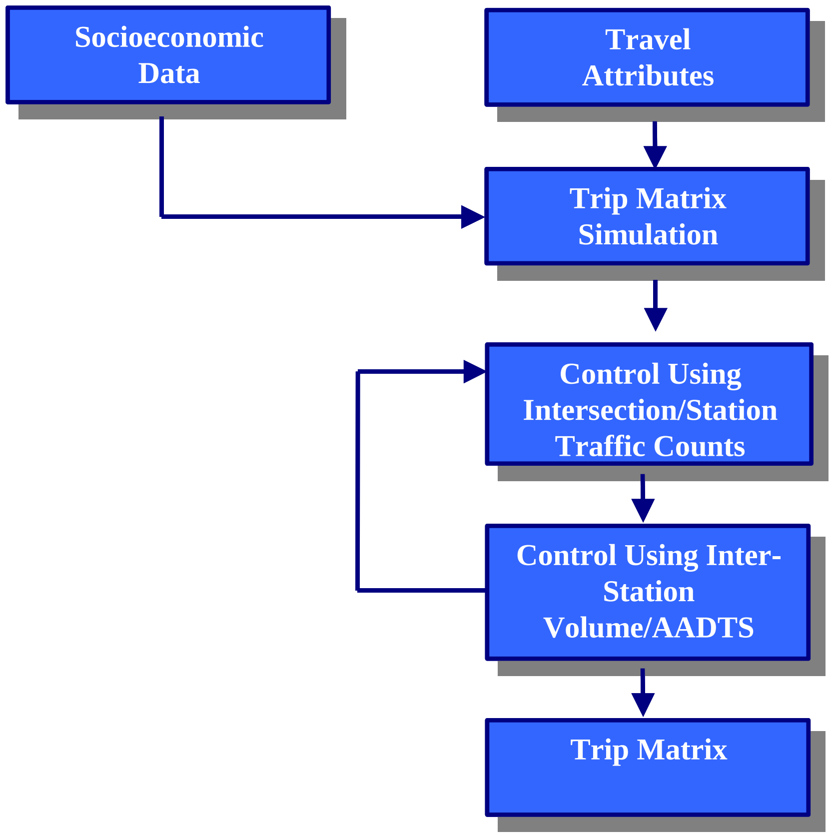
Exhibit 3-5: Sources of Total Travel Data by Mode

Mode	Data Source	Data Enhancement Required
Auto	The Metropolitan Council 2008 Trip Data The Minnesota DOT AADT count Restoration of Intercity Passenger Rail Service in the Minneapolis-Duluth/Superior Corridor 2008	Trip Simulation for Auto Flows Movement and AADT Counts
Rail	Amtrak Station Data Restoration of Intercity Passenger Rail Service in the Minneapolis-Duluth/Superior Corridor 2008	Access/Egress Simulation
Bus	Bus Schedules Estimated Bus Loading Factors	Access/Egress Simulation
Air	Bureau of Transportation Statistics 10% Ticket Sample Flight Schedules	Access/Egress Simulation

Access/egress simulation refers to the need to identify origin and destination zones for trips via passenger rail, air and bus. Otherwise, all non-auto trips would appear to begin at the bus or passenger rail terminal or airport zones. Distribution of access and egress trips to zones was accomplished using socioeconomic data and access/egress travel time and cost data. The flowchart of origin-destination trip estimation is shown in Exhibit 3-6.

For auto mode, the quality of the origin-destination trip data was assured by comparing it to the actual traffic counts such as AADT and adjustments have been made when necessary. For public travel modes, the origin-destination trip data was validated by examining station volumes and segment loadings. For trip data collected before 2010, historical and projected ridership data were used together with socioeconomic data to factor the trips to 2010 level.

Exhibit 3-6: Origin-Destination Trip Matrix Generation and Validation



The total estimated person trip volume within the corridor in 2010 is 22.16 million as shown in Exhibit 3-7.

Exhibit 3-7: Base 2010 Origin-Destination Trip Summary (millions)

Business	Commuter	Other (include Casino)	Total
3.17	7.57	11.42	22.16
14.31%	34.16%	51.53%	100.00%

4 RIDERSHIP AND REVENUE

4.1 INTRODUCTION

This chapter presents the passenger rail ridership and revenue forecast results obtained for Routes 9, 11 and 11A for the Duluth-Minneapolis corridor. It should be noted that the model databases do not include special events (e.g., concerts or sporting events) and therefore, reflect conservative estimates of the ridership potential based only on regular, daily city interactions.

4.2 BASIC STRUCTURE OF THE COMPASS™ MODEL

The *COMPASS*™ Multimodal Demand Forecasting Model is a flexible demand forecasting tool used to compare and evaluate alternative passenger rail network and service scenarios. It is particularly useful in assessing the introduction or expansion of public transportation modes such as air, rail or bus into new markets. Exhibit 4-1 shows the structure and working process of *COMPASS*™ Model. As shown in Exhibit 4-1, the inputs to the *COMPASS*™ Model are base and proposed transportation networks, base and projected socioeconomic data, value of time and value of frequency from MWRRI Stated Preference surveys, and base year trip data obtained from MPO, Transit and State DOT sources. All the data has been brought up to a 2010 base.

The *COMPASS*™ Model structure incorporates two principal models: a Total Demand Model and a Hierarchical Modal Split Model. These two models are calibrated separately. In each case, the models are calibrated for origin-destination trip making in the study area. The Total Demand Model provides a mechanism for replicating and forecasting the total travel market. The total number of trips between any two zones for all modes of travel is a function of (1) the socioeconomic characteristics of the two zones and (2) the travel opportunities provided by the overall transportation system that exists (or will exist) between the two zones. Typical socioeconomic variables include income, employment, and population. The quality of the transportation system is measured in terms of total travel time and travel cost by all modes.

The role of the *COMPASS*™ Modal Split Model is to estimate relative modal shares of travel given the estimation of the total market by the Total Demand Model. The relative modal shares are derived by comparing the relative levels of service offered by each of the travel modes. Three levels of binary choice were calibrated for the Duluth-Minneapolis corridor (see Exhibit 4-2). The third level of the hierarchy separates private auto travel, with its perceived spontaneous frequency, low access/egress times, and highly personalized characteristics, from public modes (i.e., bus, rail and air). The second structure level separates air, the most expensive but quickest public mode, from rail and bus surface modes. It should be noted that air travel is today much slower than prior to 9/11 because of increased security. The first level separates rail, the fast ground transportation technology from the slow bus services. The model forecasts changes in riders, revenue and market share based on changes travel time, frequency and cost for each mode.

Exhibit 4-1: Structure of the COMPASS™ Model

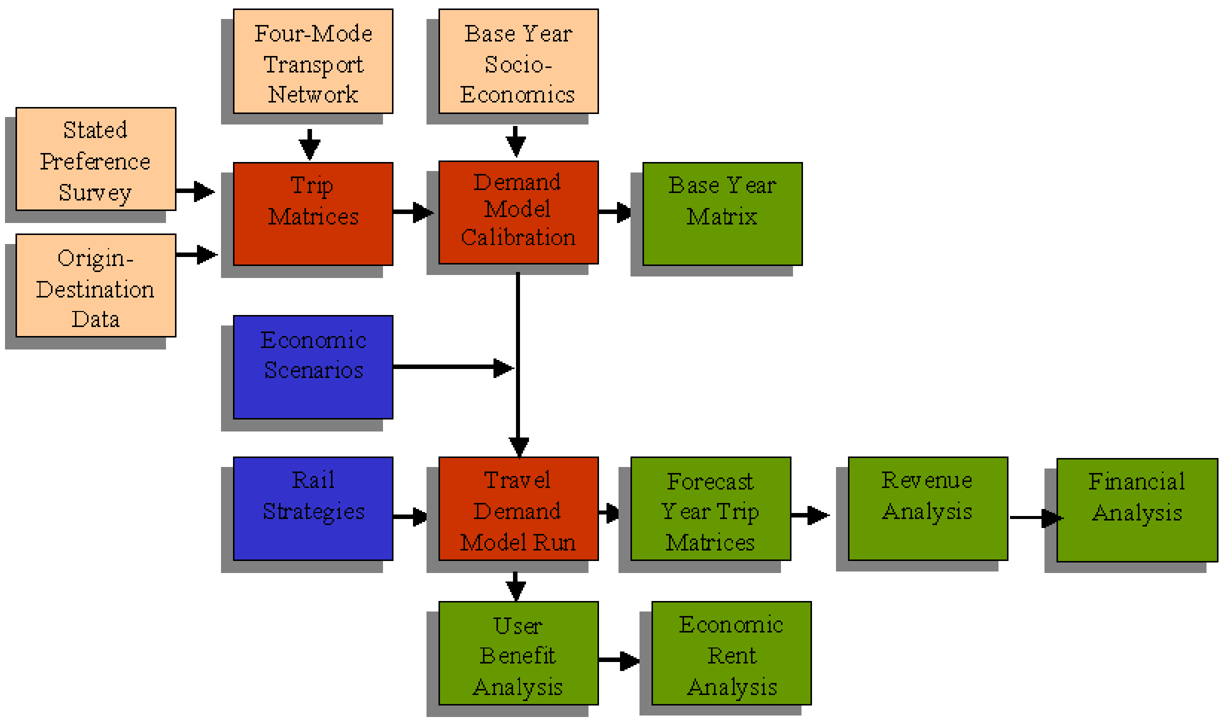
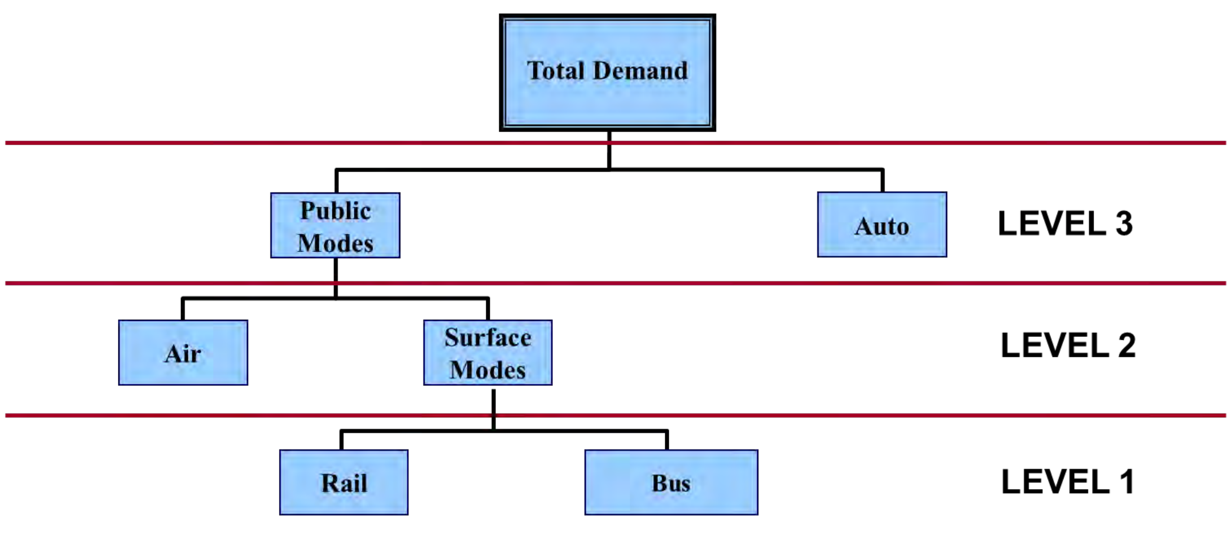


Exhibit 4-2: Hierarchical Structure of the Modal Split Model



A full description of the model and its calibration is given in Appendix A.

4.3 FUTURE TRAVEL MARKET STRATEGIES

4.3.1 FUEL PRICE FORECASTS

A crucial factor in the future attractiveness of the high speed rail is the price of gas. Forecasts of oil prices from the Energy Information Agency suggest that oil price will return at least to $100 per barrel in the next five years and will remain at that level in real terms to 2030 and beyond. See Exhibit 4-3. The implication of this is a central case gas price of 4 dollars per gallon with a high case price of $5 per gallon and a low case price of $3 per gallon. Since gas is currently at least $2.80 a gallon in a weak economic environment, $4 per gallon once the economy starts to grow again seems very realistic. Exhibit 4-4 shows the relationship of gas prices to oil acquisition cost from 1993 to 2010. It shows that gas prices rise directly with oil prices. As a result, gas prices are likely to rise as shown in Exhibit 4-5. This gives high, low and central scenarios for gas price to use in the travel demand forecast.

Exhibit 4-3: U.S. Crude Oil Composite Acquisition (Wholesale) Cost by Refiners – Historical Data and EIA Forecasts[1]

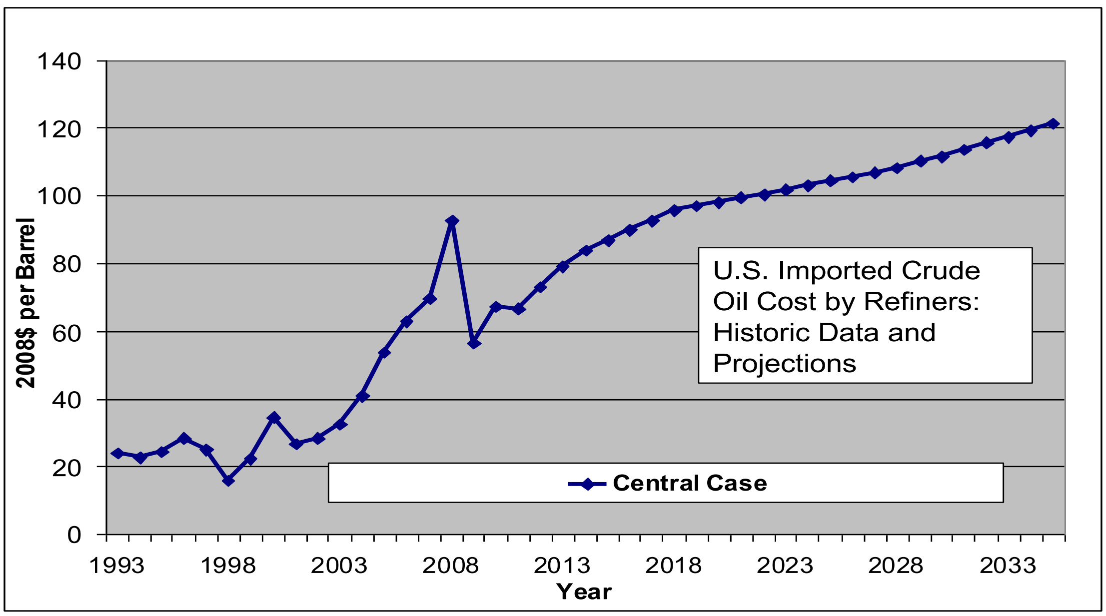


Exhibit 4-4: U.S. Retail Gasoline Prices as a Function of Crude Oil Prices (1993-2010) [2]

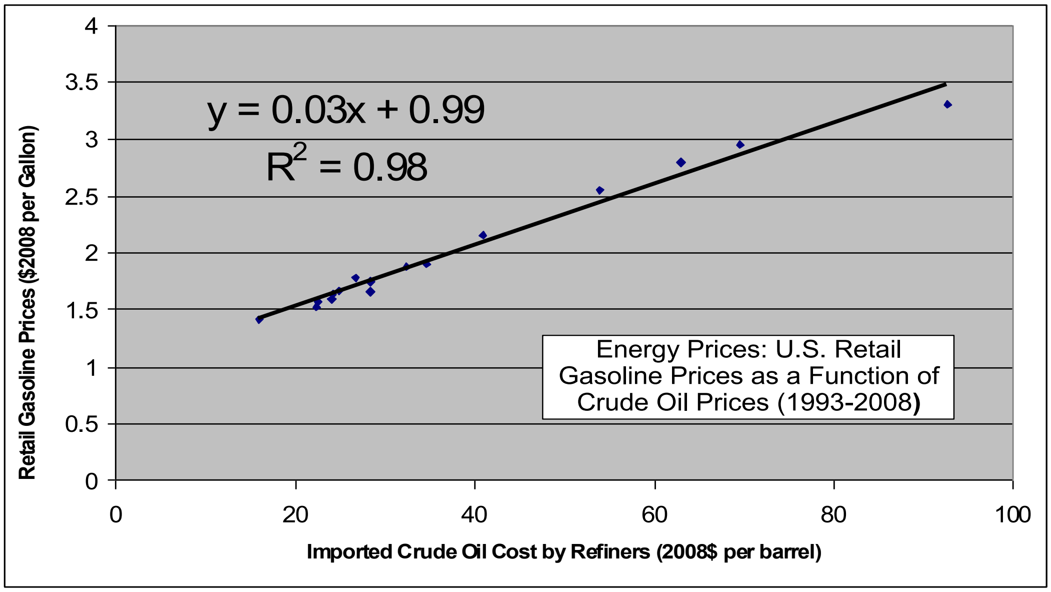
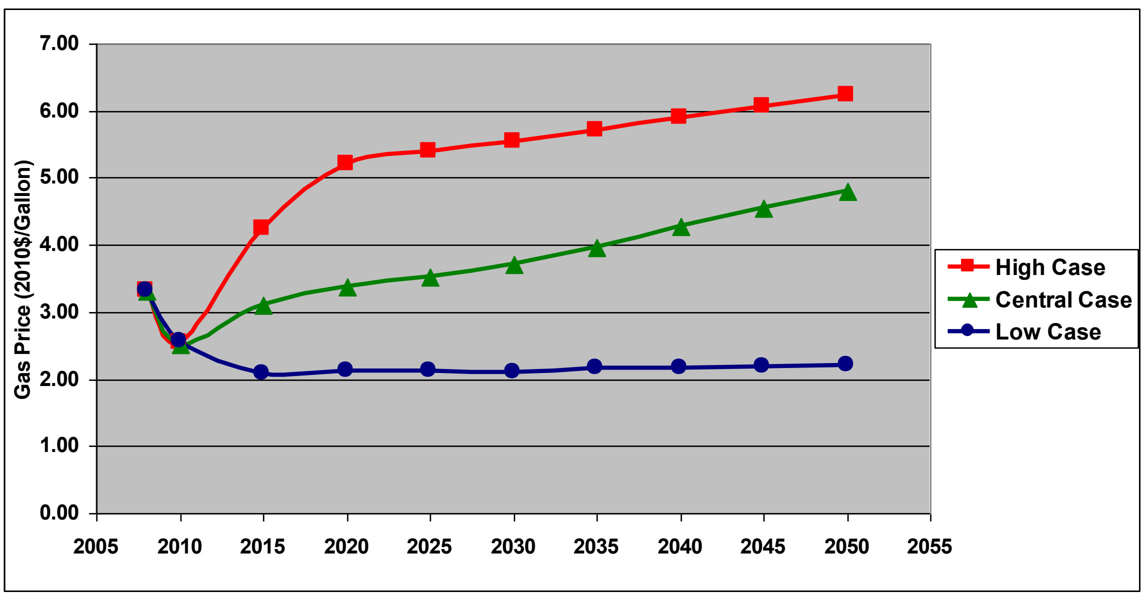


Exhibit 4-5: U.S. Retail Gasoline Prices – Historic Data and the Forecast



[1] Sources: EIA - http://www.eia.doe.gov/oiaf/aeo/aeoref_tab.html and http://www.eia.doe.gov/dnav/pet/pet_pri_rac2_dcu_nus_a.htm

[2] Analysis developed by TEMS, Inc. for MARAD US DOT. Sources: http://tonto.eia.doe.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mg_tt_us&f=a and http://www.eia.doe.gov/dnav/pet/pet_pri_rac2_dcu_nus_a.htm

4.3.2 HIGHWAY TRAFFIC CONGESTION

The level of service of auto and bus travel incorporates the MPO congestion scenarios to ensure that the automobile traveling impedances are properly reflected. The average highway travel time in the Duluth-Minneapolis corridor is estimated to have an average annual growth rate of 0.5% due to increased travel demand and congestion. This means that the auto travel time from Duluth to Minneapolis will increase from a current average 2 hours and 26 minutes to 2 hours and 49 minutes in 2040, which is a 16% increase.

As a result, high speed rail offers an increasing time advantage over auto and bus travel markets that rely upon highway infrastructure and are affected by increasing congestion and travel times. The time advantage will have greater impact on business and commuter travel purposes which have higher values of time and which makes the high speed rail more competitive with these travelers.

4.4 RIDERSHIP AND REVENUE FORECAST RESULTS FOR DIFFERENT ROUTES

Exhibit 4-8 presents the rail ridership forecasts for the Duluth-Minneapolis corridor for years 2020 and 2040. For Route 9, the system generates 938 thousand annual riders in 2020 growing to 1302 thousand annual riders in 2040. (A trip is defined as a passenger making a one-way trip. A round trip generates two one way trips). For Route 11, the annual riders are 834 thousand in 2020 growing to 1158 thousand in 2040. Route 11A has the longest route length and many commuter trips between Minneapolis and St. Paul are diverted to this service. In 2020, Route 11A has 981 thousand annual riders, and it grows to 1391 thousand in 2040.

Exhibit 4-8: 2020 and 2040 Forecast Ridership (Thousand)

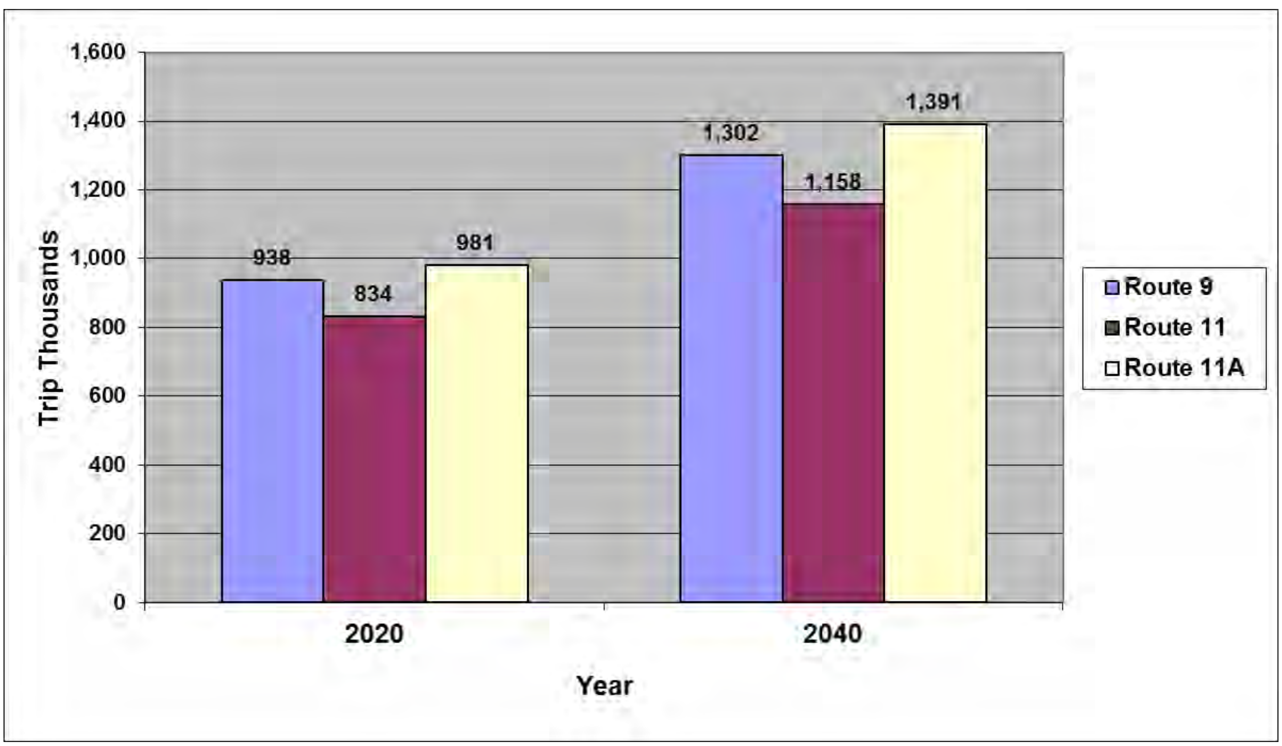


Exhibit 4-9 shows the annual passenger miles associated with trips made in 2020 and 2040. It can be seen that Route 9 has the greatest passenger miles, even though Route 11A has the greatest volume of passengers. This is because Route 11A attracts a large number of short distance trips between St. Paul and Minneapolis. The circuitous of Route 11A produces a slower train time and as a result, loses longer-distance trips from White Bear north.

Exhibit 4-9: 2020 and 2040 Passenger Mile Forecasts (Millions)

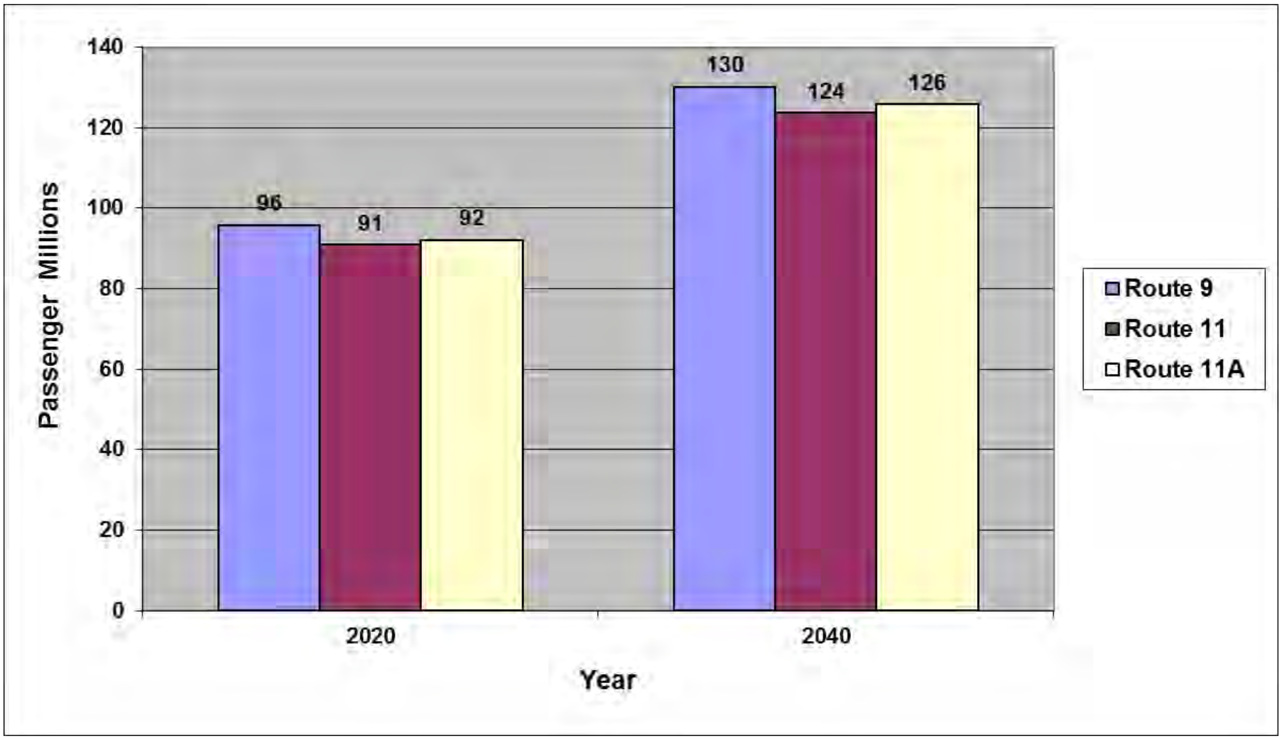
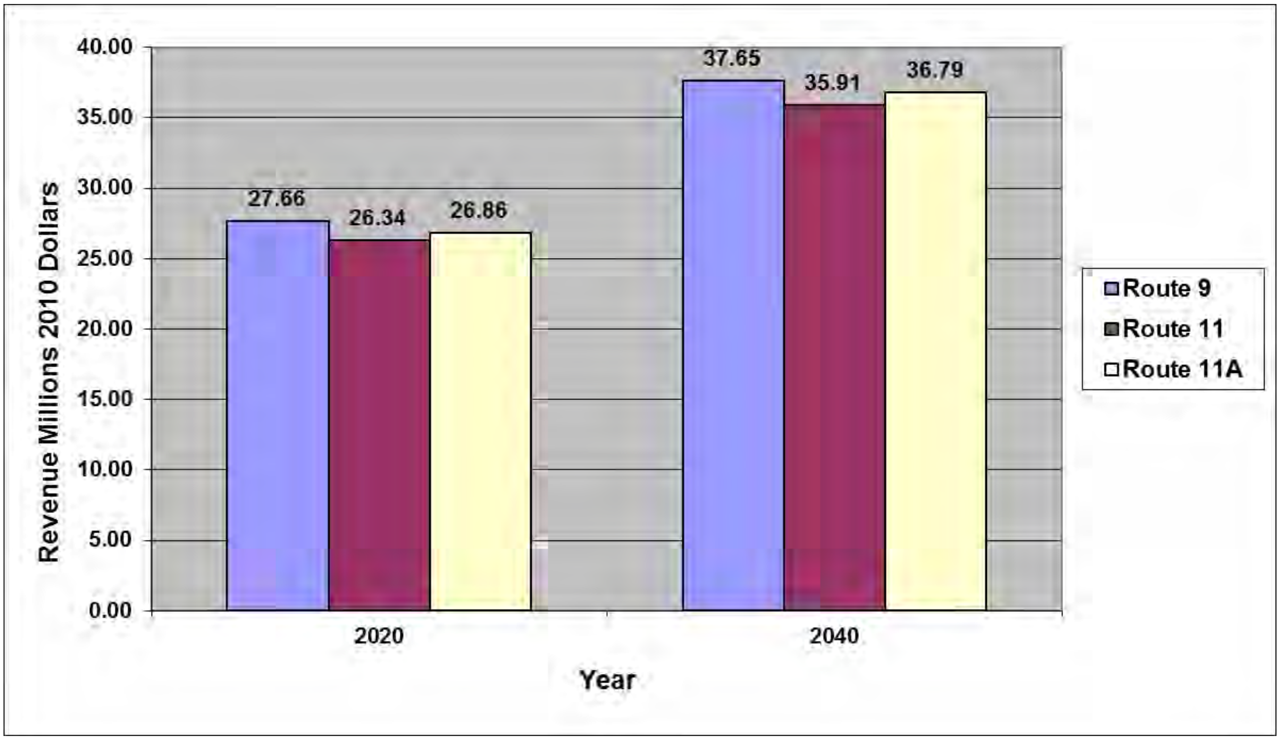


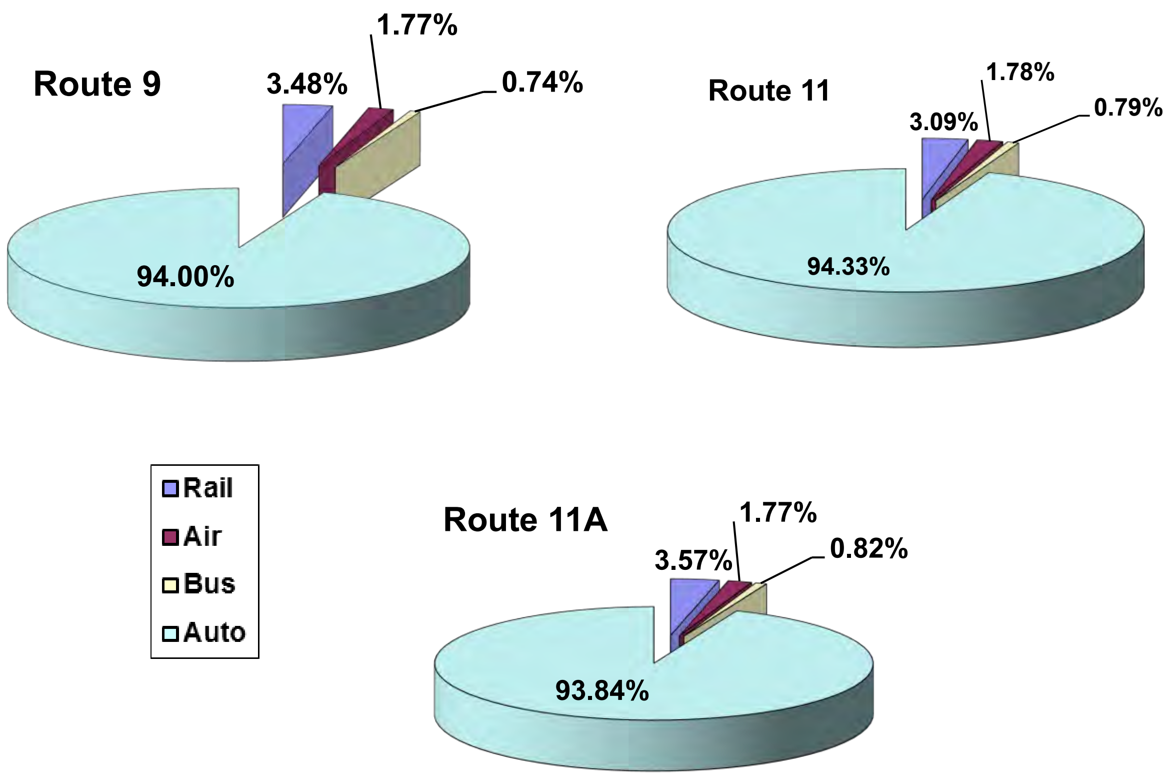
Exhibit 4-10 shows the annual fare-box revenue for years 2020 and 2040. It can be seen that the annual revenue of Route 9 in 2020 is $27.66 million increasing to $37.65 million in 2040. The revenue of Route 11 is $26.34 million in 2020 and $35.91 million in 2040. Route 11A produces $26.86 million annual revenue in 2020 and $36.79 in 2040. The reason that Route 11A has a lower revenue than Route 9 is that it captures extra ridership from St. Paul to Minneapolis who pay only for the short trip, but loses longer distance travellers to Minneapolis from places like Duluth, Superior, North Branch and White Bear Lake due to the circuitry and slowness of the trip to Minneapolis.

Exhibit 4-10: 2010 and 2020 Forecast Revenue (Million 2010 dollars)



The 2020 ridership mode split shares for these three routes is shown in Exhibit 4-11. Auto mode continues to demonstrate its dominance in the corridor for all routes, while rail has 3 to 4 percent market share. However, this is bigger than both air and bus. Among the routes, 11A has higher rail market share than the other two routes, because this route captures extra local trips between St. Paul and Minneapolis. Without the extension to Minneapolis from St. Paul, the volume of trips on Route 11A would be less than that of Route 9.

Exhibit 4-11: 2020 Travel Market Shares



The purpose split of the rail ridership as illustrated in Exhibit 4-12 shows that percentage of each trip purposes are very similar for all three routes. The Other purpose accounts for about 68% of the overall ridership, the Business purpose accounts for about 19%, and the casino accounts for 9%-12%. Route 11A has more commuters than others because it has many short distance commuter trips between Minneapolis and St. Paul.

Exhibit 4-12: 2020 Rail Trip Purpose Breakdown

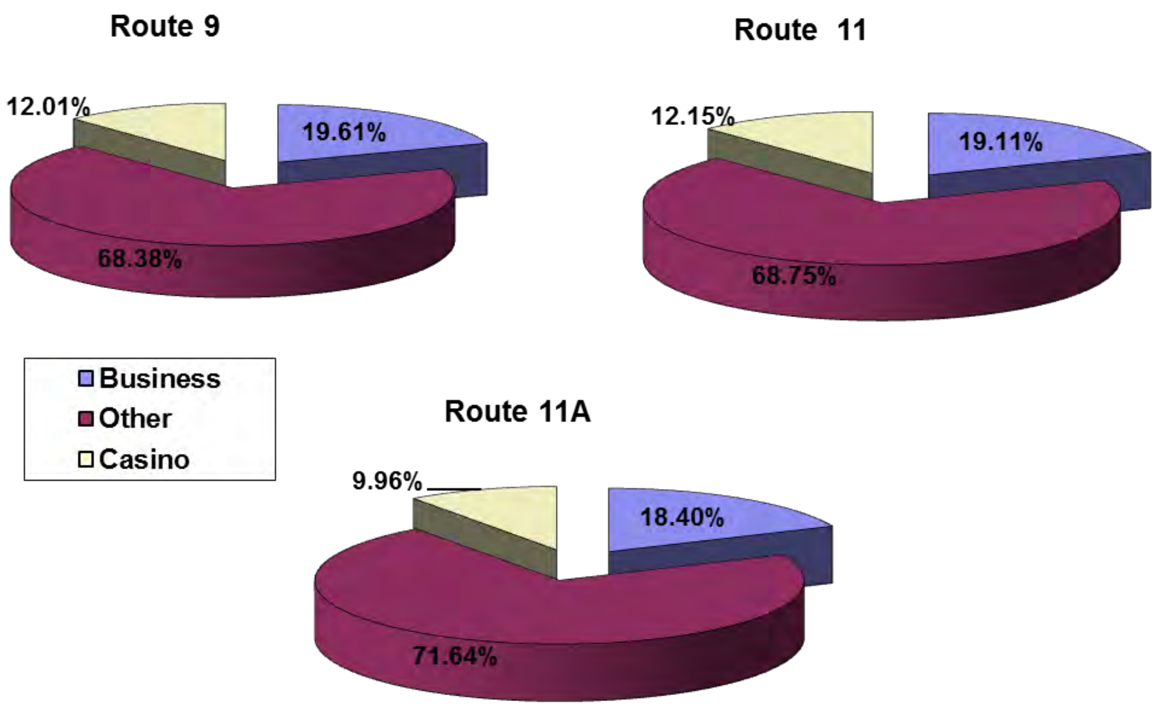
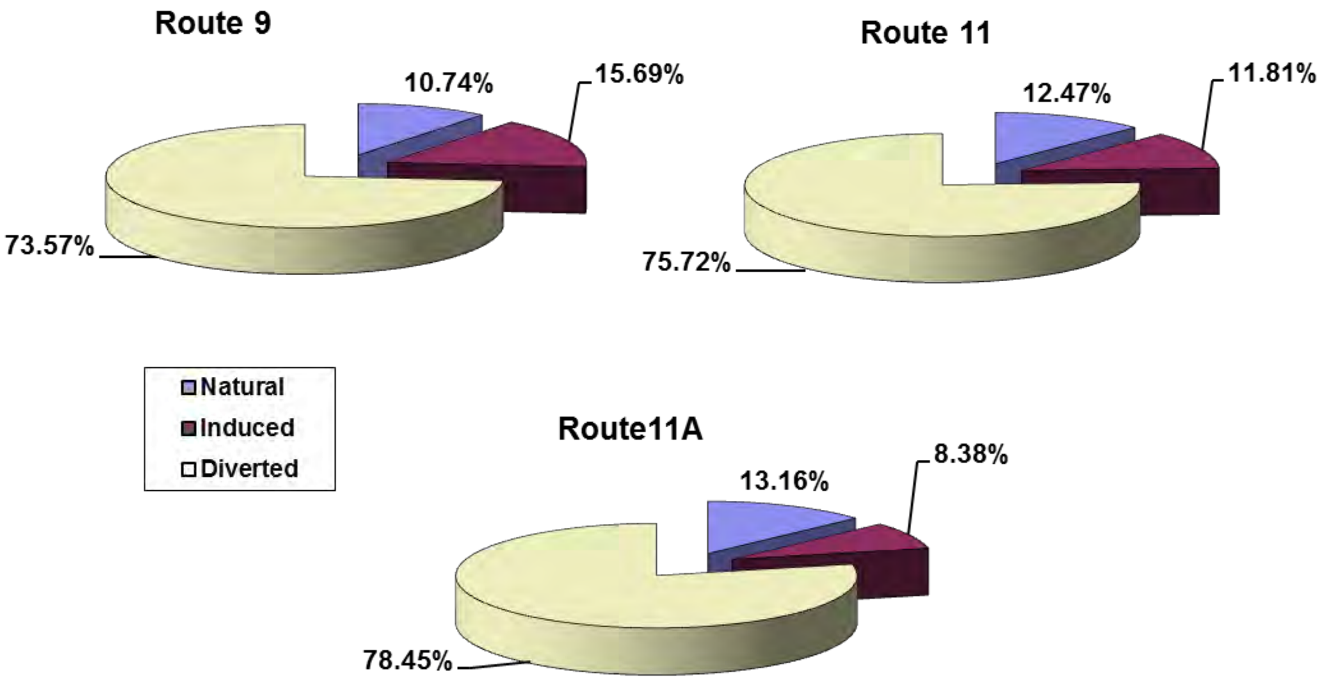


Exhibit 4-13 illustrates the sources of the rail trips of 2020 for three routes. The trips diverted from other modes are the most important source of rail trips, which account for about 75% of overall rail trips. Given the time saving, reasonable choice of station locations and other convenience, Route 9 is for, people living in the corridor, and more attractive than other routes, so it has the highest induced trips. Natural growth accounts for 10-13% percent of the three routes, which is in line with the results of other studies.

Exhibit 4-13: 2020 Sources of Rail Trips

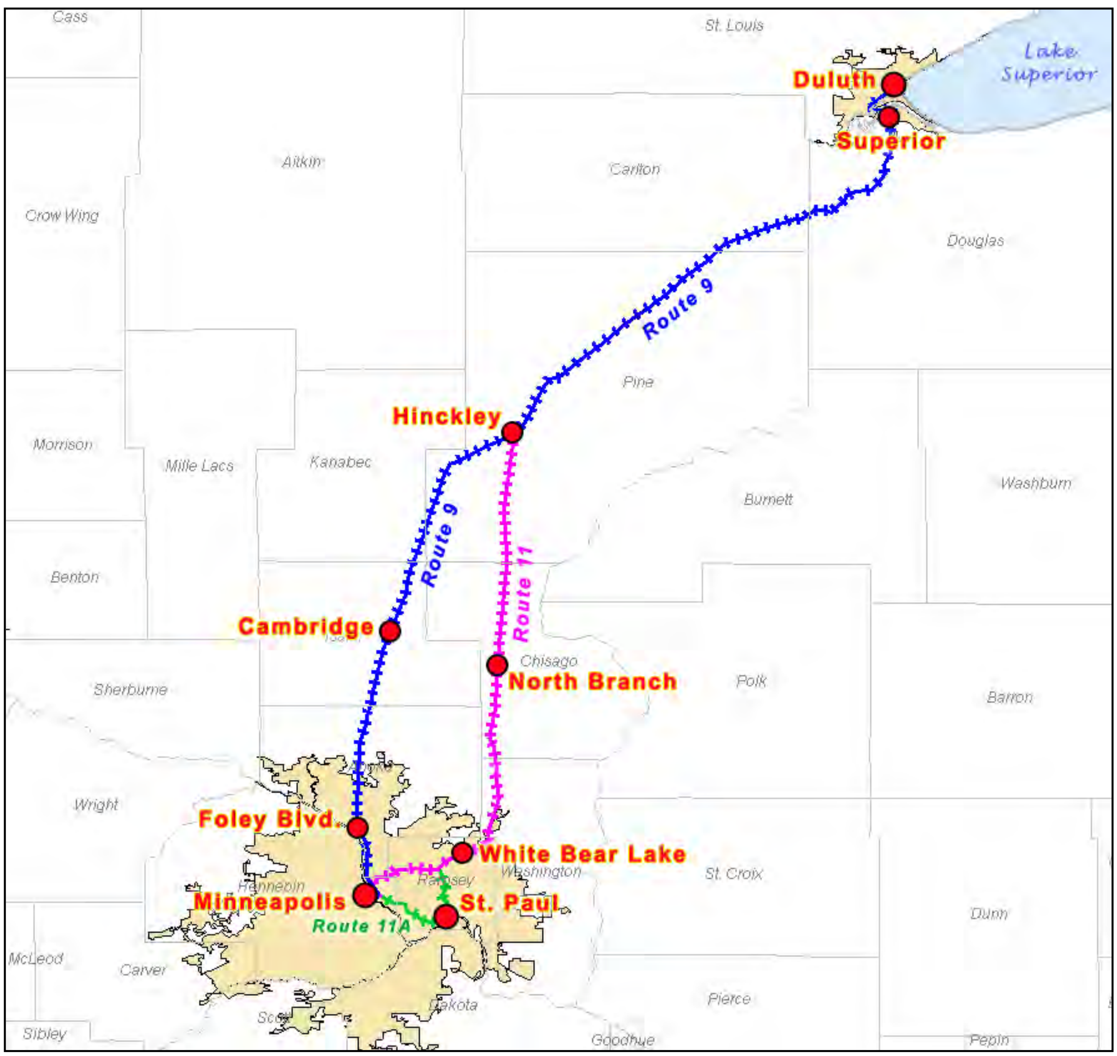


5 CAPITAL INVESTMENT NEEDS

5.1 INTRODUCTION

The study corridor extends from downtown Minneapolis, MN, to Downtown Duluth, MN. The three routes evaluated between the Twin Cities and the Twin Ports includes some multiple track, heavily utilized mainlines and pass several complex junctions as well as major freight marshaling yards, which impact the capital costs of some of the routes. This chapter compares the capital costs of three routes, as shown in Exhibit 5-1. Route 9 (152.9 miles) uses the existing single track BNSF rail line following the Hinckley subdivision the whole way. It is the most direct route. Route 11 (158.1 miles) utilizes an alternative route more closely paralleling I-35 called the "Rush Line". Route 11A (166.2 miles) loops south through St. Paul Union Depot, then follows the Rush Line corridor north to Hinckley. The northern part of the route from Hinckley to Duluth follows the Hinckley subdivision, and is the same for all three routes.

Exhibit 5-1: Minneapolis-Duluth/Superior Rail Corridors



All costs were developed on a consistent basis using 30% Contingency and 24% Soft Costs rates. The same rates were applied to all corridors for comparative purposes, although because of previous studies, more engineering data exists for the Route 9 corridor than for the other two alternatives. As a result, the 30% Contingency rate could possibly be reduced in the future, but this was not reflected in the current analysis.

Details of the field inspection and engineering assessment of the three routes will be described in a report under separate cover. This chapter only presents the summary results that were used as the basis of the Economic Analysis and FRA Cost Benefit screening of the three route alternatives.

All costs were developed on a line segment basis, and then added together to develop the total costs for each route. The segments shown in Exhibit 5-2 were used as the basis for developing the costs:

Exhibit 5-2: Minneapolis-Duluth/Superior Costing Segments

Segment Number	Segment Limits	Segment Length (miles)	Owner
1	Target Field to Minneapolis Junction	1.9	BNSF
2	Minneapolis Junction to University Avenue	1.9	BNSF
3	University Ave to Coon Creek Junction	9.2	BNSF
4	Coon Creek Junction to Isanti	23.6	BNSF
5	Isanti to Cambridge	6.1	BNSF
6	Cambridge to Hinckley	34.9	BNSF
7	University Ave. to Cardigan Junction	8.6	CP
8	Cardigan Junction to Bald Eagle	6.7	CP
9	Bald Eagle to Hugo	4.2	Minnesota Commercial Railway
10	Hugo to North Branch	24.0	Public
11	North Branch to Hinckley	35.5	St. Croix Valley Railway
12	Minneapolis Junction to MN Transfer	3.2	BNSF
13	MN Transfer to Fordson Junction	5.6	Minnesota Commercial Railway / CP
14	Fordson Junction to St. Paul Union Depot	1.5	CP
15	St. Paul Union Depot to Soo Junction	3.0	BNSF
16	Soo Junction to Cardigan Junction	5.3	CP
17	Hinckley to Boylston	60.5	BNSF
18	Boylston to Superior	8.5	BNSF
19	Superior to Duluth	6.3	BNSF

5.2 ROUTE 9 CAPITAL COST EVALUATION

Route 9 follows the existing BNSF route all the way from Minneapolis to Duluth, and consists of segments 1, 2, 3, 4, 5, 6, 17, 18, and 19. Exhibit 5-3 gives a map of the route, and Exhibit 5-4 gives the segment costs, including contingency and soft costs.

Exhibit 5-3: Route 9 Segment Map

Exhibit 5-4: Route 9 Costs by Segment

Segment Number	Segment Limits	Segment Length (miles)	Owner	Segment Cost (1000's)	Cost Per Mile (1000's)
1	Target Field to Minneapolis Junction	1.9	BNSF	$8,221	$4,350
2	Minneapolis Junction to University Avenue	1.9	BNSF	$11,943	$6,319
3	University Ave to Coon Creek Junction	9.2	BNSF	$67,909	$7,357
4	Coon Creek Junction to Isanti	23.6	BNSF	$48,542	$2,059
5	Isanti to Cambridge	6.1	BNSF	$52,156	$8,607
6	Cambridge to Hinckley	34.9	BNSF	$289,338	$8,283
17	Hinckley to Boylston	60.5	BNSF	$190,702	$3,154
18	Boylston to Superior	8.5	BNSF	$68,022	$7,974
19	Superior to Duluth	6.3	BNSF	$84,654	$13,480
Total		**152.9**		**$821,487**	**$5,372.71**

5.3 ROUTE 11 CAPITAL COST EVALUATION

Route 11 follows the BNSF from Minneapolis to University Avenue, CP from University Avenue to Bald Eagle, former Rush Line (segments of which are abandoned) from Bald Eagle to Hinckley, then BNSF the rest of the way into Duluth. It consists of segments 1, 2, 7, 8, 9, 10, 11, 17, 18, and 19. Exhibit 5-5 gives a map of the route, and Exhibit 5-6 gives the segment costs.

Exhibit 5-5: Route 11 Segment Map

Exhibit 5-6: Route 11 Costs by Segment

Segment Number	Segment Limits	Segment Length (miles)	Owner	Segment Cost (1000's)	Cost Per Mile (1000's)
1	Target Field to Minneapolis Junction	1.9	BNSF	$8,221	$4,350
2	Minneapolis Junction to University Avenue	1.9	BNSF	$11,943	$6,319
7	University Ave. to Cardigan Junction	8.6	CP	$224,373	$26,090
8	Cardigan Junction to Bald Eagle	6.7	CP	$66,876	$10,057
9	Bald Eagle to Hugo	4.2	Minnesota Commercial Railway	$208,280	$49,709
10	Hugo to North Branch	24	Public	$217,138	$9,036
11	North Branch to Hinckley	35.5	St. Croix Valley Railway	$282,144	$7,950
17	Hinckley to Boylston	60.5	BNSF	$190,702	$3,154
18	Boylston to Superior	8.5	BNSF	$68,022	$7,974
19	Superior to Duluth	6.3	BNSF	$84,654	$13,480
Total		**158.1**		**$1,362,353**	**$8,617.03**

Route 11A follows the BNSF from Minneapolis to Midway, Minnesota Commercial and CP from Midway to St Paul Union Station, BNSF and CP from Union Station to Bald Eagle, former Rush Line (segments of which are abandoned) from Bald Eagle to Hinckley, then BNSF the rest of the way into Duluth. It consists of segments 1, 12, 13, 14, 15, 16, 8, 9, 10, 11, 17, 18, and 19. Exhibit 5-7 gives a map of the route, and Exhibit 5-8 gives the segment costs.

Exhibit 5-7: Route 11A Segment Map

Exhibit 5-8: Route 11A Costs by Segment

Segment Number	Segment Limits	Segment Length (miles)	Owner	Segment Cost (1000's)	Cost Per Mile (1000's)
1	Target Field to Minneapolis Junction	1.9	BNSF	$8,221	$4,350
12	Minneapolis Junction to Minnesota Transfer	3.2	BNSF	$24,694	$7,717
13	Minnesota Transfer to Fordson Junction	5.6	Minnesota Commercial Railway / CP	$90,486	$16,101
14	Fordson Junction to St. Paul Union Depot	1.5	CP	$47,939	$31,130
15	St. Paul Union Depot to Soo Junction	3.0	BNSF	$90,976	$30,325
16	Soo Junction to Cardigan Junction	5.3	CP	$112,828	$21,450
8	Cardigan Junction to Bald Eagle	6.7	CP	$66,876	$10,057
9	Bald Eagle to Hugo	4.2	Minnesota Commercial Railway	$208,280	$49,709
10	Hugo to North Branch	24.0	Public	$217,138	$9,036
11	North Branch to Hinckley	35.5	St. Croix Valley Railway	$282,144	$7,950
17	Hinckley to Boylston	60.5	BNSF	$190,702	$3,154
18	Boylston to Superior	8.5	BNSF	$68,022	$7,974
19	Superior to Duluth	6.3	BNSF	$84,654	$13,480
Total		**166.2**		**$1,492,960**	**$8,982.91**

5.4 OVERALL CAPITAL COSTS

The infrastructure cost assessment was performed by Quandel Consultants and included only the cost for basic route infrastructure (track, signals, grade crossings, right of way, etc.)

Additional cost for stations was estimated by TEMS to cover the cost for platforms and basic minimal passenger facilities only. Equipment costs for four 200-seat Diesel Multiple Unit trains and a small maintenance support base were also estimated and added to the total. This resulted in a total capital cost for each route alternative as shown in Exhibit 5-9. These overall capital costs were carried forward into the Economic assessment performed in Chapter 8.

Exhibit 5-9: Overall Capital Cost by Route Alternative

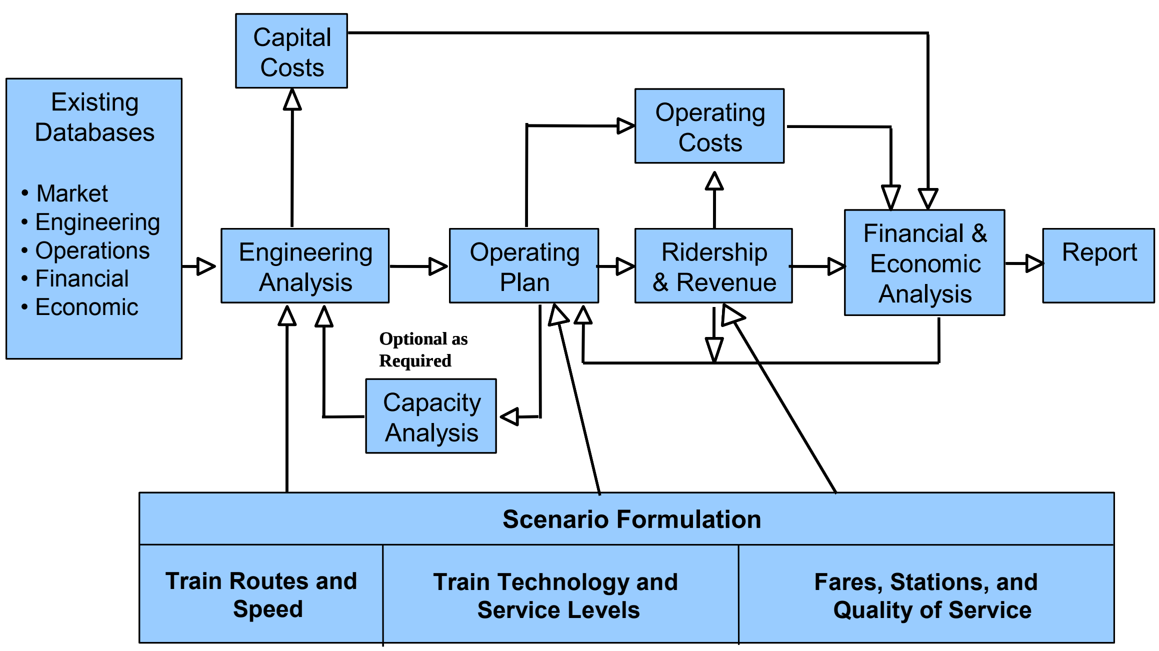
Route	Route Length (miles)	Capital Cost Infrastructure	Stations	Equipment	Total Capital Cost
9	152.9	$821,487	$9,766	$108,100	$939,356
11	158.1	$1,362,353	$9,766	$108,100	$1,480,216
11A	166.2	$1,492,960	$11,271	$108,100	$1,612,331

6 OPERATIONS

6.1 INTRODUCTION

This section describes the key assumptions used to develop the passenger rail service scenarios and operating plans; it identifies potential station locations and provides an assessment of equipment technologies and fleet requirements. The TRACKMAN™, LOCOMOTION™ and COMPASS™ software programs (components of the RightTrack™ software system) are used in an interactive analysis to calculate train travel times, build corridor train schedules, and to recommend train technology and rail system operating strategies. As Exhibit 6-1 shows, the business plan is the final result of an iterative process that requires progressive fine-tuning of the operating strategy, in order to accommodate the specific requirements of travel demand in the study corridor. A key requirement for the analysis is to adjust the train size and frequency levels to appropriately match demand, providing enough capacity while still producing acceptable load factors, and respecting the financial constraints on the operation of the system (e.g., the requirement to produce a positive operating ratio.) The results of the interactive analysis are then used to identify the system operating costs.

Exhibit 6-1: Business Planning Process – Interactive Analysis



6.2 TRAIN SERVICE AND OPERATING ASSUMPTIONS

The objective of the study is to assess the impact of the Route 9, 11 or 11A route alternatives on the economic viability of the proposed Minneapolis-Duluth/Superior Corridor.

Previous studies (in 2000, 2007 and 2009) assessed a whole range of Route 9 speed options from 50-mph up to 125-mph, using rail equipment appropriate for each speed. More recent evaluations included the impact of BNSF Railway requirements for dedicated track for speeds above 90-mph. It was found that the economic performance of the Route 9 corridor was optimized by installing dedicated 110-mph track only from Cambridge/Isanti to Hinckley, shown in Exhibit 6-2, while operating the remainder of the line north of Coon Creek at 90-mph.

This assumption was used as the basis of the current Route 9 evaluation. In addition to providing a speed benefit, this track configuration also optimizes the operational flexibility and capacity of the corridor by locating a high speed double track passing area close to the geographical center of the corridor. As a result, the proposed investment supports both speed and capacity objectives for investment in the corridor.

Exhibit 6-2: Route 9 110-mph/90-mph Evaluated Option

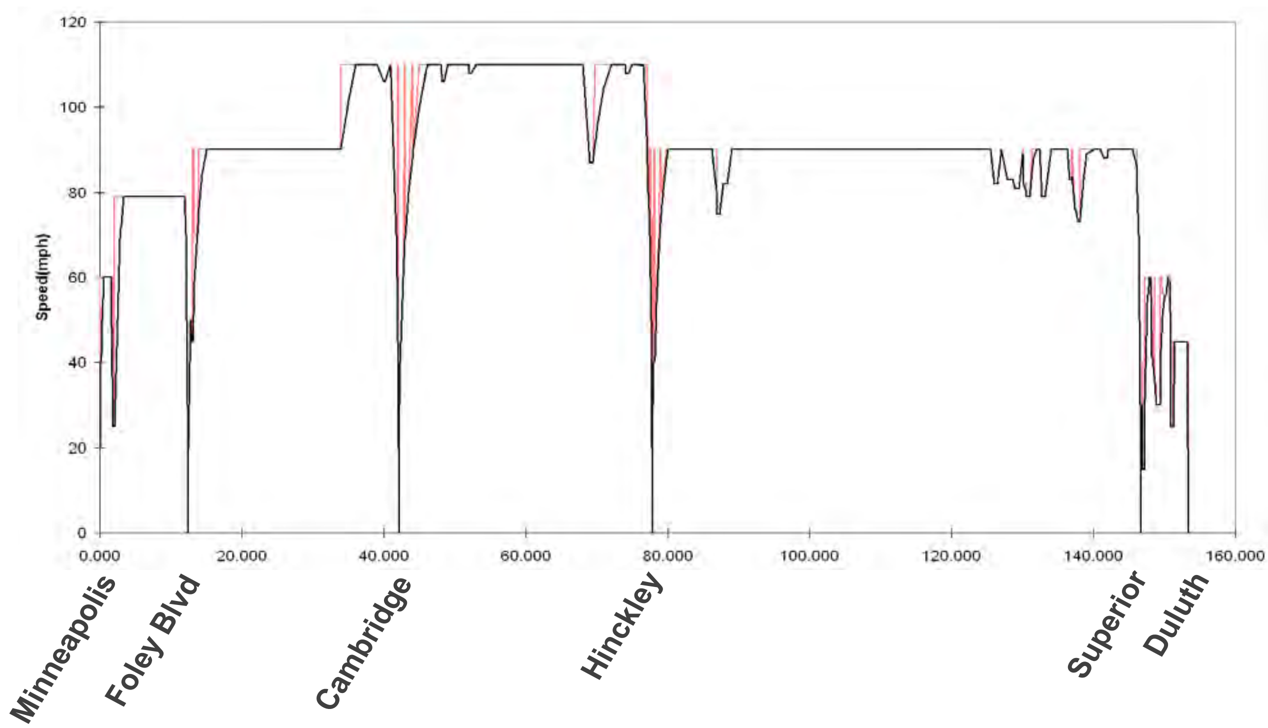
FRA Tier-I Compliant tilting trains as shown in Exhibit 6-3 were assumed. Examples of such trains may include the Midwest Regional Rail System "generic 110-mph train" which was characterized as a Talgo T-21, a locomotive-hauled train, or an equivalent DMU option, characterized as the ICE TD. It should be noted that the earlier MWRRS equipment assessment had already demonstrated that a tilting DMU could exceed the acceleration and braking performance of the T-21. As a result, using the T-21 as a representative generic 110-mph train would develop a conservative schedule.

Exhibit 6-3: "Generic 110-mph Train Options" Represented by Talgo T-21 and Tilting DMU

Talgo T21 | **ICE TD / ACE 3**

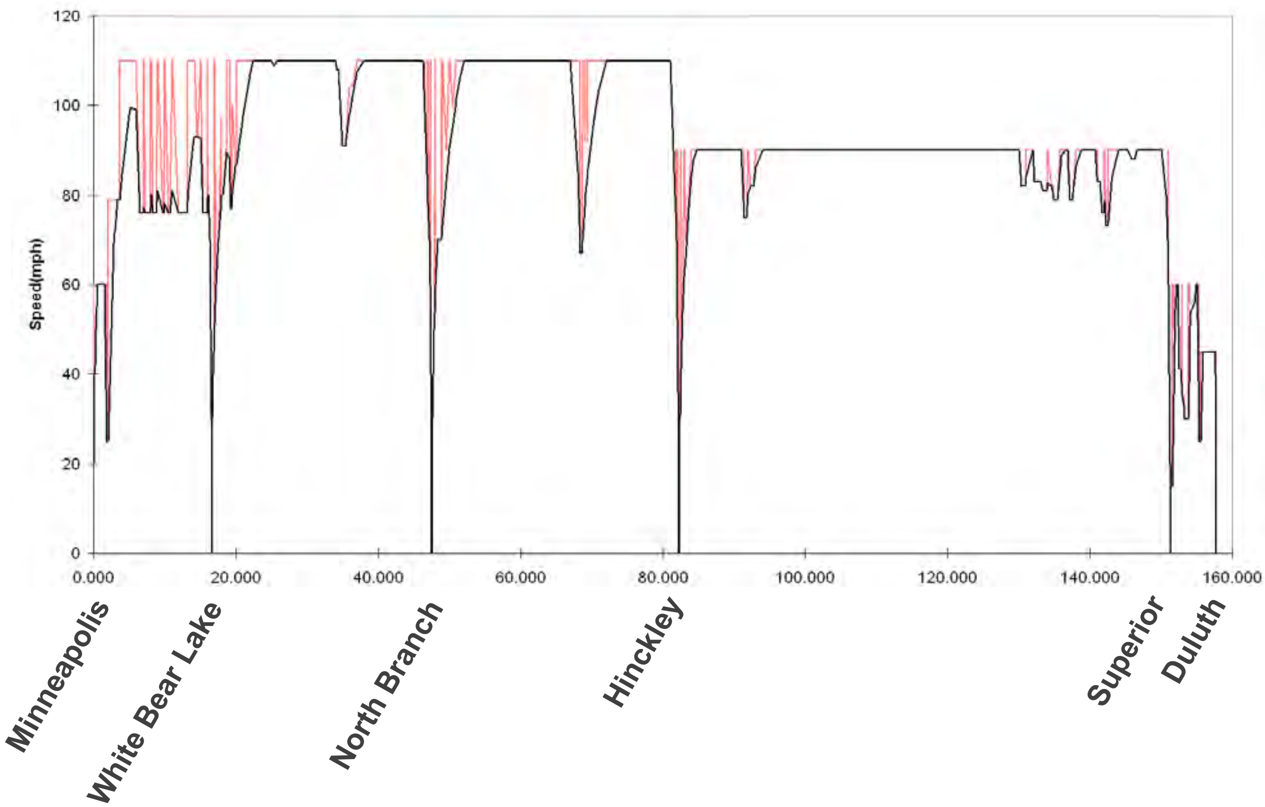
The proposed track configuration for Route 9 as shown in Exhibit 6-2 results in a 2 hour 17 minute timetable, as opposed to an even 2 hour timetable that could be achieved by maximizing the use of 110-mph speeds. The 17 minutes difference is a result of both added running time and added schedule slack time, due to the higher degree of comingling with freight trains that was envisioned under this new scenario. The proposed revised passenger train schedules were submitted to BNSF Railway for the purpose of capacity evaluation, which is still ongoing. The speed profile for the evaluated Route 9 option is shown in Exhibit 6-4.

Exhibit 6-4: Speed Profile – Route 9 – 2:17 Schedule



By comparison, Route 11 that uses the Rush Line, even though the route is a little longer, has the same schedule because a greater distance can be operated at 110-mph speeds, all the way from Bald Eagle Junction all the way north to Hinckley. Since the track has to be rebuilt anyway and there are only a few local freight trains, there is little advantage to limiting the train speed to 90-mph. It was assumed that this route would operate at 110-mph north of Bald Eagle Junction. The speed profile for Route 11, also resulting in a 2:17 schedule, is shown in Exhibit 6-5.

Exhibit 6-5: Speed Profile – Route 11 – 2:17 Schedule



Route 11 has the same number of station stops as does Route 9. White Bear Lake replaces Foley Boulevard, and North Branch replaces the Cambridge stop. With two stations, the Route 11 schedule is the same as the Route 9 schedule. This treatment optimizes the economic performance of both Routes 9 and 11 given the current ridership forecast (that does not include the Hinckley casino.) However:

- It is unlikely that the Route 11 timetable could be further improved because all tracks that are geometrically able to support 110-mph speeds are being operated at that speed.
- In contrast, the Route 9 timetable could be further reduced by adding more dedicated track. As a result the Route 9 timetable in the current assessment does not reflect the ultimate technical potential of the route, but still leaves room for improvements in the future.

Exhibit 6-6 shows that including St Paul Union Depot adds considerable circuity to the Minneapolis-Duluth routing. Route 11A via St Paul is 8 miles longer than Route 11, and 13 miles longer than Route 9, which provides the most direct routing option between the two cities. In addition, Route 11A segments are owned by multiple railroads, so the operation of this route will be challenging because of the need for multiple dispatching handoffs, geometric constraints limiting speeds, and freight train congestion in St Paul (particularly around Hoffman Avenue interlocking and from St Paul up to Cardigan Junction.) The speed profile for Route 11A is shown in Exhibit 6-7 and results in a 2:41 schedule. Route 11A suffers a time penalty not only from the added distance but from the added station stop. Running Minneapolis trains to Duluth via St Paul extends the schedule to the point where the end-to-end service is no longer auto time-competitive.

Exhibit 6-6: Rail Alignment Routes in the Twin Cities

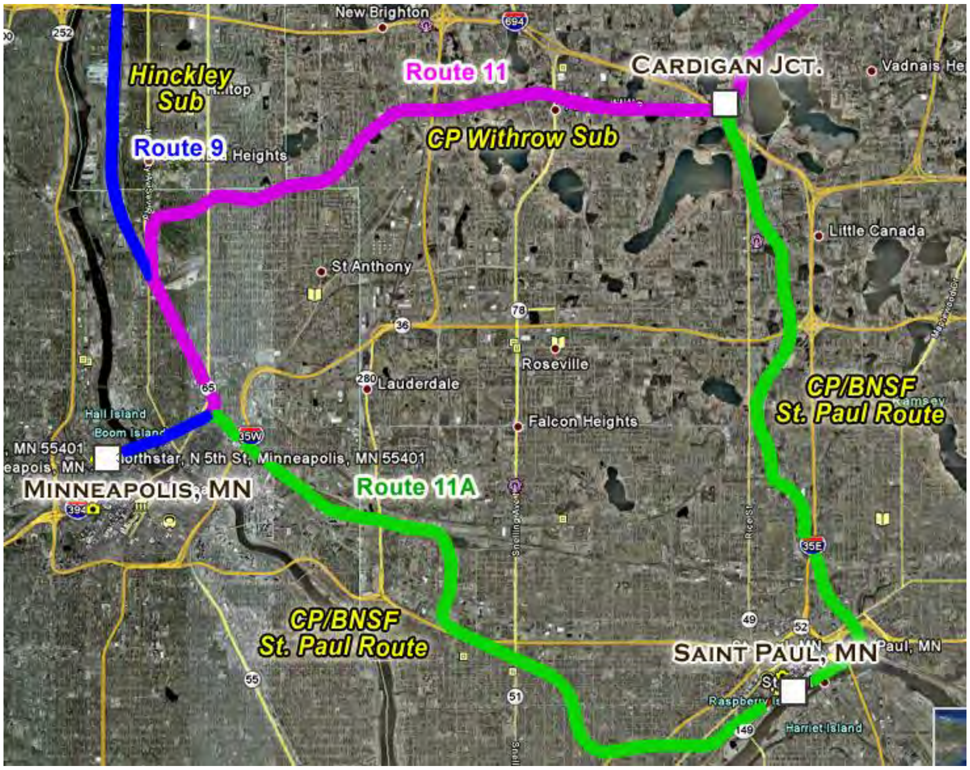
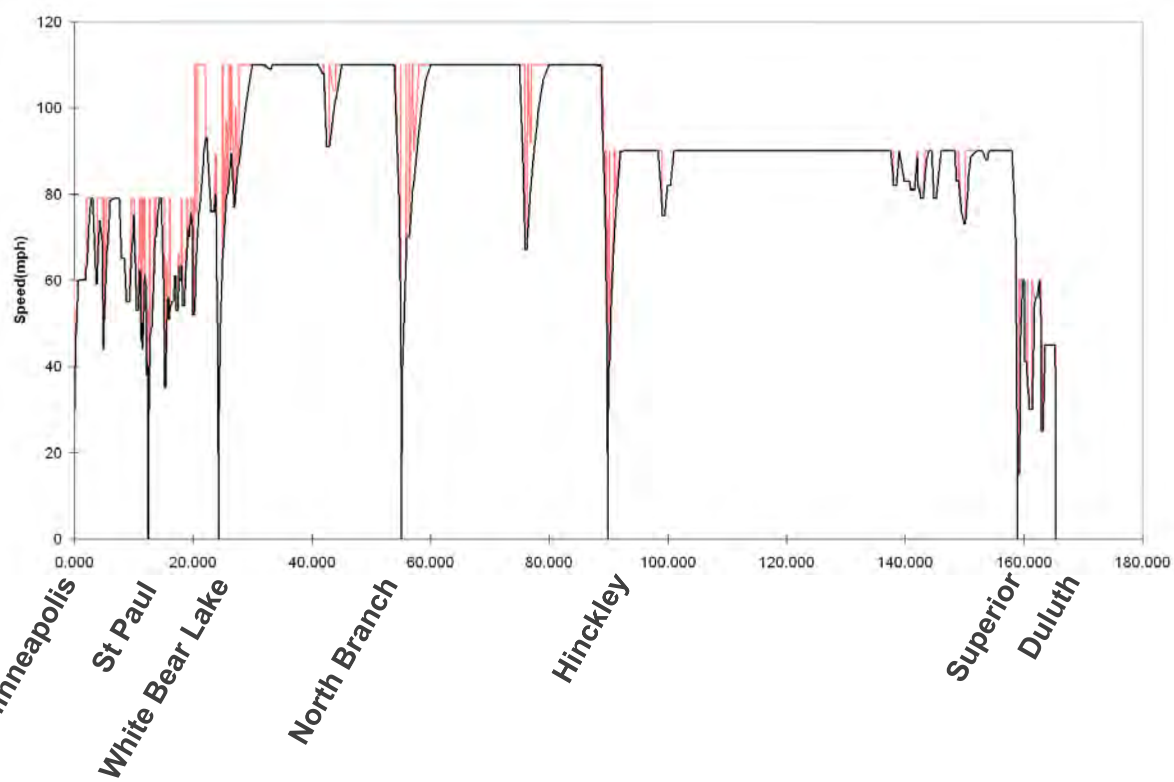


Exhibit 6-7: Speed Profile – Route 11A – 2:41 Schedule

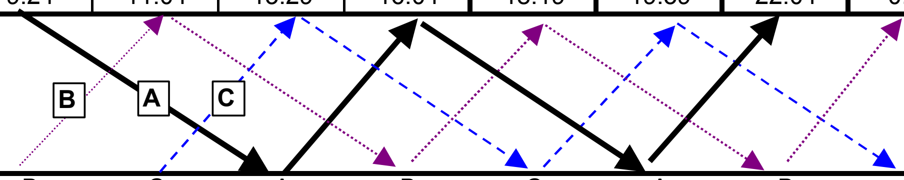


6.3 TRAIN SCHEDULING AND FLEET REQUIREMENTS

Detailed train schedules have been developed and submitted to the BNSF Railway for inclusion in their capacity assessment of the Route 9 corridor. These are shown in Exhibit 6-8 and a time distance diagram is shown in Exhibit 6-9. Equivalent schedules for Route 11 and 11A are shown in Exhibits 6-10 and 6-11. Most train meets are centered in the long double track segment between Cambridge and Hinckley; but many passenger train meets also need to occur in the double track areas just south of Superior and around Foley Boulevard. As a result, there are three areas where passenger train meets need to occur, two of them in existing double track sections and one utilizing the proposed new dedicated double track section. The schedules were developed using a three-train active fleet rotation (a fourth train held for equipment protections and maintenance reserve) with train meets only in double track areas (not in freight sidings) and also avoiding North Star commuter train slots.

Exhibit 6-8: Route 9 – Proposed Timetable

Trainset	A	B	C	A	B	C	A	B
Northbound	***#7000***	***#7002***	***#7004***	***#7006***	***#7008***	***#7010***	***#7012***	***#7014***
MTI	7:05	8:45	11:10	13:35	16:00	17:20	19:45	22:10
Foley Blvd	7:20	9:00	11:25	13:50	16:15	17:35	20:00	22:25
Cambridge	7:46	9:26	11:51	14:16	16:41	18:01	20:26	22:51
Hinckley	8:12	9:52	12:17	14:42	17:07	18:27	20:52	23:17
Sandstone	-	-	-	-	-	-	-	-
Superior	9:11	10:51	13:16	15:51	18:06	19:26	21:51	0:16
Duluth Depot	9:24	11:04	13:29	16:04	18:19	19:39	22:04	0:29



Trainset	B	C	A	B	C	A	B	C
Southbound	***#7003***	***#7005***	***#7007***	***#7009***	***#7011***	***#7013***	***#7015***	***#7017***
Duluth Depot	5:10	6:30	10:35	13:00	14:00	16:35	19:10	21:35
Superior	5:25	6:45	10:50	13:15	14:15	16:50	19:25	21:50
Sandstone	-	-	-	-	-	-	-	-
Hinckley	6:23	7:43	11:48	14:13	15:13	17:58	20:23	22:48
Cambridge	6:51	8:11	12:16	14:41	15:41	18:26	20:51	23:16
Foley Blvd	7:17	8:37	12:42	15:07	16:07	18:52	21:17	23:42
MTI	7:30	8:50	12:55	15:20	16:20	19:05	21:30	23:55

Equipment Rotations:
Train A: 7000,7007,7006,7013,7012 Starts at MTI, Ends at Duluth
Train B: 7003,7002,7009,7008,7015,7014 Starts at Duluth, Ends at Duluth
Train C: 7005,7004,7011,7010,7017 Starts at Duluth, Ends at MTI

1) #7011 need to get equipment back into Minneapolis as quickly as possible for evening rush, this is a lightly used midday departure so meet opposing train #7006 (delaying #7006) in freight siding north of Sandstone.
2) #7008 is advanced to meet peak hour capacity requirement must meet opposing #7013 in freight sidings north of Sandstone; delay opposing #7013 which will be less heavily loaded
3) Schedules of #7003 and #7010 have to be slotted in between Northstar Commuter Trains

Schedule Locked due to Northstar Slot (green)

Meet Point with opposing NLX Train (yellow)

Exhibit 6-9: Route 9 - Time Distance Diagram

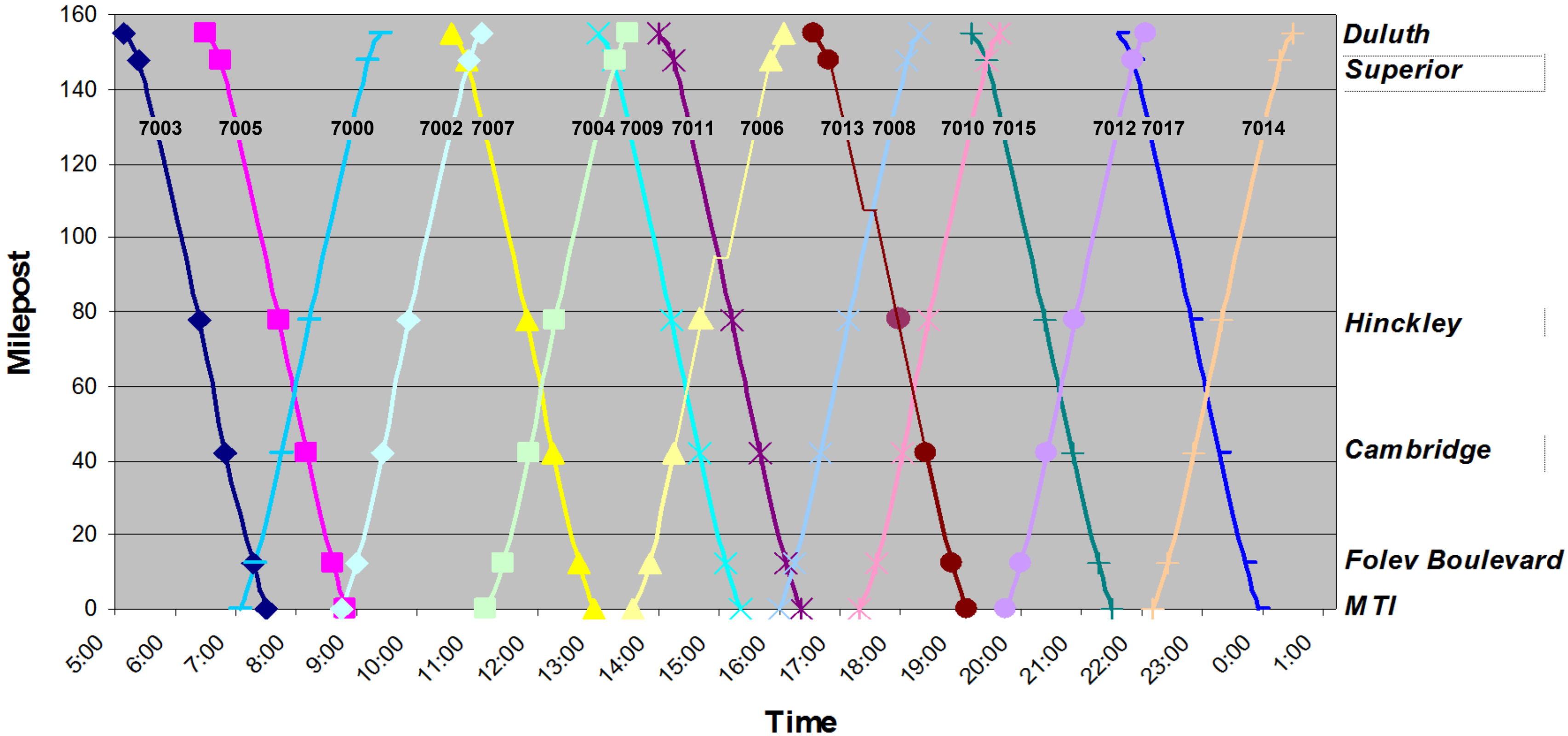


Exhibit 6-10: Route 11 - Proposed Timetable

Trainset								
Northbound	***#7000***	***#7002***	***#7004***	***#7006***	***#7008***	***#7010***	***#7012***	***#7014***
MTI	7:05	8:45	11:10	13:35	16:00	17:20	19:45	22:10
White Bear	7:20	9:00	11:25	13:50	16:15	17:35	20:00	22:25
North Branch	7:46	9:26	11:51	14:16	16:41	18:01	20:26	22:51
Hinckley	8:12	9:52	12:17	14:42	17:07	18:27	20:52	23:17
Sandstone	-	-	-	-	-	-	-	-
Superior	9:11	10:51	13:16	15:51	18:06	19:26	21:51	0:16
Duluth Depot	9:24	11:04	13:29	16:04	18:19	19:39	22:04	0:29

Trainset								
Southbound	***#7003***	***#7005***	***#7007***	***#7009***	***#7011***	***#7013***	***#7015***	***#7017***
Duluth Depot	5:10	6:30	10:35	13:00	14:00	16:35	19:10	21:35
Superior	5:25	6:45	10:50	13:15	14:15	16:50	19:25	21:50
Sandstone	-	-	-	-	-	-	-	-
Hinckley	6:23	7:43	11:48	14:13	15:13	17:58	20:23	22:48
North Branch	6:51	8:11	12:16	14:41	15:41	18:26	20:51	23:16
White Bear	7:17	8:37	12:42	15:07	16:07	18:52	21:17	23:42
MTI	7:30	8:50	12:55	15:20	16:20	19:05	21:30	23:55

Exhibit 6-11: Route 11A – Proposed Timetable

Trainset								
Northbound	***#7000***	***#7002***	***#7004***	***#7006***	***#7008***	***#7010***	***#7012***	***#7014***
MTI	6:42	8:22	10:47	13:12	15:37	16:57	19:22	21:47
St. Paul	7:01	8:41	11:06	13:31	15:56	17:16	19:41	22:06
White Bear	7:20	9:00	11:25	13:50	16:15	17:35	20:00	22:25
North Branch	7:46	9:26	11:51	14:16	16:41	18:01	20:26	22:51
Hinckley	8:12	9:52	12:17	14:42	17:07	18:27	20:52	23:17
Sandstone	-	-	-	-	-	-	-	-
Superior	9:11	10:51	13:16	15:51	18:06	19:26	21:51	0:16
Duluth Depot	9:24	11:04	13:29	16:04	18:19	19:39	22:04	0:29

Trainset								
Southbound	***#7003***	***#7005***	***#7007***	***#7009***	***#7011***	***#7013***	***#7015***	***#7017***
Duluth Depot	5:10	6:30	10:35	13:00	14:00	16:35	19:10	21:35
Superior	5:25	6:45	10:50	13:15	14:15	16:50	19:25	21:50
Sandstone	-	-	-	-	-	-	-	-
Hinckley	6:23	7:43	11:48	14:13	15:13	17:58	20:23	22:48
North Branch	6:51	8:11	12:16	14:41	15:41	18:26	20:51	23:16
White Bear	7:17	8:37	12:42	15:07	16:07	18:52	21:17	23:42
St. Paul	7:36	8:56	13:01	15:26	16:26	19:11	21:36	0:01
MTI	7:55	9:15	13:20	15:45	16:45	19:30	21:55	0:20

In terms of a requirement for Route 11 or 11A infrastructure, it is clear that there would be a need for constructing passing areas to mirror the equivalent facilities on the Route 9 side, in particular, two 10-mile double track zones:

- A northern passing area between North Branch and Hinckley would replace the passing capability provided by the Cambridge/Isanti to Hinckley dedicated track, but would not need to be as long;
- A southern passing area between Hugo and Cardigan Junction would accommodate train meets that would otherwise occur in the Foley Boulevard areas.

This assumes that the ability to meet passenger trains in the double track area south of the Superior station would not be changed.

The requirement for these two passing areas for passenger train meets was included in the development of cost estimates for Routes 11 and 11A. The ability to meet passenger trains would be further enhanced by the proposed double tracking of the CP Withrow Subdivision (for Route 11) and of the Minneapolis Junction to St Paul Union Depot line (for Route 11A.) Although these double tracked areas could be used for occasional passenger train meets, because those capacity enhancements were primarily intended to protect freight train needs, no passenger train meets have been intentionally scheduled to occur in these areas.

In should be noted that Routes 11 and 11A need extensive 110-mph dedicated track from Bald Eagle Junction to Hinckley, including not only the mainline mileage, but also 20 additional miles of high-speed double track for allowing running meets between passenger trains. The maintenance responsibility for this track will be the sole responsibility of passenger service.

It contrast, Route 9 primarily co-mingles with BNSF freight trains at 90-mph. Passenger trains will have to bear the full responsibility for the difference in cost for raising the track class to FRA Class V, but gets to share the base track maintenance cost with the freight trains. On Route 9, passenger service has to pay only for the single dedicated track added between Cambridge/Isanti and Hinckley, not for the full length of the route. As a result it can be seen that the track maintenance cost will be much lower for Route 9 than for the Route 11 or 11A alternatives. The approach to track maintenance costing will be discussed again in more detail in the Operating Costs chapter.

7 OPERATING COSTS

This chapter describes the various costs associated with operating a Minneapolis to Duluth passenger rail service. Operating costs are categorized as variable or fixed:

- **Variable or Direct costs** change with the volume of activity and are directly dependent on ridership, passenger miles or train miles. For each variable cost, a principal cost driver is identified and used to determine the total cost of that operating variable. An increase or decrease in any of these will directly drive operating costs higher or lower.
- **Fixed costs** are generally predetermined, but may be influenced by external factors, such as the volume of freight tonnage or may include a relatively small component of activity-driven costs. As a rule, costs identified as fixed should remain stable across a broad range of service intensities. Within fixed costs are two sub-categories:
  - **Route** costs such as track maintenance and station expense that, although fixed, can still be clearly identified at the route level.
  - **Overhead or System** costs such as headquarters management, call center, accounting, legal, and other corporate fixed costs that are shared across routes or even nationally. A portion of overhead cost (such as direct line supervision) may be directly identifiable but most of the cost is fixed. Accordingly, assignment of such costs becomes an allocation issue that raises equity concerns. These kinds of fixed costs are handled separately.

Operating costs were developed based on the following premises:

- Results of recent studies, a variety of sources including suppliers, current operators' histories, testing programs and prior internal analysis from other passenger corridors were used to develop the cost data. However, as the rail service is implemented, actual costs will be subject to negotiation between the passenger rail authority and the contract rail operator(s).
- Freight railroads will maintain the track and right-of-way, but ultimately, the actual cost of track maintenance will be resolved through negotiations with the railroads. For this study a track maintenance cost model was used that reflects actual freight railroad cost data.
- Maintenance of train equipment will be contracted out to the equipment supplier.
- Train operating practices follow existing work rules for crew staffing and hours of service. Operating expenses for train operations, crews, management and supervision were developed through a bottoms-up staffing approach based on typical passenger rail organizational needs.

The costing approach originally developed for the Midwest Regional Rail System (MWRRS) was adapted for use in this study. Following the MWRRS methodology, nine specific cost areas were applicable to this study.[1] As shown in Exhibit 7-1, variable costs include equipment maintenance, energy and fuel, train and onboard (OBS) service crews, and insurance liability. Ridership influences marketing, sales and station costs. Fixed costs include administrative costs, and track and right-of-way maintenance costs. The MWRRS cost model was updated to reflect current 2010 costs.

[1] This corridor has no planned feeder bus services for which the rail service is financially responsible, and the treatment of operator profit will be discussed in parallel to Service Administration.

Exhibit 7-1: Cost Categories and Primary Drivers

Drivers	Cost Categories
Train Miles	*Equipment Maintenance* *Energy and Fuel* *Train and Engine Crews* *Onboard Service Crews*
Passenger Miles	*Insurance Liability*
Ridership and Revenue	*Sales and Marketing* *Ridership*
Fixed Cost	*Service Administration* *Track and ROW Maintenance* *Station Costs*

The MWRRS costing framework was developed in conjunction with nine states that comprised the MWRRS steering committee and with Amtrak. In addition, freight railroads, equipment manufacturers and others provided input to the development of the costs. The original concept for the MWRRS was for development of a new service based on operating methods directly modeled after state-of-the-art European rail operating practice. Along with anticipated economies of scale, modern train technology could reduce operating costs when compared to existing Amtrak practice. In the original 2000 MWRRS Plan, European equipment costs were measured at 40 percent of Amtrak's costs. However, in the final MWRRS plan that was released in 2004, train-operating costs were significantly increased to a level that is more consistent with Amtrak's current cost structure. However, adopting an Amtrak cost structure for Minneapolis to Duluth financial planning does not suggest that Amtrak would actually be selected for the corridor operation. Rather, this selection increases the flexibility for choosing an operator without excluding Amtrak, because multiple operators and vendors will be able to meet the broader performance parameters provided by this conservative approach.

The analysis was conducted using 2010 constant dollars.

7.1 MINNEAPOLIS-DULUTH/SUPERIOR CORRIDOR – VARIABLE OR DIRECT COSTS

7.1.1 TRAIN EQUIPMENT MAINTENANCE

Equipment maintenance costs include all costs for spare parts, labor and materials needed to keep equipment safe and reliable. The costs include periodical overhauls in addition to running maintenance. It also assumes that facilities for servicing and maintaining equipment are designed specifically to accommodate the selected train technology. This arrangement supports more efficient and cost-effective maintenance practices. Acquiring a large fleet of trains with identical features and components, allows for substantial savings in parts inventory and other economies of scale. In particular, commonality of rolling stock and other equipment will standardize maintenance training, enhance efficiencies and foster broad expertise in train and system repair.

The MWRRS study developed a cost of $9.87 per train mile for a 300-seat train in 2002 dollars, or applying an 18% inflation cost adjustment, $11.67 in 2010 dollars. Before this figure could be used for the Duluth corridor, however, it must be adjusted to reflect the smaller 200-seat train that will be used in the early years of the system. Data provided by equipment manufacturers at the original MWRRI 1999 equipment symposium was used to calculate these adjustments. The smaller (locomotive hauled) 200-seat train was estimated to cost $8.95 per train mile in 2002 dollars, or $10.58 in 2010 dollars.

The available evidence suggests that the maintenance cost for a 300-seat DMU would be about the same as for a Talgo T21, but for smaller trains DMU costs scale more directly to seating capacity. Accordingly the DMU maintenance cost for a 200-seat train was estimated as two-thirds of the cost for a 300-seat train. With the economies of scale, inflation and train size adjustments, this would come to $7.78 per train mile in 2010 dollars for a DMU, as compared to $10.58 for a locomotive hauled train. The DMU cost was used in this assessment. It can be seen that the DMU is substantially more cost effective for smaller trains, and because of its greater flexibility, it allows closer matching of seating capacity to travel demand.

7.1.2 TRAIN AND ENGINE CREW COSTS

Crew costs are those costs incurred by the onboard train operating crew. The operating crew consists of an engineer, a conductor and an assistant conductor and is subject to federal Hours of Service regulations. Costs for the crew include salary, fringe benefits, training, overtime and additional pay for split shifts and high mileage runs. An overtime allowance is included as well as scheduled time-off, unscheduled absences and time required for operating, safety and passenger handling training. Fringe benefits include health and welfare, FICA and pensions. The cost of employee injury claims under FELA is also treated as a fringe benefit for this analysis. The overall fringe benefit rate was calculated as 55 percent. In addition, an allowance was built in for spare/reserve crews on the extra board. The costing of train crews was based on Amtrak's 1999 labor agreement, adjusted for inflation to 2010.

Crew costs depend upon the level of train crew utilization, which is largely influenced by the structure of crew bases and any prior agreements on staffing locations. Train frequency strongly influences the amount of held-away-from-home-terminal time, which occurs if train crews have to stay overnight in a hotel away from their home base. Since train schedules have continued to evolve throughout the lifetime of this study and a broad range of service frequencies and speeds have been evaluated, a parametric approach was needed to develop a system average per train mile rate for crew costs. Such an average rate necessarily involves some approximation, but to avoid having to reconfigure a detailed crew-staffing plan whenever the train schedules change, an average rate is necessary and appropriate for a planning-level study.

In the previous Ohio Hub study, crew costs varied from $3.42 per train mile for efficient round trips with no need for overnight accommodations, up to $3.94 per train mile if some overnight layovers are required (consistent with the MWRRS result) and rising to $6.60 per train mile because of extremely poor crew utilization in some of the start-up scenarios. For this study, an intermediate value inflated to 2010 of $4.66 per train mile was chosen.

7.1.3 FUEL AND ENERGY

A consumption rate of 2.42 gallons/mile was estimated for a 110-mph 300-seat train, based upon nominal usage rates of all three technologies considered in Phase 3 of the MWRRS Study. In the MWRRS plan, a diesel fuel cost of $0.96 per gallon led to a train mile rate of $2.32 per train mile for a 110-mph 300-seat train (in 2002 dollars). For each scenario, fuel costs were raised to reflect the fuel cost increases described in the Department of Energies' Central Case Fuel Projections. However, for smaller trains, DMU fuel costs scale down more proportionately than they do for locomotive-hauled trains so the fuel cost per train mile would be $1.56 (in 2002 dollars). A cost of $2.63 per train mile was used in this analysis, reflecting a roughly 68% increase in the cost of fuel.

7.1.4 ONBOARD SERVICES (OBS)

Onboard service (OBS) costs are those expenses for providing food service onboard the trains. OBS adds costs in three different areas: equipment, labor and cost of goods sold. Equipment capital and operating cost is built into the cost of the trains and is not attributed to food catering specifically. However, the Duluth corridor study assumes none of the small 200-seat trains will have a dedicated dining or bistro car. Instead, an OBS employee or food service vendor would move through the train with a trolley cart, offering food and beverages for sale to the passengers. In the future, larger 300-seat trains may be able to provide as an enhancement a small walk-up café area where the attendant works when not passing through the train with the trolley cart.

The goal of the OBS franchising should be to ensure a reasonable profit for the provider of on-board services, while maintaining a reasonable and affordable price structure for passengers. The key to attaining OBS profitability is selling enough products to recover the train mile related labor costs. If small 200-seat trains are used for start-up, given the assumed OBS cost structure, even with a trolley cart service the OBS operator will be challenged to attain profitability. However, the expanded customer base on larger 300-seat trains can provide a slight positive operating margin for OBS service.

In practice, it is difficult for a bistro-only service to sell enough food to recover its costs. Bistro-only service may cover its costs in Amtrak's northeast corridor that operates very large trains, but it will be difficult to scale down this business model to the Duluth corridor that will, by necessity, operate much smaller 200 to 300-seat trains. While only a limited menu can be offered from a cart, the ready availability of food and beverages at the customer's seat is a proven strategy for increasing sales. Many customers appreciate the convenience of a trolley cart service and are willing to purchase food items that are brought directly to them. While some customers prefer stretching their legs and walking to a bistro car, other customers will not bother to make the trip.

The cost of goods sold is estimated as 50 percent of OBS revenue, based on Amtrak's route profitability reports. Labor costs, including the cost of commissary support and OBS supervision, have been estimated at $1.81 per train mile. This cost is consistent with Amtrak's level of wages and staffing approach for conventional bistro car services. However, this Business Plan recommends that an experienced food service vendor provide food services and use a trolley cart approach.

A key technical requirement for providing trolley service is to ensure the doors and vestibules between cars are designed to allow a cart to easily pass through. Since trolley service is a standard feature on most European railways, most European rolling stock is designed to accommodate the carts. Although convenient passageways often have not been provided on U.S. equipment, the ability to support trolley carts is an important equipment design requirement for the planned service.

7.1.5 INSURANCE COSTS

Liability costs were estimated at 1.3¢ per passenger-mile, the same rate that was assumed in the earlier MWRRS study brought to 2010 dollars. In 2025, for example, insurance is projected to cost nearly $1.35 million a year, and this expense continues to go up as ridership rises. Federal Employees Liability Act (FELA) costs are not included in this category but are applied as an overhead to labor costs.

The Amtrak Reform and Accountability Act of 1997 (§161) provides for a limit of $200 million on passenger liability claims. Amtrak carries that level of excess liability insurance, which allows Amtrak to fully indemnify the freight railroads in the event of a rail accident. This insurance protection has been a key element in Amtrak's ability to secure freight railroad cooperation. In addition, freight railroads perceive that the full faith and credit of the United States Government is behind Amtrak, while this may not be true of other potential passenger operators. A General Accounting Office (GAO) review[2] has concluded that this $200 million liability cap applies to commuter railroads as well as to Amtrak. If the GAO's interpretation is correct, the liability cap may also apply to potential Duluth corridor franchisees. If this liability limitation were in fact available to potential franchisees, it would be much easier for any operator to obtain insurance that could fully indemnify a freight railroad at a reasonable cost.

7.2 MINNEAPOLIS-DULUTH/SUPERIOR CORRIDOR - ROUTE FIXED COSTS

7.2.1 TRACK AND RIGHT-OF-WAY COSTS

Currently, it is industry practice for passenger train operators providing service on freight-owned rights-of-way to pay for track access, dispatching and track maintenance. The rates for all of these activities will ultimately be based upon a determination of the appropriate costs that result from negotiations between the parties. The purpose here is to provide estimates based on the best available information; however, it is important to recognize that this Study is a feasibility-level analysis and that as the project moves forward, additional study and discussions with the railroads will be needed to further refine these costs. Both capital and operating costs will be estimated.

To accommodate passenger trains on the Minneapolis to Duluth rail line, the corridor requires a substantial increase in capacity. Once constructed, these improvements will need to be maintained to FRA standards required for reliable and safe operations. The costing basis assumed in this report is that of *incremental* or *avoidable* costs. Avoidable costs are those that are eliminated or saved if an activity is discontinued. The term *incremental* is used to reference the change in costs that results from a management action that increases volume, whereas *avoidable* defines the change in costs that results from a management action that reduces volume. Following the same standard that was established for the MWRRS, the following cost components were included within the Track and Right-of-Way category:

- **Track Maintenance Costs.** Costs for track maintenance were estimated based on Zeta-Tech's January 2004 draft technical monograph *Estimating Maintenance Costs for Mixed High-Speed Passenger and Freight Rail Corridors*.[3] However, Zeta-Tech's costs are conceptual and are still subject to negotiation with the freight railroads.
- **Dispatching Costs and Out-of-Pocket Reimbursement.** Passenger service must also reimburse a freight railroad's added costs for dispatching its line, providing employee efficiency tests and for performing other services on behalf of the passenger operator. These costs are included as an additive to Track and Right-of-Way Maintenance costs.
- **Costs for Access to Track and Right-of-Way.** Access fees, particularly train mile fees incurred as an operating expense, are specifically excluded from this calculation. Any such payments would have to be calculated and negotiated on a route-specific and railroad-specific basis. Such a calculation would have to consider the value of the infrastructure improvements made to the corridor for balancing up-front capital with ongoing operating payments.[4]

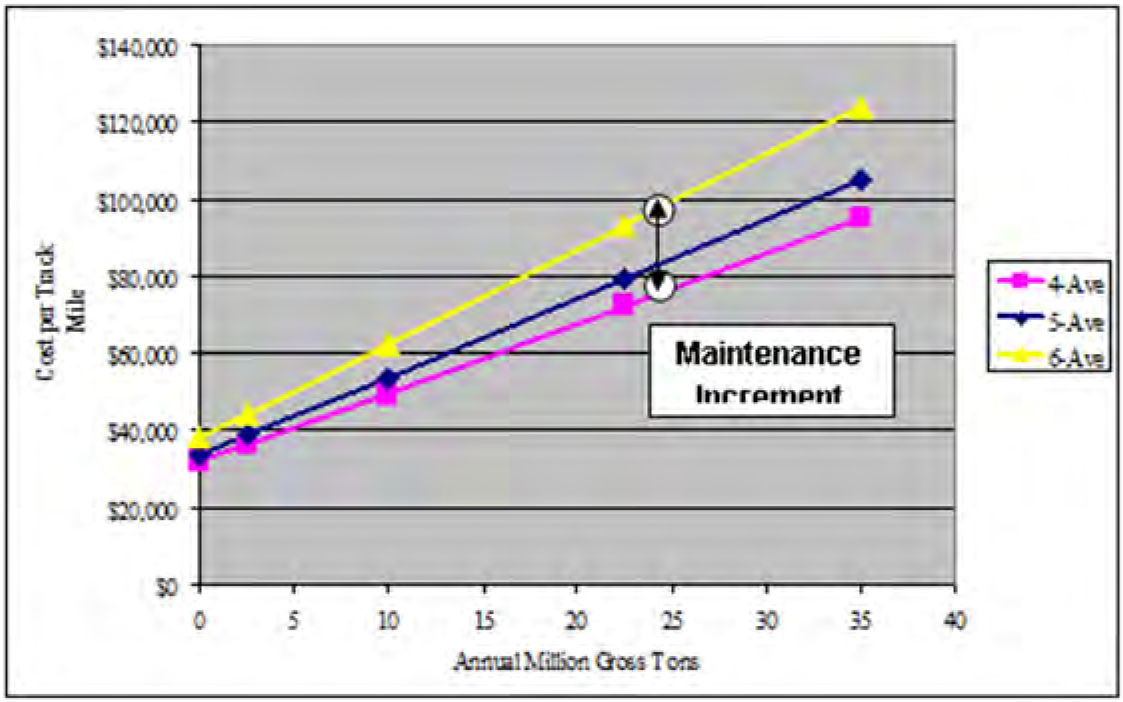
[2] See: http://www.gao.gov/highlights/d04240high.pdf

[3] Zeta-Tech, a subsidiary of Harsco (a supplier of track maintenance machinery) is a rail consulting firm who specializes in development of track maintenance strategies, costs and related engineering economics.

[4] For 110-mph service, the level of infrastructure improvements to the corridor called for in this study should provide enough capacity to allow superior on-time performance for both freight and passenger operations. It is believed that the capacity improvements proposed in the Engineering evaluation provide a reasonable planning basis for establishing costs for this study; but needs to be confirmed by a detailed capacity analysis. The recommended strategy for 110-mph service is to provide enough up-front capital improvement to mitigate not only freight delays, but also the need for providing additional operating incentives that could adversely affect the passenger system's ability to attain a positive operating ratio.

Exhibit 7-2 shows the conceptual relationship between track maintenance cost and total tonnage that was calibrated from the earlier Zeta Tech study. It shows a strong relationship between tonnage and maintenance cost. At low tonnage, the cost differential for maintaining a higher track class is not very large, but as tonnage grows, so too does the added cost. If freight needs only Class 4 track, the passenger service would have to pay the difference, called the "maintenance increment", which for a 25 MGT line as shown in Exhibit 7-2, came to about $25,000 per mile per year. The required payment to reimburse BNSF for its added track cost would be less for lower freight tonnage, more for higher freight tonnage.

Exhibit 7-2: Track Maintenance Cost Function



Following the Zeta Tech methodology, a "maintenance increment" is calculated based on *freight tonnage only*, since a flat rate of $1.56 per train mile (in 2002 dollars) as used in the Zeta-Tech report was added to reflect the direct cost of added passenger tonnage regardless of track class. This cost, which was developed by Zeta-Tech's TrackShare® model, includes not only directly variable costs, *but also an allocation of a freight railroad's fixed cost*. Accordingly, it complies with the Surface Transportation Board's definition of "avoidable cost."

Because passenger trains don't add much tonnage, the added cost for maintaining 110-mph track is largely independent of the number of passenger trains operated. Once the track is built there is an incentive to operate as many trains as possible, for reducing the average unit cost. However, if fewer than eight trains are operated, the average cost goes up since this fixed cost must be spread across a smaller base of passenger train miles.

In addition to an *operating* component of track maintenance cost (which is shown in Exhibit 7-3) the track cost methodology also identifies *a cyclic capital* cost component. For track maintenance:

- **Operating costs** cover expenses needed to keep existing assets in service and include both surfacing and a regimen of facility inspections.
- **Cyclic Capital** costs are those related to the physical replacement of the assets that wear out. They include expenditures such as for replacement of rail and ties, but these costs are not incurred until many years after construction. In addition, the regular maintenance of a smooth surface by reducing dynamic loads actually helps extend the life of the underlying rail and tie assets. Therefore, capital maintenance costs are gradually introduced using a table of ramp-up factors provided by Zeta-Tech (Exhibit 7-3). A normalized capital maintenance level is not reached until 20 years after completion of the rail upgrade program.

Exhibit 7-3: Ramp Up Factors for Cyclic Capital Maintenance Cost

Year	% of Capital Maintenance	Year	% of Capital Maintenance
0	0%	11	50%
1	0%	12	50%
2	0%	13	50%
3	0%	14	50%
4	20%	15	75%
5	20%	16	75%
6	20%	17	75%
7	35%	18	75%
8	35%	19	75%
9	35%	20	100%
10	50%		

For development of the Business Plan, only the operating component of track maintenance cost is treated as a direct operating expense. Capital maintenance costs are incorporated into the Financial Plan and into the Benefit Cost analysis. Because these capital costs do not start occurring until rather late in the project life, usually they have a very minor effect on the Benefit Cost calculation. These costs can be financed using direct capital grants or from surplus operating cash flow. The latter option has been assumed in this study. Accordingly, maintenance capital expenses only reduce the net cash flow generated from operations; they do not affect the operating ratio calculations.

7.2.2 STATION OPERATIONS

A simplified fare structure, heavy reliance upon electronic ticketing and avoidance of a reservation system will minimize station personnel requirements. Station costs include personnel, ticket machines and station operating expenses.

- Staffed stations were assumed at the route endpoints of Duluth and Minneapolis for Routes 9. Additional unstaffed stations for Route 9 were assumed at Foley Blvd, Cambridge, Hinckley, and Superior. All stations were assumed open for two shifts. The cost for the staffed stations includes eight positions at each new location.

- Staffed stations were assumed at the route endpoints of Duluth and Minneapolis for Route 11. Additional unstaffed stations for Route 11 were assumed at North Branch, White Bear Lake, Hinckley and Superior. All stations were assumed open for two shifts. The cost for the staffed stations includes eight positions at each new location.
- For Route 11A staffed stations were assumed at Duluth, St. Paul and Minneapolis. Additional unstaffed stations for Route 11A were assumed at North Branch, White Bear Lake, Hinckley and Superior. All stations were assumed open for two shifts. The cost for the staffed stations includes eight positions at each new location.
- The cost for unstaffed stations covers the cost of utilities, ticket machines, cleaning and basic facility maintenance, which is also included in the staffed station cost. Volunteer personnel such as Traveler's Aid, if desired could staff these stations.

The total annual operating cost for stations in Route 9 and 11 individually comes to $1.4 million, while Route 11A station cost comes to $1.99 million due to its additional major station. Stations cost is practically independent of the number of trains operated or their speed, so running the largest number of trains at the highest speed possible generates the best economies of scale.

7.2.3 MINNEAPOLIS-DULUTH/SUPERIOR CORRIDOR – SYSTEM OVERHEAD COSTS

Previous studies have developed an institutional management structure that would be capable of running a passenger corridor service. The MWRRI study developed, in conjunction with Amtrak, a hypothetical stand-alone management organization, including a President, Operations supervision, Finance and Marketing structure, including a dedicated call center.

Later however, the Ohio Hub[5] study further refined the organizational structure proposed by the MWRRS to convert some of the administrative cost, primarily staff and field supervisory positions, into a variable cost based on train miles. The result was development of a Fixed + Variable cost framework for the implementation of a stand-alone management structure, which had a fixed cost of $8.9 million plus $1.43 per train-mile (in 2002 dollars) for added staff requirements as the system grew. Inflated to 2010 dollars, this became $10.5 million plus $1.69 per train mile. However, the Sales and Marketing category also had a substantial fixed cost component for advertising and call center expense, adding another $2.5 million per year fixed cost, plus variable call center expenses of 57¢ per rider (in 2002 dollars.)[6] Finally, credit card and travel agency commissions were all variable: 1.8 percent and 1 percent of revenue, respectively.

The issue of a reasonable allocation of system overheads or fixed management cost to the Duluth corridor was extensively discussed in the 2007 feasibility study. From benchmarking to other corridors it was estimated that a $5.00 per train-mile contribution to fixed cost, plus full coverage of all variable administrative cost ($1.69 per train mile, plus 67¢ per rider and 2.8% of revenue) would comprise a reasonable contribution that a relatively small corridor like Duluth could make to the overhead costs of a larger entity, like Amtrak.

[5] The Ohio Hub is a proposed 1,244 mile intercity passenger rail system that would serve over 22 million people in five states and southern Ontario, Canada. Seven rail corridors with 44 stations would connect twelve major metropolitan areas, and many smaller cities and towns. For more information see: http://www.ohiohub.com
[6] In the MWRRS cost model, call center costs were built up directly from ridership, assuming 40 percent of all riders call for information, and that the average information call will take 5 minutes for each round trip. Call center costs, therefore, are variable by rider and not by train-mile. Assuming some flexibility for assigning personnel to accommodate peaks in volume and a 20 percent staffing contingency, variable costs came to 57¢ per rider. These were inflated to 67¢ per rider in 2010 dollars.

7.3 MINNEAPOLIS-DULUTH/SUPERIOR CORRIDOR – COST RESULTS

Exhibit 7-4 summarizes the average cost per train mile results from the variety of scenarios that were evaluated for the Minneapolis-Duluth/Superior Corridor. For Route 9 the costs per train mile were assessed as $41.18, the Route 11 costs per train mile as $42.18 and the 11A costs per train mile as $42.75 in 2010 dollars, based on 2020 traffic levels. These results reflect the economies from spreading route-level fixed costs over a broader base as the number of train-miles are increased, but assume a fixed allocation of $5 per train-mile as each route's contribution towards fixed overhead administrative costs. All three routes have similar costs, with most of the divergence coming from the additional station in Route 11A and the higher costs associated with Dedicated Track and increased train-miles on Routes 11 and 11A.

Exhibit 7-4: Percentage Breakdown of Route 9 Costs (Year 2025)

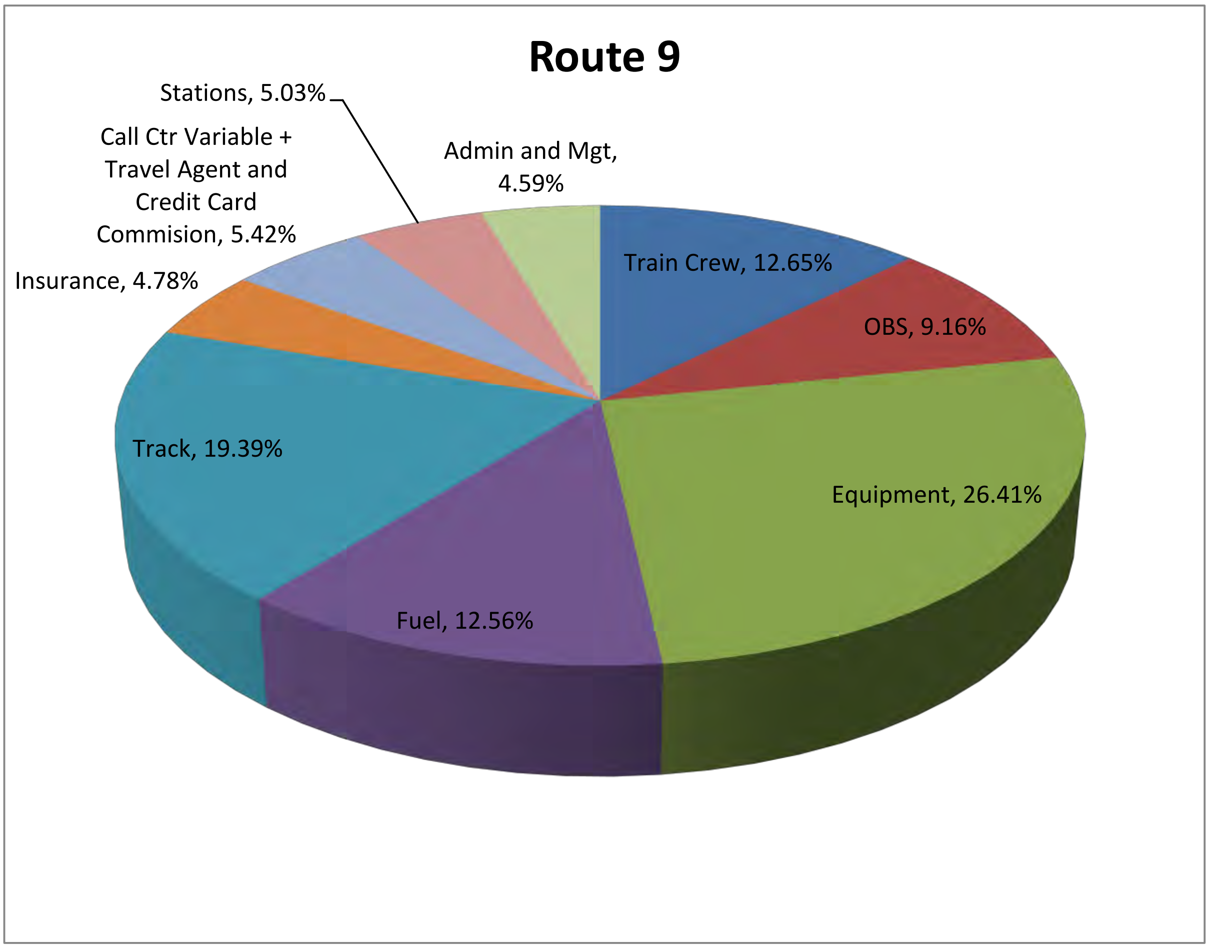


Exhibit 7-5: 2020 Operating Costs by Route

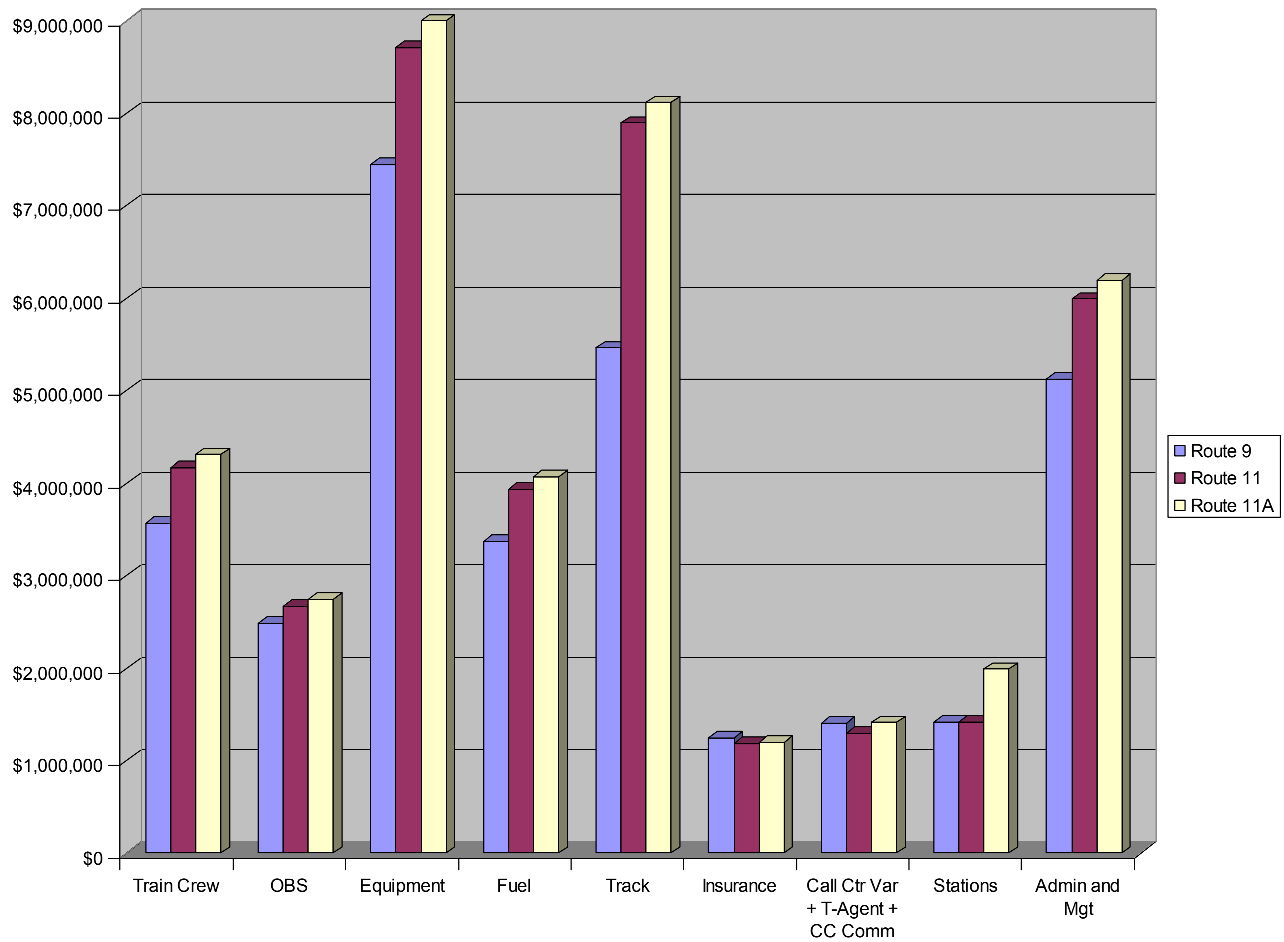


Exhibit 7-6 summarizes the costing basis that was used for each of the three routes.

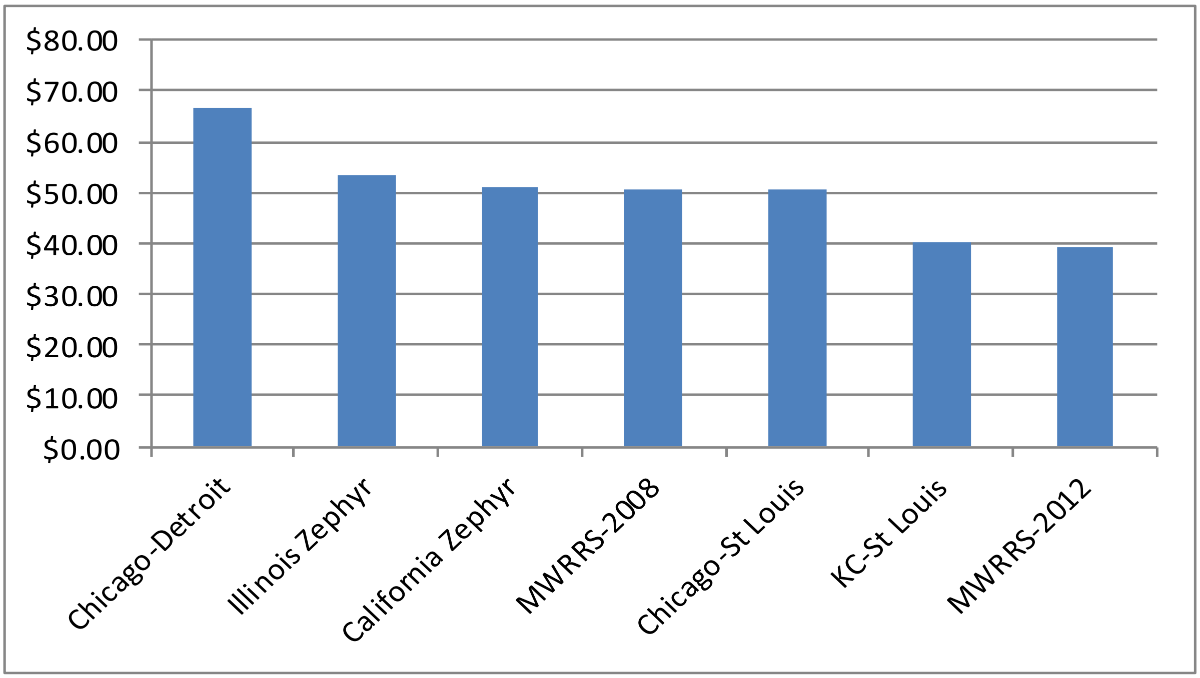
Exhibit 7-6: Operating Cost Summary by Expense Type (in 2010 dollars)

Category	Basis	Type	Route 9 Cost	Route 11 Cost	Route 11A Cost
Train Crew	Train Miles	Variable	$4.66		
OBS	Train Miles + OBS Revenue	Variable	$1.81 (labor) + 50% OBS Revenue		
Equipment Maintenance	Train Miles	Variable	$7.78 for 200-seat DMU		
Energy/Fuel	Train miles	Variable	$2.63 for a 200-seat DMU		
Track/ROW	Train Miles	Fixed	$5,464,338	$7,895,190	$8,114,456
Station Costs	Passenger	Fixed	$1.4 million		$1.99 million, Higher due to St Paul station
Insurance	Pass-miles	Variable	$0.013		
Sales/Mktg/Admin	Passenger + Ticket Revenue	Both Fixed and Variable	Allocation of $5 fixed per train mile, plus $1.69 variable per train mile, 67¢ per rider and 2.8% of revenue		

7.4 VALIDATION OF COST RESULTS

This study uses a well-established costing framework that traces its roots back to a number of previous rail studies. However, the current form of the costing model was mainly established as a result of the extensive work that was performed for the Midwest Regional Rail Initiative, with the active support and participation of Amtrak, freight railroads, and a consortium of nine Midwestern States. The MWRRS costing framework was extensively validated at the time when it was first developed. Exhibit 10-22 (updated to 2010 dollars) from the MWRRS report (Exhibit 7-7 below) compared model-projected MWRRS costs to Amtrak's fully allocated RPS costs.[7] Since then, the costing framework has been continuously updated and enhanced as a result of subsequent rail planning projects in Ohio and Florida.

Exhibit 7-7: Comparison: Projected MWRRS vs. Amtrak RPS Costs (in 2010 dollars)



As can be seen in Exhibit 7-7, the model-predicted costs were in the same range as actual Amtrak experience – in fact, projected average cost for the "MWRRS 2008" start-up service of $50.72 (in 2010 dollars) came in slightly higher than Amtrak's fully-allocated RPS cost for the Chicago-St. Louis corridor at the time. Amtrak's costs for the Chicago-Detroit corridor were higher because of the high cost of maintaining dedicated passenger track, spread over the relatively few train miles operated.

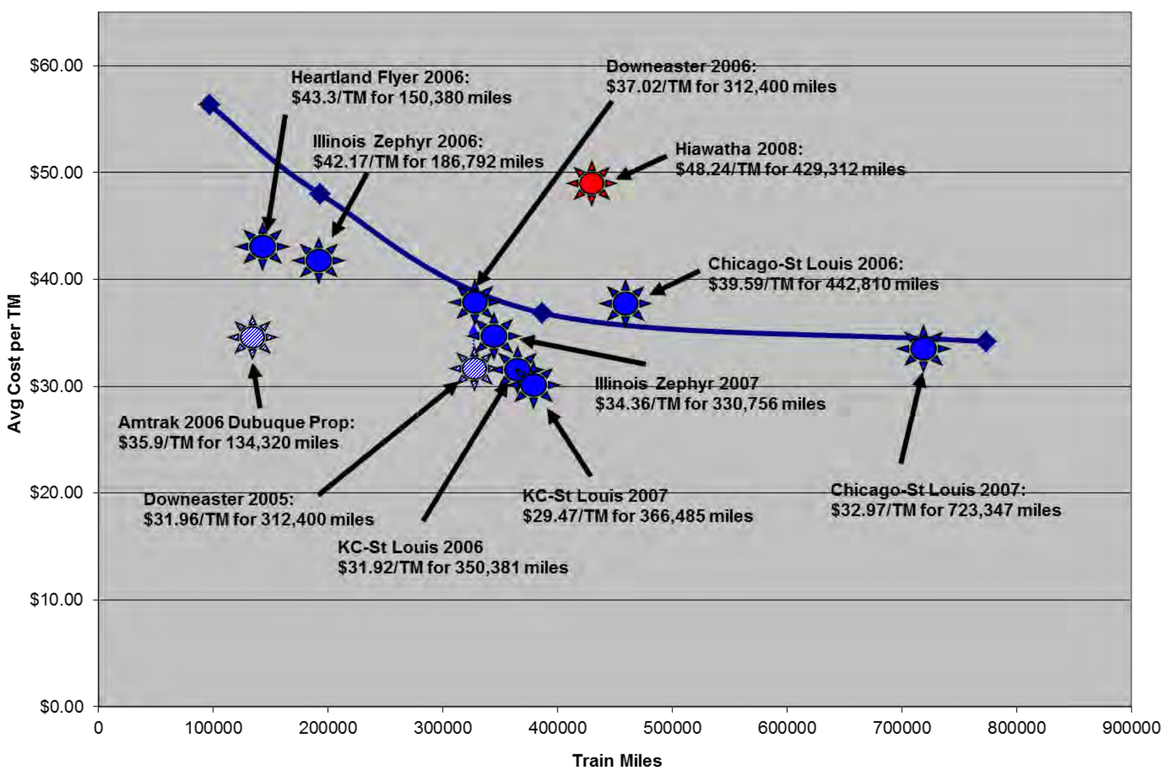
[7] 1997 Amtrak costs adjusted for inflation to 2010, excluding depreciation. Source*: Intercity Passenger Rail: Financial Performance of Amtrak's routes*, U.S. General Accounting Office, May 1998. This validation chart was included in the MWRRS report that was published in 2004.

The results of the 79-mph costing were then further validated against a number of current Amtrak operations. A combination of RPS data furnished by Amtrak along with published information on the financial performance of other state-supported services was used to establish the benchmark data. Several comparable services were included in the benchmark:

- Downeaster
- Illinois Zephyr
- St Louis to Chicago
- St Louis to Kansas City
- Heartland Flyer
- Rockford, Il (Proposed)

These results, as compared to the cost function calculated for the 79-mph Minneapolis to Duluth service, are summarized in Exhibit 7-8, which has been adjusted to reflect current 2010 dollars.

Exhibit 7-8: Benchmark Comparisons of Duluth Projection vs. Actual (in 2010 dollars)



It should also be noted that most of the Amtrak routes are running trains that are larger than the 200-seat trains currently proposed for the Duluth corridor, although those costs were developed for 79-mph services and so do not have much dedicated track maintenance expense. With 8 round trips per day the NLX would be operating over 760,000 train miles per year and would be running in the upper (rightmost) range of the graph, where average costs are lower. With a benchmark cost comparison of $33 per train-mile for Chicago to St Louis service, the current projection of costs in the $41-43 range per train mile certainly seems reasonable and even conservative, considering the added costs of the dedicated track that is included in the cost structure for the Minneapolis-Duluth/Superior corridor.

8 FINANCIAL AND ECONOMIC VIABILITY

This Chapter describes the application of USDOT FRA financial and economic analysis to provide comparative financial statistics and to develop Cost Benefit and Net Present Value assessments at the OMB approved Discount Rate of 3 and7 percent.

The analysis uses the same criteria and structure as the 1997 FRA *Commercial Feasibility Study.*[1] The study set out criteria for establishing a public-private partnership between the federal government, state and local communities, and the private sector for intercity rail projects. The study described two conditions that were considered essential for receiving federal funding support for proposed intercity passenger rail projects:

- An operating cost ratio of at least 1.0, defined as a pre-condition for an effective public/private partnership, so that once the system has been constructed, a private operator could operate the system on a day-to-day without requiring an operating subsidy[2], and

- A benefits/cost ratio greater than 1.0, to ensure that the project makes an overall positive contribution to the economy, at both the regional and national levels.

The Commercial Feasibility Study makes it clear that *"federal consideration of specific High-Speed Ground Transportation project proposals could apply additional criteria that could differ from, and be much more stringent than, this report's threshold indicators for partnership potential."*

This chapter discusses both the operating performance and economic performance of Routes 9, 11 and 11A and presents the financial and economic analysis of the system's construction and operation. This analysis integrates operating and maintenance costs with revenue projections for the year-by-year calculation of operating ratios. User benefits, externalities, and other mode benefits such as reduced highway congestion, time savings, fuel savings and emissions reduction are assessed against capital and operating costs for calculation of Benefit Cost ratios over the lifetime of the project.

8.1 FINANCIAL ANALYSIS

Financial performance was evaluated by analyzing the operating cash flows for each Route. The ratio of operating revenues to operating costs (i.e., operating cost ratio) provides a key indicator of the financial viability of the Minneapolis-Duluth Corridor. The key elements of the financial analysis conducted for this study are listed in Exhibit 8-1 and further discussed below.

Exhibit 8-1: Key Elements of the Financial Analysis

Types of Benefits	Types of Costs	Financial Performance Measures
Revenues	Operating Cost and Maintenance Cost	Operating Ratio Net Present Value

[1] U.S. Federal Railroad Administration, *High-Speed Ground Transportation for America*, pp. 3-7 and 3-8, September 1997
[2] As defined in the Commercial Feasibility Study, a positive operating ratio does not imply that a passenger service can attain "commercial profitability." Since "operating ratio" as defined here does not include any capital-related costs, this report shows that the proposed Ohio Hub network meets the requirements of the Commercial Feasibility Study by covering at least its direct operating costs and producing a cash operating surplus.

The financial analysis integrates the operating and maintenance costs along with the revenue projections for 30 years and addresses financing alternatives. The analysis was based on the following components:

- Operating and implementation plans for the Minneapolis-Duluth/Superior passenger rail service
- Cost estimates for operations and maintenance of the system, including cyclical costs
- Ridership and revenue estimates based on projected travel demand and assumptions regarding fare levels and other services
- Cash flow analysis that includes statements of revenues and expenses as well as sources and uses of funds, including the impact of the financing alternatives

Two measures of financial benefit were used to evaluate the Routes 9, 11 and 11A: net present value (NPV) and operating ratio, which are defined as follows,

Net Present Value = Present Value of Total Benefits – Present Values of Total Costs

The operating ratio is calculated as follows:

$$\text{Operating Ratio} = \frac{\text{Total Annual Revenue}}{\text{Total Annual Operating Cost}}$$

8.2 ECONOMIC BENEFITS

The Minneapolis-Duluth/Superior corridor will provide a wide range of benefits that contribute to economic growth and strengthen the region's manufacturing, service and tourism industries. It will improve mobility and connectivity between regional centers and smaller urban areas, and will create a new passenger travel alternative. This will stimulate further economic growth within corridors. These economic benefits were evaluated using TEMS' *RENTS*™ Model.

The methodology used to estimate economic benefits and costs is based on the approach the Federal Railroad Administration (FRA)[3] used in its analysis of the feasibility of implementing high-speed passenger rail service in selected travel corridors throughout the country. In that study, revenues and benefits were quantified in terms of passenger rail system revenues, other-mode user benefits and resources benefits. The key elements of the economic benefits analysis conducted for this study are listed in Exhibit 8-2 and further discussed below.

Exhibit 8-2: Key Elements of the Economic Benefits Analysis

Types of Benefits	Types of Costs	Measures of Economic Benefits
Consumer surplus System revenues Benefits for users of other modes Resource benefits	Capital investment needs Operations and maintenance expenses	Benefit-cost ratio Net Present Value

[3] U.S. Federal Railroad Administration, *High-Speed Ground Transportation for America*, pp. 3-7 and 3-8, September 1997

Two measures of economic benefit were used to evaluate the Routes 9, 11 and 11A: net present value (NPV) and cost/benefit ratio, which are defined as follows,

Net Present Value = Present Value of Total Benefits – Present Values of Total Costs

$$\text{Cost Benefit Ratio} = \frac{\text{Present Value of Benefits}}{\text{Present Value of Costs}}$$

Present values are calculated using the standard financial discounting formula:

$$PV = \sum C_t / (l + r)^t$$

Where:

PV = Present value of the project benefits or costs (e.g., revenue)
C_t = Cash flow for t years
r = Interest Rate reflecting opportunity cost of capital
t = Time

For this analysis, revenues and cost cash flows were discounted to the 2010 base year using two discount rates: 3 percent and 7 percent[4]. The 3 percent discount rate reflects the real cost of money in the market as reflected by the long term bond markets, and the 7 percent discount rate reflects the federal government's desire to establish a benchmark comparison by discounting long term benefits at a greater rate than the market for public securities.

8.3 ESTIMATE OF ECONOMIC BENEFITS

A transportation improvement is seen as providing economic benefits in terms of time and cost savings, as well as convenience, comfort and reliability. Benefits are expected to include the following:

- **Users** of the system enjoy a consumer surplus benefit that reflects the additional fare value that the individual would be willing to pay for riding the train, as a result not only of time savings, but other aspects of the service (quality, frequency, reliability) as measured by the Generalized Cost framework.

- **Non-user** benefits are for people who continue to drive their cars, but who benefit from reduced congestion and improved air quality as a result of diversion from the highway to rail. The analysis measures benefits to the motoring public from decongestion that is a product of travelers diverted from the highway to the rail mode, and benefits to society as a whole resulting from reduction of air pollution from reduced emissions.

Revenues, operating costs and capital costs have already been described in the financial analysis. This section describes the calculation of additional non-cash benefits, and merges the results of these calculations together with the cash benefits to develop an overall Cost Benefit assessment. Following OMB guidelines the results are aggregated over a 30-year system life using net present values at real interest rates of 3% and 7%.

[4] The discount rate used in this Study is based on *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, Circular N. A-94, issued by the Office of Management and Budget.

8.3.1 USER BENEFITS

The analysis of user benefits is based on the measurement of *generalized cost* of travel, which includes both time and money. Time is converted into money by the use of a Values of Time calculation. The Values of Time (VOT) used in this Study were derived from stated preference surveys conducted in previous study phases and used in the *COMPASS*™ multimodal demand model for developing ridership and revenue forecasts. These VOTs are consistent with previous academic and empirical research, and other transportation studies conducted by TEMS.

Benefits to users of the rail system are measured by the sum of *system revenues* and *consumer surplus*, which is defined as the additional benefit, or *surplus* individuals receive from the purchase of a commodity or service. Consumer surplus is used to measure the demand side impact of a transportation improvement on users of the service. It is defined as the additional benefit consumers (users of the service) receive from the purchase of a commodity or service (travel), above the price actually paid for that commodity or service.

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).

Revenues are included in the measure of consumer surplus as a proxy measure for the consumer surplus foregone because the price of rail service is not zero. This is an equity decision made by the FRA to compensate for the fact that highway users pay zero for use of the road system (the only exception being the use of toll roads). The benefits apply to existing rail travelers as well as new travelers who are induced (those who previously did not make a trip) or diverted (those who previously used a different mode) to the new passenger rail system.

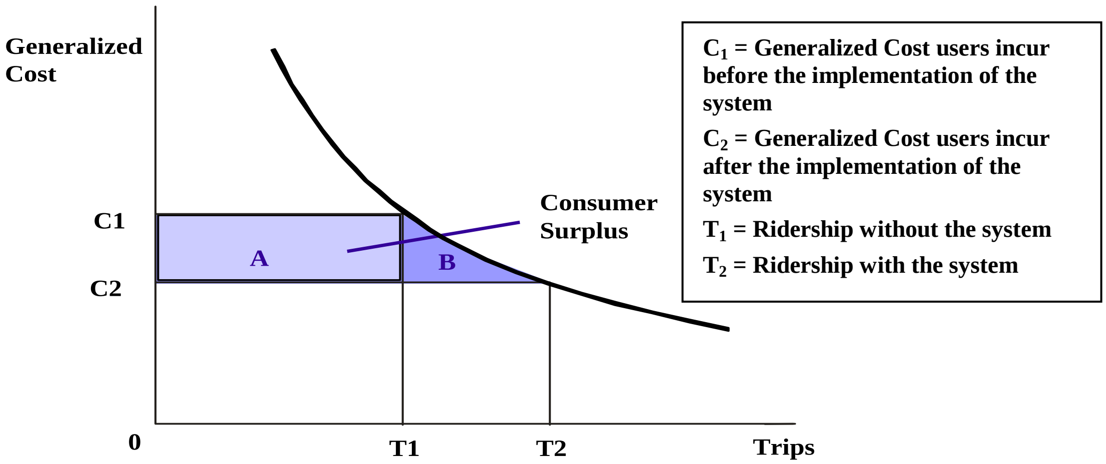
User benefits incorporate both the measured consumer surplus and the system revenues, since the revenues are user benefits transferred from the rail user to the rail operator.

8.3.2 CONSUMER SURPLUS

In consumer surplus analysis, improvements in service (for all modes of transportation in the corridor) are measured by improvements in generalized cost (combination of time spent and fares paid by users to take a trip). In some cases, individuals (for example, current bus and rail users) may pay higher fares to use an improved mode of travel, but other aspects of the improvement will likely compensate for the increased fare. A transportation improvement that leads to improved mobility reduces the generalized cost of travel, which in turn leads to an increase in consumer surplus.

To calculate consumer surplus, the number of trips and generalized cost of travel without the system were compared to the number of trips and generalized cost of after the Minneapolis-Duluth/Superior rail service were implemented. In Exhibit 8-3, the shaded area under a typical demand curve represents improvements in the generalized cost of travel for induced and/or diverted users (the consumer surplus). The shaded area is defined by the points $(0, C_1)$, $(0, C_2)$, (T_1, C_1), and (T_2, C_2). The equation assumes that Area B is a triangle and the arc of the demand curve is a straight line. Equation 1, which follows the exhibit, measures consumer surplus.

Exhibit 8-3: Consumer Surplus Graphically Displayed



Equation 1: CS = $[(C_1 - C_2)\ T_1] + [(C_1 - C_2)(T_2 - T_1)(0.5)]$

Where:

CS	=	Consumer Surplus
Rectangle A	=	$(C_1 - C_2)\ T_1$
Triangle B	=	$(C_1 - C_2)(T_2 - T_1)(0.5)$

The formula for consumer surplus is as follows:

Consumer Surplus = $(C_1 - C_2)*T_1 + ((C_1 - C_2)*(T_2 - T_1))/2$

Where:

C_1	=	Generalized Cost users incur before the implementation of the system
C_2	=	Generalized Cost users incur after the implementation of the system
T_1	=	Number of trips before operation of the system
T_2	=	Number of trips during operation of the system

TEMS' *COMPASS*™ demand forecasting model estimates consumer surplus by calculating the increase in regional mobility (i.e., induced travel) and traffic diverted to the system (Area B in Exhibit 8-3), and the reduction in travel costs, measured in terms of generalized cost, for existing system users (Area A). The reduction in generalized cost generates the increase in users' benefits. Consumer surplus consists of the additional benefits derived from savings in time, fares and other utility improvements.

8.3.3 PASSENGER REVENUES

Passenger revenues provide another measure of system benefit. A comprehensive travel demand model was developed using the latest socioeconomic, traffic volumes (air, bus, auto, and rail) and updated network data (e.g., gas prices) to test likely ridership response to service improvements over time. The ridership and revenue demand estimates, developed using the *COMPASS*™ demand modeling system, are sensitive to trip purpose, service frequencies, travel times, fares, fuel prices, congestion and other trip attributes.

A revenue yield assessment has been completed to optimize the fare systems and train frequencies for the final service plan. For each service, the market data and the service plan has been used to derive revenue and ridership estimates that reflect the supply and demand conditions that will exist.

These fares and frequencies, when applied to the market, provide the key input to financial models for basic traffic and the ancillary revenues of the incremental rail services.

8.4 BENEFITS TO USERS OF OTHER MODES

In addition to rail-user benefits, travelers using other modes will also benefit from the rail system because it will contribute to highway congestion relief and reduce travel times for users of other modes. Two major categories of highway Non-User benefits were assessed: Emission savings and Congestion reduction. These are described in the next two subsections.

8.4.1 EMISSION REDUCTION

These were estimated from the vehicle miles traveled (VMT) reductions derived from the ridership model. The assumption is that a reduction in VMT is directly proportional to the reduction in emissions. Several critical pollutants were included for evaluation in estimating the potential highway emission saving value. The dollar amounts applied for the reduced pollutant volume resulting from the VMT reduction were obtained from the Commercial Feasibility study[5] and were inflated to a 2010 number to obtain an estimated monetary value for the pollutants. Exhibit 8-4 shows the current unit values in 2010 dollars for the anticipated VMT reduction and the estimated pollutant tonnage reduction.

Consistent with the approach used by the FRA, the number of vehicle-miles saved was calculated by multiplying the number of diverted auto trips, times average trip length, divided by an average vehicle occupancy factor. The net emission reduction is obtained by subtracting locomotive emissions produced by the trains from the highway emissions saved. Locomotive emissions were calculated using the Tier 4 Line-Haul locomotive emissions standards[6].

Exhibit 8-4: Emissions Reduction Current 2010 Dollar Values

Pollutant	Dollars per Ton (2010 dollars)	Average Emission per Mile (gram)
CO	$ 510.33	25
NOx	$39,658.09	1.3
VOC	$28,393.09	1.05
PM	$ 8,560.89	0.09
CO_2	$ 22.74	607

8.4.2 HIGHWAY CONGESTION TIME SAVINGS AND FUEL

The highway congestion delay savings consists of two components, one to reflect the time savings to the remaining highway users that results from diversion of auto users to the rail mode and the second to reflect the reduction in excess fuel expenditure that results from the reduction in overall congestion on the highway system. The excess fuel component is used instead of actual fuel consumed component because the base fuel cost is already included in the generalized cost components and is embedded in the consumer surplus results. As such, only the excess congestion fuel over and above the normally consumed fuel levels for a trip can be considered an added benefit

5 High-Speed Ground Transportation for America, Federal Railroad Administration, September 1997
6 US Code of Federal Regulations, 40 CFR Parts 85, 89 and 92.

of the system. The excess fuel consumed refers to the fuel consumed while sitting in traffic congestion and is unrelated to the actual fuel consumed by each traveler.

The assumption is that less congestion leads to improved operating speeds for the remaining road users, which results in shorter overall travel times and less fuel consumption. Applying an average regional value of time, which was derived from surveys, to the remaining highway automobile occupants, monetizes the time saving. Due to diverted auto trips to rail and improved highway conditions, the remaining auto users benefit from the fuel savings.

8.5 TYPE OF COSTS

Costs are the other side of the equation in the cost/benefit analysis. Costs include up-front capital costs, as well as ongoing operating and maintenance expenses.

Capital Investment Needs: The capital investment needs for each route were calculated using input from the Engineering Assessment outlined in Chapter 5. The capital investment estimates include both infrastructure and rail equipment needs and also include capital for fleet expansion, equipment refurbishment and cyclic track maintenance.

Operating and Maintenance Expenses: The operating and maintenance expenses for each alternative were calculated using the output of the operating cost analysis set forth in Chapter 7. A capital track maintenance component was separately calculated for the High-Speed Scenario. Since the need for infrastructure replacement does not occur for some years into the future, this cost has minimal impact on the cost/benefit ratio calculation, but has been included for completeness.

8.6 FINANCIAL ANALYSIS RESULTS

For Routes 9, 11 and 11A, Exhibit 8-5 compares the forecast revenue and operating cost NPV at 3 percent discount rate in 2010 constant dollars, to develop operating surplus and also show operating ratios for year 2025 and 2040 for the three Routes. Exhibit 8-6 shows the operating ratio of each Route for year 2025 and 2040 and shows that Route 9 has positive operating ratio and thus, meets the FRA criteria.

Further, it can be seen that the Operating Ratios progressively improve from 1.02 in 2025 to 1.14 in 2040 reflecting ridership and revenue gains over the years. This results in a strong positive cash flow leading to the ability for Route 9 to cover its operating costs out of the farebox and make a substantial contribution towards capital cost.

Exhibits 8-6 and 8-7 show that Routes 11 and 11A will require ongoing subsidy whereas Route 9 can return an operating surplus.

Exhibit 8-5: Financial Analysis Results (Present Value in 2010 dollars – 3% discount rate)

Financial Analysis	Route 9	Route 11	Route 11A
Revenue	$590.59	$562.75	$575.19
Operating Cost	$568.75	$669.54	$700.77
Operating Surplus	$21.84	($106.79)	$(125.58)
Operating Ratio	**Route 9**	**Route 11**	**Route 11A**
2025 Operating Ratio	1.02	0.82	0.80
2040 Operating Ratio	1.14	0.92	0.90

Exhibit 8-6: Operating Ratios: Route 9, Route 11 and Route 11A

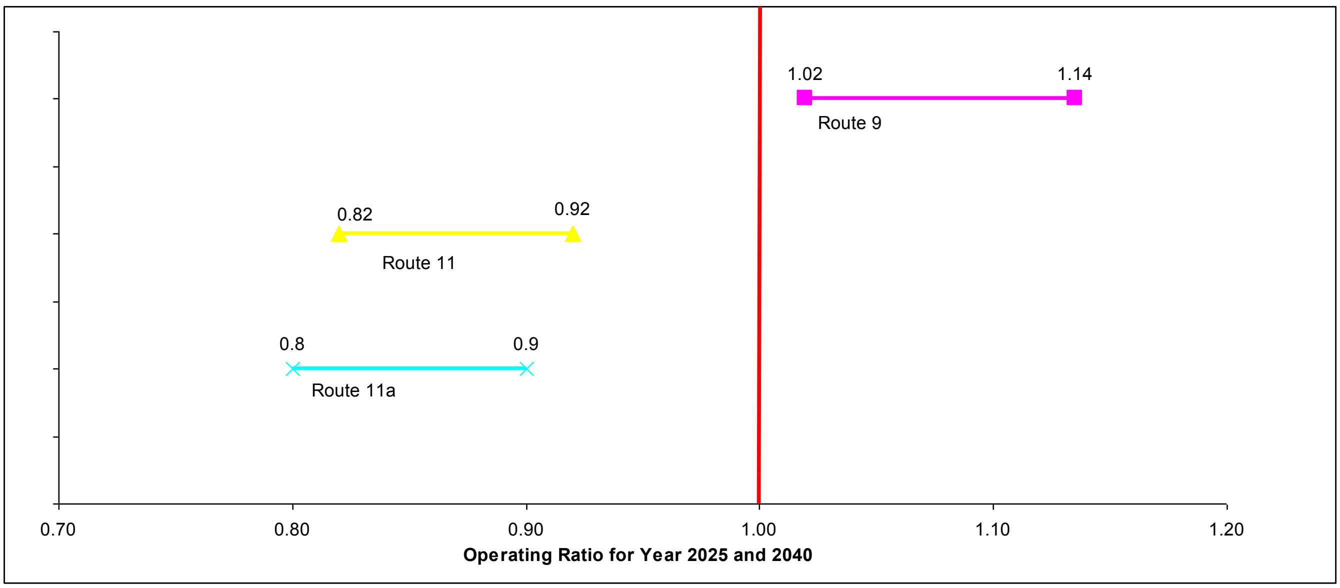
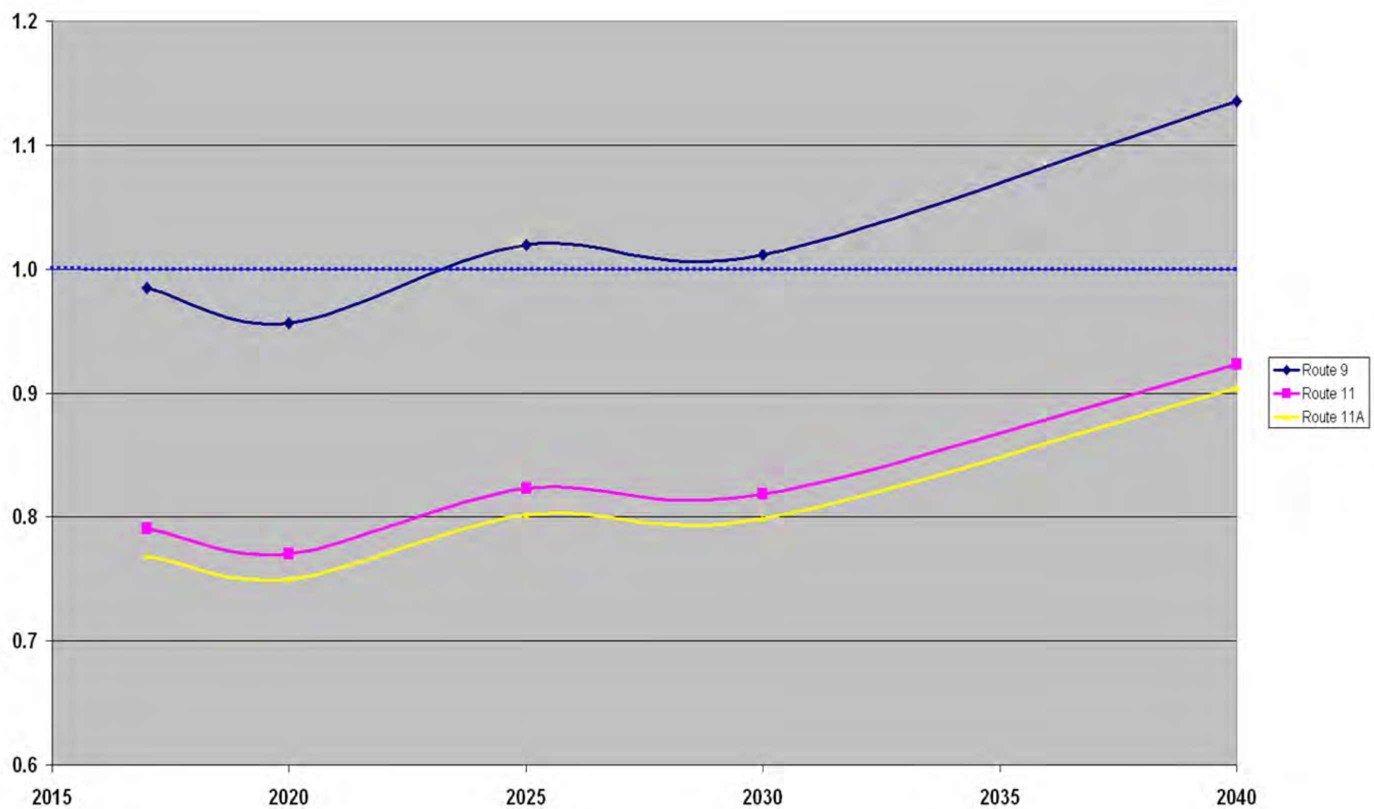


Exhibit 8-7: Operating Ratios: Route 9, Route 11 and Route 11A



8.7 COST BENEFIT ANALYSIS

A preliminary Cost Benefit analysis was conducted using the methodology for estimating costs and benefits as described in the report "High-Speed Ground Transportation for America" (HSGT), Federal Railroad Administration (FRA), 1997. The analysis incorporated the project capital and operating costs, as well as the updated ridership and revenue estimate.

The key inputs for this analysis included System Passenger Revenues, Ancillary Revenues, OBS revenues, Consumer Surplus, Highway Congestion Delay Savings, Highway Fuel Savings, Reduced Emissions, Capital Costs, and Operating and Maintenance (O&M) Costs for the system.

In order to calculate the Cost Benefit Ratio, an analysis of the project economic benefit and cost cash flows were discounted to the 2010 base year using two discount rates: 3 percent and 7 percent as shown in Exhibits 8-8 and 8-9. The 3 percent discount rate reflects the real cost of money in the market as reflected by the long term bond markets, and the 7 percent discount rate reflects the federal government's desire to establish a benchmark comparison by discounting long term benefits at a greater rate than the market for public securities.

The results for the Routes 9, 11 and 11 A show that only Route 9 meets the FRA criteria at 3 and 7 percent, whereas Routes 11 and 11A have a cost benefit ratio below 1.0 at 3 and 7 percent market rate. See Exhibits 8-8 and 8-9. Using the 3 percent market rate, Route 9 produces a Cost Benefit Ratio of 1.5 and net benefits over $2.2 Billion Net Present Value as seen in Exhibit 8-8. At the 7 percent rate, Route 9 produces a Cost Benefit Ratio of 1.03 and net benefits over $1.0 Billion Net Present Value as seen in Exhibit 8-9.

Exhibit 8-8: Cost Benefit Evaluation of Routes at 3% Discount Rate (Millions 2010 dollars)

	Route 9	Route 11	Route 11A
Benefits to User	**(Present Value Discount at 3%)**		
System Passenger Revenues	$541.82	$516.28	$527.70
Advertising Revenues	$5.42	$5.16	$5.28
OBS Revenue	$43.35	$41.30	$42.22
Total Operating Revenues	**$590.59**	**$562.75**	**$575.19**
Users Consumer Surplus	$718.71	$650.59	$600.15
Total User Benefits	**$1,309.29**	**$1,213.33**	**$1,175.34**
Benefits to Public at Large			
Highway Congestion Delay Savings	$590.22	$533.64	$540.85
Highway Reduced Emissions	$46.28	$36.46	$51.56
Highway Fuel Savings	$210.47	$190.29	$192.84
Total Public at Large Benefits	**$846.98**	**$760.39**	**$785.25**
Total Benefits	**$2,156.28**	**$1,973.72**	**$1,960.59**
Capital Cost	$810.53	$1,277.22	$1,389.92
Operating Cost	$568.75	$669.54	$700.77
Cyclic Maintenance	$30.38	$44.50	$45.67
Fleet Expansion	$32.44	$32.44	$32.44
Total Costs	**$1,442.11**	**$2,023.70**	**$2,168.80**
Benefits Less Costs	**$714.17**	**($49.98)**	**($208.21)**
Project Benefit/Cost Ratio	**1.5**	**0.98**	**0.9**

Exhibit 8-9: Cost Benefit Evaluation of Routes at 7% Discount Rate (Millions 2010 dollars)

	Route 9	Route 11	Route 11A
Benefits to User	**(Present Value Discount at 7%)**		
System Passenger Revenues	$258.47	$246.23	$251.49
Advertising Revenues	$2.58	$2.46	$2.51
OBS Revenue	$20.68	$19.70	$20.12
Total Operating Revenues	**$281.73**	**$268.39**	**$274.13**
Users Consumer Surplus	$342.43	$309.90	$285.67
Total User Benefits	**$624.16**	**$578.29**	**$559.80**
Benefits to Public at Large			
Highway Congestion Delay Savings	$266.77	$241.22	$244.54
Highway Reduced Emissions	$22.26	$17.46	$24.75
Highway Fuel Savings	$91.48	$82.71	$83.85
Total Public at Large Benefits	**$380.50**	**$341.40**	**$353.13**
Total Benefits	**$1,004.67**	**$919.69**	**$912.93**
Capital Cost	$670.77	$1,056.98	$1,150.25
Operating Cost	$278.21	$327.91	$343.22
Cyclic Maintenance	$11.85	$17.35	$17.81
Fleet Expansion	$19.17	$19.17	$19.17
Total Costs	**$980.00**	**$1,421.42**	**$1,530.45**
Benefits Less Costs	**$24.67**	**($501.73)**	**($617.52)**
Project Benefit/Cost Ratio	**1.03**	**0.65**	**0.6**

8.8 SUMMARY

- **Route 9** with a capital cost of $939.4 million and a positive cost benefit and operating ratio, meets the FRA criteria. This option has a break even by 2023 with surplus increasing to $7 million a year by 2040.
- **Route 11** with a negative cost benefit and operating ratio, fails the FRA criteria. It needs an annual subsidy of $7-10 million a year, at least to 2030.
- **Route 11A** with a negative cost benefit and operating ratio, fails the FRA criteria. It needs an annual subsidy of $7-10 million a year, at least to 2030.

These results show a strong case for Route 9 for Minneapolis-Duluth/Superior Corridor with the key issue being the value placed on long-term benefits to the consumer.

9 CONCLUSION

1. Comparing the performance of Routes 9, 11, and 11A using the Commercial Feasibility criteria established in FRA's September 1997 report, *High-Speed Ground Transportation for America*, only Route 9 has a positive Operating Ratio and a positive Benefit Cost ratio.

2. The lower capital costs of Route 9 -- $939 million versus $1,480 million for Route 11, and $1,612 million for Route 11A -- enables Route 9 to have a positive Benefit Cost ratio. The higher capital costs of Routes 11 and 11A cause these routes to return a negative Benefit Cost ratio (< 1.0.)

3. While Route 9 produces an operating surplus resulting in a positive Operating Ratio, Routes 11 and 11A generate operating losses that will require an annual subsidy of $7-12 million at least to the year 2030. The operating costs for Routes 11 and 11A are higher than those for Route 9 because of the need for running more train-miles over a longer route, and for maintaining more dedicated track.

4. The ridership for Route 9 is lower than that for Route 11A due to the heavy use of the system by short-haul riders between St. Paul and Minneapolis. However, the passenger miles are greater for Route 9 and the overall revenue is highest for Route 9 reflecting the strong intermediate stations at Cambridge and Foley Boulevard that help boost the ridership of this route.

5. The revenues for Route 11 are lower than those for Route 9, primarily because of the weaker population demographics associated with the Route 11 stations. (White Bear Lake vs. Foley, and North Branch vs. Cambridge).

6. Adding a loop through St. Paul Union Station in Route 11A adds more than 20 minutes to the end-to-end Minneapolis to Duluth travel time. As a result, the route loses more in long-haul traffic than it gains in short-haul potential.

7. The overall result of the analysis is that Route 9 meets the economic criteria established by the FRA Commercial Feasibility Study, while Routes 11 and 11A fail these criteria.

APPENDIX A: SOCIOECONOMIC DATA

The study corridor is divided into 123 zones. The following table shows the base year socioeconomic data for each zone.

Zone	Centroid Name	County	State	2010 Population	2010 Employment	2010 Per Capita Income
1	Duluth Downtown	St. Louis	MN	19,299	15,159	$34,436
2	Duluth Heights	St. Louis	MN	34,324	15,940	$38,680
3	Bloomington	Hennepin	MN	82,512	108,592	$62,706
4	Eden Prairie	Hennepin	MN	57,863	60,974	$81,135
5	Richfield	Hennepin	MN	189,526	76,604	$42,074
6	St. Louis Park - Edina	Hennepin	MN	166,628	142,410	$72,792
7	Minneapolis Downtown	Hennepin	MN	24,137	153,619	$63,234
8	N. Minneapolis - St. Anthony	Hennepin	MN	71,554	78,373	$40,579
9	Brooklyn Center-Robinsdale	Hennepin	MN	107,867	42,612	$41,717
10	Roseville	Ramsey	MN	58,676	74,052	$42,793
11	Shoreview - North Oaks	Ramsey	MN	35,160	11,232	$66,250
12	White Bear Lake	Ramsey	MN	36,477	22,376	$50,674
13	Maplewood - North St. Paul	Ramsey	MN	137,837	66,503	$37,653
14	Inner Grove Heights	Dakota	MN	34,790	18,100	$48,972
15	Burnsville	Dakota	MN	71,856	48,023	$53,336
16	Cottage Grove	Washington	MN	54,501	13,764	$44,557
17	Woodbury	Washington	MN	46,773	24,944	$58,602
18	Columbia Heights	Anoka	MN	23,620	14,299	$38,186
19	Fridley	Anoka	MN	29,235	30,985	$39,650
20	Chisago	Chisago	MN	27,699	15,241	$43,460
21	Chanhassen	Carver	MN	33,350	16,655	$68,152
22	Shakopee	Scott	MN	44,672	20,931	$40,106
23	Hutchinson	Mcleod	MN	38,930	21,344	$36,078
24	Buffalo	Wright	MN	136,110	41,214	$37,215
25	Big Lake	Sherburne	MN	101,560	26,847	$34,318
26	Cambridge	Isanti	MN	10,958	16,697	$42,789

Zone	Centroid Name	County	State	2010 Population	2010 Employment	2010 Per Capita Income
27	Milaca	Mille Lacs	MN	17,224	6,557	$33,372
28	Aitkin	Aitkin	MN	17,050	4,627	$29,527
29	Cloquest-Scanlon	Carlton	MN	36,950	14,782	$31,663
30	City of Hinckley	Pine	MN	5,114	1,427	$25,478
31	Ashland	Ashaland, Bayfield	WI	16,114	4,658	$30,091
32	Hayward	Rusk, Sawyer, Washburn	WI	51,230	21,929	$28,501
33	Hudson	St. Croix	WI	87,123	32,788	$40,661
34	Ellsworth	Pierce	WI	41,695	11,923	$34,589
35	Red Wing	Goodhue	MN	48,030	25,388	$39,003
36	Menomonie	Dunn, Pepin	WI	52,336	22,821	$29,650
37	Chippewa Falls	Chippewa	WI	63,413	26,120	$32,679
38	Mora	Kanabec	MN	4,084	4,994	$33,282
39	Arlington	Sibley	MN	15,370	4,331	$29,973
40	Winona	Winona	MN	49,430	29,474	$33,855
41	Rochester	Olmsted	MN	148,130	101,339	$46,170
42	Fairbault	Rice	MN	66,420	27,334	$32,746
43	Le Sueur	Le Sueur	MN	29,910	9,772	$35,295
44	Mankato	Blue Earth, Nicollet	MN	100,420	58,632	$35,878
45	Willmar	Kandiyohi, Meeker	MN	66,470	34,194	$34,935
46	St. Cloud	Benton, Sterns	MN	43,730	18,465	$34,102
47	Brainerd	Crow Wing, Morrison	MN	99,700	45,835	$31,697
48	Wadena	Cass, Todd, Wadena	MN	70,350	26,053	$30,193
49	Grand Rapids	Itasca, Koochiching	MN	59,300	24,435	$31,462
50	Two Harbors	Lake	MN	11,480	4,600	$35,673
51	St. Croix Falls	Polk	MN	31,850	14,532	$30,806
52	Superior	Douglas	WI	25,754	14,881	$29,651
53	Arcadia	Buffalo, Trempealeau	WI	43,126	21,069	$33,627
54	Wabasha	Wabasha	MN	22,940	8,309	$36,893
55	Min-St. Paul Int. Airport	Hennepin	MN	1,175	42,250	$41,430
56	Duluth International Airport	St. Louis	MN	72	2,748	$36,094

Zone	Centroid Name	County	State	2010 Population	2010 Employment	2010 Per Capita Income
57	Grand Casino Hinckley	Pine	MN	52	1,902	$25,478
58	Owatonna	Dodge, Steele, Waseca	MN	79,810	39,134	$35,667
59	Duluth West	St. Louis	MN	29,231	12,299	$34,368
60	Hermantown	St. Louis	MN	23,419	5,299	$39,265
61	Virginia - Giants Ridge Ski Resort	St. Louis	MN	51,542	29,431	$34,787
62	Pine City	Pine	MN	4,126	1,099	$31,949
63	Crossing Rd. 2 & Rd. 53	Douglas	WI	13,364	2,744	$29,254
64	Coon Rapids	Anoka	MN	54,466	22,962	$39,716
65	Blaine	Anoka	MN	60,576	23,980	$45,766
66	Andover	Anoka	MN	89,764	29,914	$44,367
67	Crossing Rd. 65 & Rd. 22	Anoka	MN	29,729	5,050	$47,788
68	Waconia	Carver	MN	67,480	21,898	$47,196
69	Lakeville	Dakota	MN	79,879	21,332	$49,009
70	Apple Valley-Rosemont	Dakota	MN	77,873	22,195	$48,652
71	Castle Rock	Dakota	MN	8,829	1,934	$41,480
72	Mendota Heights	Dakota	MN	13,172	11,047	$75,291
73	Savage	Scott	MN	61,666	17,387	$48,788
74	Jordan	Scott	MN	25,783	7,659	$33,030
75	Stillwater	Washington	MN	41,128	21,007	$58,769
76	Lakeland Shores	Washington	MN	15,461	3,050	$54,740
77	Oakdale	Washington	MN	36,074	11,670	$46,891
78	St. Paul Downtown	Ramsey	MN	77,182	98,880	$32,416
79	Crystal-New Hope-Golden Valley	Hennepin	MN	58,494	47,248	$50,880
80	Plymouth	Hennepin	MN	106,015	81,752	$72,905
81	Brooklyn Park-Maple Grove-Champlin	Hennepin	MN	143,476	78,622	$50,187
82	Minnetonka-Hopkins	Hennepin	MN	52,235	50,635	$78,012
83	Long Lake-Minnetonka Beach	Hennepin	MN	53,393	20,511	$92,945
84	Spencer Brook	Isanti	MN	4,783	594	$40,830
85	Eagan	Dakota	MN	60,922	46,498	$55,717
86	Southwest St. Paul	Dakota	MN	37,923	22,186	$41,510

Zone	Centroid Name	County	State	2010 Population	2010 Employment	2010 Per Capita Income
87	Hastings	Dakota	MN	28,876	13,140	$42,112
88	Cedar Lake	Scott	MN	22,389	1,331	$50,084
89	Forest Lake	Washington	MN	47,053	10,953	$49,901
90	Loretto	Hennepin	MN	34,415	19,739	$62,636
91	Isanti - draw boundaries	Isanti	MN	12,145	1,508	$37,203
92	Sandstone	Pine	MN	5,154	1,624	$29,076
93	Willow River	Pine	MN	8,636	1,624	$27,923
94	Fond-Du-Lutheran Casino	St. Louis	MN	1,739	14,694	$18,281
95	Arnold-Lakewood	St. Louis	MN	17,604	2,273	$39,584
96	Ely	St. Louis	MN	19,023	6,764	$36,793
97	Spirit Mountain Ski Resort	St. Louis	MN	1,757	380	$32,470
98	Solon Springs	Douglas	WI	5,396	967	$31,147
99	Grand Casino Mille Lacs (Onamia)	Mille Lacs	MN	3,719	2,462	$23,085
100	Eau Claire	Eau Claire	WI	101,148	64,838	$34,146
101	Rice Lake	Barron	WI	48,399	25,436	$31,693
102	Redwood Falls	Redwood, Renville, Brown	MN	59,120	31,191	$33,541
103	Siren	Burnett	WI	17,098	5,559	$29,130
104	Grand Marais	Cook	MN	5,570	3,203	$37,917
105	Macalester - Groveland	Ramsey	MN	73,188	80,572	$47,264
106	Roseville East	Ramsey	MN	58,512	26,174	$38,807
107	Mounds View	Ramsey	MN	29,503	20,216	$48,159
108	Centerville	Anoka	MN	27,661	3,470	$47,738
109	St. Francis	Anoka	MN	20,219	2,810	$42,646
110	Linwood	Anoka	MN	9,839	1,240	$49,287
111	Weber	Isanti	MN	4,349	540	$39,747
112	Stanfield	Isanti	MN	3,560	442	$36,921
113	Taylors Falls	Chisago	MN	3,108	1,710	$37,220
114	North branch	Chisago	MN	11,710	6,443	$40,203
115	Dalbo	Isanti	MN	4,159	517	$37,621
116	Harris	Chisago	MN	7,140	3,929	$33,300

Zone	Centroid Name	County	State	2010 Population	2010 Employment	2010 Per Capita Income
117	Rush Point	Chisago	MN	4,452	2,450	$40,642
118	Rock Creek	Pine	MN	3,850	1,026	$35,780
119	Pine City (West)	Pine	MN	3,887	1,036	$35,886
120	Brunswick	Kanabec	MN	5,411	6,617	$33,905
121	Ogilvie	Kanabec	MN	4,234	5,177	$34,034
122	Woodland	Kanabec	MN	3,727	4,557	$30,927
123	Wahkon	Mille Lacs	MN	6,318	2,405	$32,360

APPENDIX B: COMPASS™ MODEL AND CALIBRATION

The *COMPASS™* Model System is a flexible multimodal demand-forecasting tool that provides comparative evaluations of alternative socioeconomic and network scenarios. It also allows input variables to be modified to test the sensitivity of demand to various parameters such as elasticities, values of time, and values of frequency. This section describes in detail the model methodology and process using in the Duluth-Minneapolis Corridor Study.

B.1 DESCRIPTION OF THE *COMPASS™* SYSTEM

The *COMPASS™* model is structured on two principal models: Total Demand Model and Hierarchical Modal Split Model. For this study, these two models were calibrated separately for four trip purposes, i.e., *Business*, *Commuter*, *Casino*, and *Other*. Moreover, since the behavior of short-distance trip making is significantly different from long-distance trip making, the database was segmented by distance, and independent models were calibrated for both long and short-distance trips. For each market segment, the models were calibrated on origin-destination trip data, network characteristics and base year socioeconomic data.

The models were calibrated on the base year data. In applying the models for forecasting, an incremental approach known as the "pivot point" method was 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 below.

B.2 TOTAL DEMAND MODEL

The Total Demand Model, shown in Equation 1, provides a mechanism for assessing overall growth in the travel market.

Equation 1:

$$T_{ijp} = e^{\beta_{0p}}(SE_{ijp})^{\beta_{1p}} e^{\beta_{2p} U_{ijp}}$$

Where,

T_{ijp}	=	Number of trips between zones *i* and *j* for trip purpose *p*
SE_{ijp}	=	Socioeconomic variables for zones *i* and *j* for trip purpose *p*
U_{ijp}	=	Total utility of the transportation system for zones *i* to *j* for trip purpose *p*
$\beta_{0p}, \beta_{1p}, \beta_{2p}$	=	Coefficients for trip purpose *p*

As shown in Equation 1, 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, Commuter,* Casino, and *Other*. Socioeconomic characteristics consist of population, employment and per capita income. The utility function provides a logical and intuitively sound method of assigning a value to the travel opportunities provided by the overall transportation system.

In the Total 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. The Total Demand Model equation may be interpreted as meaning that travel between zones will increase as socioeconomic factors such as population and income rise or as the utility (or quality) of the transportation system is improved by providing new facilities and services that reduce travel times and costs. The Total Demand Model can therefore be used to evaluate the effect of changes in both socioeconomic and travel characteristics on the total demand for travel.

B.2.1 SOCIOECONOMIC VARIABLES

The socioeconomic variables in the Total Demand Model show the impact of economic growth on travel demand. The *COMPASS™* Model System, in line with most intercity modeling systems, uses three variables (population, employment and per capita income) to represent the socioeconomic characteristics of a zone. Different combinations were tested in the calibration process and it was found, as is typically found elsewhere, that the most reasonable and stable relationships consists of the following formulations:

Trip Purpose	***Socioeconomic Variable***
Business	$E_iE_j(I_i + I_j) / 2$
Commuter	$(P_iE_j+P_jE_i) / 2\ (I_i+I_j) / 2$
Other,Casino	$P_iP_j(I_i + I_j) / 2$

The Business formulation consists of a product of employment in the origin zone, employment in the destination zone, and the average per capita income of the two zones. Since business trips are usually made between places of work, the presence of employment in the formulation is reasonable. The Commuter formulation consists of all socioeconomic factors; this is because commuter trips are between homes and places of work, which are closely related to population and employment. The formulation for Casino and Other consists of a product of population in the origin zone, population in the destination zone and the average per capita income of the two zones. Casino and Other trips encompass many types of trips, but the majority is home-based and thus, greater volumes of trips are expected from zones from higher population and income

B.2.2 TRAVEL UTILITY

Estimates of travel utility for a transportation network are generated as a function of generalized cost (GC), as shown in Equation 2:

Equation 2:

$$U_{ijp} = f(GC_{ijp})$$

Where,

GC_{ijp} = Generalized Cost of travel between zones *i* and *j* for trip purpose *p*

Because the generalized cost variable is 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. For the public modes (i.e., rail, bus and air), the generalized cost of travel 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, as shown in Equation 3. The generalized cost (GC) of travel between zones *i* and *j* for mode m and trip purpose *p* is calculated as follows:

Equation 3:

$$GC_{ijmp} = TT_{ijm} + \frac{TC_{ijmp}}{VOT_{mp}} + \frac{VOF_{mp} OH}{VOT_{mp} F_{ijm} C_{ijm}} + \frac{VOR_{mp} \exp(-OTP_{ijm})}{VOT_{mp}}$$

Where,

TT_{ijm}	=	Travel Time between zones *i* and *j* for mode *m* (in-vehicle time + station wait time + connection wait time + access/egress time + interchange penalty), with waiting, connect and access/egress time multiplied by a factor (greater than 1) to account for the additional disutility felt by travelers for these activities
TC_{ijmp}	=	Travel Cost between zones *i* and *j* for mode *m* and trip purpose *p* (fare + access/egress cost for public modes, operating costs for auto)
VOT_{mp}	=	Value of Time for mode *m* and trip purpose *p*
VOF_{mp}	=	Value of Frequency for mode *m* and trip purpose *p*
VOR_{mp}	=	Value of Reliability for mode *m* and trip purpose *p*
F_{ijm}	=	Frequency in departures per week between zones *i* and *j* for mode *m*
C_{ijm}	=	Convenience factor of schedule times for travel between zones *i* and *j* for mode *m*
OTP_{ijm}	=	On-time performance for travel between zones *i* and *j* for mode *m*
OH	=	Operating hours per week

Station wait time is the time spent at the station before departure and after arrival. Air travel generally has higher wait times because of security procedures at the airport, baggage checking, and the difficulties of loading a plane. Air trips were assigned wait times of 45 minutes while rail trips were assigned wait times of 30 minutes and bus trips were assigned wait times of 20 minutes. On trips with connections, there would be additional wait times incurred at the connecting station. Wait times are weighted higher than in-vehicle time in the generalized cost formula to reflect their higher disutility as found from previous studies. Wait times are weighted 70 percent higher than in-vehicle time for *Business* trips and 90 percent higher for *Commuter*, *Casino* and *Other* trips.

Similarly, access/egress time has a higher disutility than in-vehicle time. Access time tends to be more stressful for the traveler than in-vehicle time because of the uncertainty created by trying to catch the flight or train. Based on previous work, access time is weighted 30 percent higher than in-vehicle time for air travel and 80 percent higher for rail and bus travel.

TEMS has found from past studies that the physical act of transferring trains (or buses or planes) has a negative impact beyond the times involved. To account for this disutility, interchanges are penalized time equivalents. For both air and rail travel, each interchange for a trip results in 40 minutes being added to the *Business* generalized cost and 30 minutes being added to the *Commuter, Casino and Other* generalized cost. For bus travel, the interchange penalties are 20 minutes and 15 minutes for *Business* and *Other*, respectively.

The third term in the generalized cost function converts the frequency attribute into time units. Operating hours divided by frequency is a measure of the headway or time between departures. Tradeoffs are made in the stated preference surveys resulting in the value of frequencies on this measure. Although there may appear to some double counting because the station wait time in the first term of the generalized cost function is included in this headway measure, it is not the headway time itself that is being added to the generalized cost. The third term represents the impact of perceived frequency valuations on generalized cost. TEMS has found it very convenient to measure this impact as a function of the headway.

The fourth term of the generalized cost function is a measure of the value placed on reliability of the mode. Reliability statistics in the form of on-time performance (i.e., the fraction of trips considered to be on time) were obtained for the rail and air modes only. The negative exponential form of the reliability term implies that improvements from low levels of reliability have slightly higher impacts than similar improvements from higher levels of reliability.

B.2.3 CALIBRATION OF THE TOTAL DEMAND MODEL

In order to calibrate the Total Demand Model, the coefficients are estimated using linear regression techniques. Equation 1, the equation for the Total Demand Model, is transformed by taking the natural logarithm of both sides, as shown in Equation 4:

Equation 4:

$$\log(T_{ijp}) = \beta_{0p} + \beta_{1p}\log(SE_{ijp}) + \beta_{2p}(U_{ijp})$$

Equation 4 provides the linear specification of the model necessary for regression analysis.

The segmentation of the database by trip purpose and trip length resulted in four sets of models. Trips that would cover more than 170 miles are considered long-distance trips. Some previous studies show the traveler's behaviors are different, but in this study, as shown in the following exhibits, the difference of long distance trips and short distance trips are small. The t-test of the long distance and short distance model also shows the coefficients are not significantly different. However, two models calibrated for long and short distance are more accurate to describe the relationship between trips and socioeconomic variables and utilities than one model without distance differentiation does. It should be noted that most of trips in our study area fall into the short distance range since the distance between Minneapolis and Duluth is only about 150 miles. The long distance trips to casino are less than 1 percent of total casino trips, so only the short distance casino trips model are calibrated. The results of the calibration for the Total Demand Models are displayed in Exhibit B-1.

Exhibit B-1: Total Demand Model Coefficients [1]

Long-Distance Trips (trip length greater than 170 miles)

Business	$\log(T_{ij})$ =	-25.17+	1.08 U_{ij} + (45)	1.12 $\log(SE_{ij})$ (132)	R^2=0.94

where $U_{ij} = Log(e^{2.59+0.89*U_{Public}} + e^{-0.01*GC_{Auto}})$ for Business

Commuter	$\log(T_{ij})$ =	-18.59+	0.99 U_{ij} + (127)	0.75 $\log(SE_{ij})$ (75)	R^2=0.93

where $U_{ij} = Log(e^{1.46+0.99*U_{Public}} + e^{-0.02*GC_{Auto}})$ for Commuter

Other	$\log(T_{ij})$ =	- 17.45 +	1.02 U_{ij} + (104)	0.83 $\log(SE_{ij})$ (91)	R^2=0.94

where $U_{ij} = Log(e^{-5.24+0.97*U_{Public}} + e^{-0.01*GC_{Auto}})$

Short-Distance Trips (trip length less than 170 miles)

Business	$\log(T_{ij})$ =	-27.75+	1.17 U_{ij} + (30)	1.15 $\log(SE_{ij})$ (60)	R^2=0.70

where $U_{ij} = Log(e^{1.56+0.93*U_{Public}} + e^{-0.01*GC_{Auto}})$ for Business

Commuter	$\log(T_{ij})$ =	-10.67+	0.99 U_{ij} + (57)	0.53 $\log(SE_{ij})$ (26)	R^2=0.65

where $U_{ij} = Log(e^{-1.57+0.98*U_{Public}} + e^{-0.03*GC_{Auto}})$ for Commuter

Casino	$\log(T_{ij})$ =	0.68+	1.07 U_{ij} + (402)	0.57 $\log(SE_{ij})$ (129)	R^2=0.94

where $U_{ij} = Log(e^{-2.32+0.88*U_{Public}} + e^{-0.04*GC_{Auto}})$ for Casino

Other	$\log(T_{ij})$ =	- 20.52 +	1.15 U_{ij} + (37)	0.54 $\log(SE_{ij})$ (29)	R^2=0.55

where $U_{Total} = Log(e^{-7.07+0.95*U_{Public}} + e^{-0.02*GC_{Auto}})$ for Other

[1] *t-statistics are given in parentheses.*

In evaluating the validity of a statistical calibration, there are two key statistical measures: *t*-statistics and R^2. The *t*-statistics are a measure of the significance of the model's coefficients; values of 2 and above are considered "good" and imply that the variable has significant explanatory power in estimating the level of trips. The R^2 is a statistical measure of the "goodness of fit" of the model to the data; any data point that deviates from the model will reduce this measure. It has a range from 0 to a perfect 1, with 0.4 and above considered "good" for large data sets.

Based on these two measures, the total demand calibrations are good. The *t*-statistics are very high, aided by the large size of the Duluth-Minneapolis data set. The R^2 values imply very good fits of the equations to the data.

As shown in Exhibit 1, the average socioeconomic elasticity values for the Total Demand Model is 0.69 for short distance trips and 0.90 for long distance trips, meaning that each one percent growth in the socioeconomic term generates approximately a 0.69 percent growth in short distance trips and a 0.90 percent growth in long distance trips.

The coefficient on the utility term is not exactly elasticity, but it can be used as an approximation. Thus, the average utility elasticity of the transportation system or network is almost same for short-distance trips and long-distance trips, with each one percent improvement in network utility or quality as measured by generalized cost (i.e., travel times or costs) generating approximately a 1.03 percent increase for long-distance trips and a 1.10 percent increase for short trips. The slightly higher elasticity on short trips is partly a result of the scale of the generalized costs. For short trips, a 30-minute improvement would be more meaningful than the same time improvement on long-distance trips, reflecting in the higher elasticity on the short-distance model.

The positive intercepts for casino trips means as a special generator zone, the trips to Hinckley casino cannot be fully explained by socioeconomic and network utilities. That is to say with the similar level of population, income or employment and similar transportation costs; Hinckley will generate more trips than common zones. This is also why Hinckley and casino should be treated differently than other zones in this study.

B.2.4 INCREMENTAL FORM OF THE TOTAL DEMAND MODEL

The calibrated Total Demand Models could be used to estimate the total travel market for any zone pair using the population, employment, per capita income, and the total utility of all the modes. However, there would be significant differences between estimated and observed levels of trip making for many zone pairs despite the good fit of the models to the data. To preserve the unique travel patterns contained in the base data, the incremental approach or "pivot point" method is used for forecasting. In the incremental approach, the base travel data assembled in the database are used as pivot points, and forecasts are made by applying trends to the base data. The total demand equation as described in Equation 1 can be rewritten into the following incremental form that can be used for forecasting (Equation 5):

Equation 5:

$$\frac{T_{ijp}{}^{f}}{T_{ijp}{}^{b}} = \left(\frac{SE_{ijp}{}^{f}}{SE_{ijp}{}^{b}}\right)^{\beta_{1p}} \exp(\beta_{2p}\,(U_{ijp}{}^{f} - U_{ijp}{}^{b}))$$

Where,

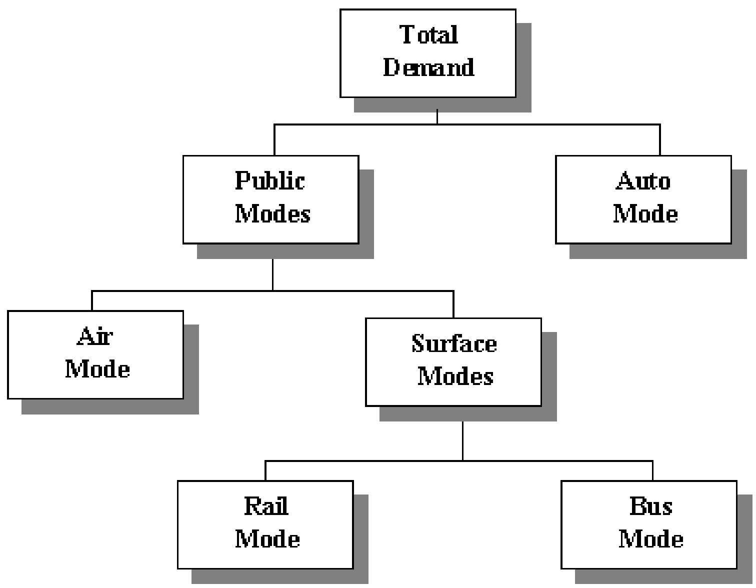
T^{f}_{ijp}	=	Number of Trips between zones *i* and *j* for trip purpose *p* in forecast year *f*
T^{f}_{ijp}	=	Number of Trips between zones *i* and *j* for trip purpose *p* in base year *b*
SE^{f}_{ijp}	=	Socioeconomic variables for zones *i* and *j* for trip purpose *p* in forecast year *f*
SE^{b}_{ijp}	=	Socioeconomic variables for zones *i* and *j* for trip purpose *p* in base year *b*
U^{f}_{ijp}	=	Total utility of the transportation system for zones *i* to *j* for trip purpose *p* in forecast year *f*
U^{b}_{ijp}	=	Total utility of the transportation system for zones *i* to *j* for trip purpose *p* in base year *b*

In the incremental form, the constant term disappears and only the elasticities are important.

B.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 Exhibit B-2, three levels of binary choice are calibrated.

Exhibit B-2: Hierarchical Structure of the Modal Split Model

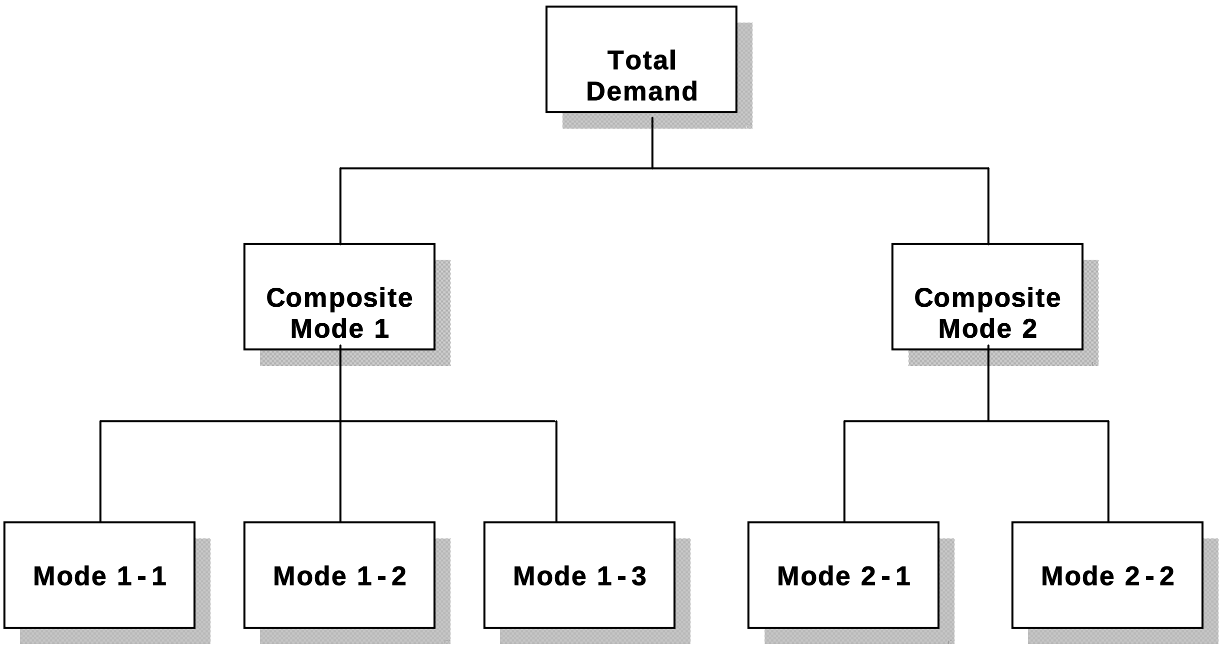


The main feature of the Hierarchical Modal Split Model structure is the increasing commonality of travel characteristics as the structure descends. The first level of the hierarchy separates private auto travel – with its spontaneous frequency, low access/egress times, low costs and highly personalized characteristics – from the public modes. The second level of the structure separates air – the fastest, most expensive and perhaps most frequent and comfortable public mode – from the rail and bus surface modes. The lowest level of the hierarchy separates rail, a potentially faster, more reliable, and more comfortable mode, from the bus mode.

B.3.1 FORM OF THE HIERARCHICAL MODAL SPLIT MODEL

The modal split models used by TEMS derived from the standard nested logit model. Exhibit B-3 shows a typical two-level standard nested model. In the nested model shown in Exhibit B-3, there are five travel modes that are grouped into two composite modes, namely, Composite Mode 1 and Composite Mode 2.

Exhibit B-3: A Typical Standard Nested Logit Model



Each travel mode in the above model has a utility function of U_j, j = 1, 2, 3, 4, 5. To assess modal split behavior, the logsum utility function, which is derived from travel utility theory, has been adopted for the composite modes in the model. As the modal split hierarchy ascends, the logsum utility values are derived by combining the utility of lower-level modes. The composite utility is calculated by

$$U_{N_k} = \alpha_{N_k} + \beta_{N_k} \log \sum_{i \in N_k} \exp(\rho U_i) \qquad (1)$$

where

N_k is composite mode k in the modal split model,

i is the travel mode in each nest,

U_i is the utility of each travel mode in the nest,

ρ is the nesting coefficient.

The probability that composite mode k is chosen by a traveler is given by

$$P(N_k) = \frac{\exp(U_{N_k} / \rho)}{\sum_{N_i \in N} \exp(U_{N_i} / \rho)} \qquad (2)$$

The probability of mode *i* in composite mode *k* being chosen is

$$P_{N_k}(i) = \frac{\exp(\rho U_i)}{\sum_{j \in N_k} \exp(\rho U_j)} \quad (3)$$

A key feature of these models is a use of utility. Typically in transportation modeling, the utility of travel between zones *i* and *j* by mode *m* for purpose *p* is a function of all the components of travel time, travel cost, terminal wait time and cost, parking cost, etc. This is measured by generalized cost developed for each origin-destination zone pair on a mode and purpose basis. In the model application, the utility for each mode is estimated by calibrating a utility function against the revealed base year mode choice and generalized cost.

Using logsum functions, the generalized cost is then transformed into a composite utility for the composite mode (e.g. Surface and Public in Exhibit 2). This is then used at the next level of the hierarchy to compare the next most similar mode choice (e.g. in Exhibit B-2, Surface is compared with Air mode).

B.3.2 DEGENERATE MODAL SPLIT MODEL

For the purpose of Duluth-Minneapolis Corridor Study (and other intercity high speed rail projects), TEMS has adopted a special case of the standard logit model, the degenerate nested logit model [*Louviere, et.al., 2000*]. This is because in modeling travel choice, TEMS has followed a hierarchy in which like modes are compared first, and then with gradually more disparate modes as progress is made up the hierarchy, this method provides the most robust and statistically valid structure. This means however, that there are singles modes being introduced at each level of the hierarchy and that at each level the composite utility of two modes combined at the lower level (e.g. the utility of Surface mode combined from Rail and Bus modes) is compared with the generalized cost of a single mode (e.g. Air mode). It is the fact that the utilities of the two modes being compared are measured by different scales that creates the term degenerate model. The result of this process is that the nesting coefficient is subsumed into the hierarchy and effectively cancels out in the calculation. That is why TEMS set ρ to 1 when using this form of the model in *COMPASS™*.

Take the three-level hierarchy shown in Exhibit 2 for example, the utilities for the modes of Rail and Bus in the composite Surface mode are

$$U_{Rail} = \alpha_{Rail} + \beta_{Rail} GC_{Rail} \quad (4)$$

$$U_{Bus} = \beta_{Bus} GC_{Bus} \quad (5)$$

The utility for the composite Surface mode is

$$U_{Surface} = \alpha_{Surface} + \beta_{Surface} \log[\exp(\rho U_{Rail}) + \exp(\rho U_{Bus})] \quad (6)$$

The utility for the Air mode is

$$U_{Air} = \beta_{Air} \log[\exp(\rho GC_{Air})] = \rho \beta_{Air} GC_{Air} \quad (7)$$

Then the mode choice model between Surface and Air modes are

$$P(Surface) = \frac{\exp(U_{Surface} / \rho)}{\exp(U_{Surface} / \rho) + \exp(U_{Air} / \rho)} \quad (8)$$

It can be seen in equation (7) that $U_{Air} = \rho\beta_{Air}GC_{Air}$, the term of $\exp(U_{Air} / \rho)$ in equation (8) reduces to $\exp(\beta_{Air}GC_{Air})$, thus that the nesting coefficient ρ is canceled out in the single mode nest of the hierarchy. As a result, ρ loses its statistical meaning in the nested logit hierarchy, and leads to the degenerate form of the nested logit model, where ρ is set to 1

B.3.3 CALIBRATION OF THE HIERARCHICAL MODAL SPLIT MODEL

Working from the bottom of the hierarchy up to the top, the first analysis is that of the rail mode versus the bus mode. As shown in Exhibit B-4, the model was effectively calibrated for the four (three for long distance trip) trip purposes and the two trip lengths, with reasonable parameters and R^2 and *t* values. All the coefficients have the correct signs such that demand increases or decreases in the correct direction as travel times or costs are increased or decreased, and all the coefficients appear to be reasonable in terms of the size of their impact.

Exhibit B-4: Rail versus Bus Modal Split Model Coefficients [(1)]

Long-Distance Trips (trip length greater than 170 miles)					
Business	log(PRail/PBus) =	2.95	- 0.01 GCRail (33)	+ 0.01GCBus (25)	R2=0.70
Commuter	log(PRail/PBus) =	4.10	- 0.02 GCRail (118)	+0.02 GCBus (88)	R2=0.93
Other	log(PRail/PBus) =	2.52	-0.01 GCRail (45)	+0.01GCBus (72)	R2=0.90
Short-Distance Trips (trip length less than 170 miles)					
Business	log(PRail/PBus) =	3.39	- 0.01 GCRail (154)	+ 0.01GCBus (83)	R2=0.92
Commuter	log(PRail/PBus) =	3.60	- 0.03 GCRail (361)	+0.04 GCBus (300)	R2=0.96
Casino	log(PRail/PBus) =	-1.41	- 0.01 GCRail (20)	+ 0.01 GCBus (22)	R2=0.88
Other	log(PRail/PBus) =	2.49	- 0.02 GCRail (286)	+ 0.03GCBus (199)	R2=0.93

[(1)] *t-statistics are given in parentheses.*

The constant term in each equation indicates the degree of bias towards one mode or the other. For example, if the constant term is positive, there is a bias towards rail travel that is not explained by the variables (e.g., times, costs, frequencies, reliability) used to model the modes. In considering the bias it is important to recognize that small values indicate little or no bias, and that small values have error ranges that include both positive and negative values. However, large biases may well reflect strong feelings to a modal option due to its innate character or network structure. The terms of Business Commuter and Other trips are positive in all the market segments; this means that there is a bias towards rail travel. The constant term of casino is negative. It is because, in the base rail network, the Hinckley casino is connected by a shuttle bus service and rail service (frequency is 2 trains/day and speed is 79mph) is not attractive to gambler and tourists.

For the second level of the hierarchy, the analysis is of the surface modes (i.e., rail and bus) versus air. Accordingly, the utility of the surface modes is obtained by deriving the logsum of the utilities of rail and bus. As shown in Exhibit B-5, the model calibrations for both trip purposes are all statistically significant, with good R^2 and *t* values and reasonable parameters. As indicated by the constant terms, there are biases towards the air mode for both long and short distant trips. The biases for short distant trips are relatively smaller and this is understandable since travelers for long distance trips prefer air travel to travelers for short distance trips.

Exhibit B-5: Surface versus Air Modal Split Model Coefficients (1)

Long-Distance Trips (trip length greater than 170 miles)

Purpose	Equation	R^2
Business	$\log(P_{Surf}/P_{Air}) = -0.30 + 0.99U_{Surf} + 0.01GC_{Air}$ t: (2973) (11)	R^2=0.95
	where $U_{Surface} = Log(e^{2.95-0.01*GC_{Rail}} + e^{-0.01*GC_{Bus}})$ for Business	
Commuter	$\log(P_{Surf}/P_{Air}) = -8.83 + 0.99U_{Surf} + 0.01\,GC_{Air}$ t: (101) (44)	R^2=0.92
	where $U_{Surface} = Log(e^{4.10-0.02*GC_{Rail}} + e^{-0.02*GC_{Bus}})$ for Commuter	
Other	$\log(P_{Surf}/P_{Air}) = -2.12 + 0.99\,U_{Surf} + 0.03\,GC_{Air}$ t: (5892) (169)	R^2=0.96
	where $U_{Surface} = Log(e^{2.52-0.01*GC_{Rail}} + e^{-0.01*GC_{Bus}})$ for Other	

Short-Distance Trips (*trip length less than 170 miles*)

Purpose	Equation	R^2
Business	$\log(P_{Surf}/P_{Air}) = -0.20 + 0.98U_{Surf} + 0.01\,GC_{Air}$ t: (77) (17)	R^2=0.88
	where $U_{Surface} = Log(e^{3.39-0.01*GC_{Rail}} + e^{-0.01*GC_{Bus}})$ for Business	
Commuter	$\log(P_{Surf}/P_{Air}) = -8.23 + 0.99U_{Surf} + 0.03\,GC_{Air}$ t: (227) (110)	R^2=0.95
	where $U_{Surface} = Log(e^{3.60-0.03*GC_{Rail}} + e^{-0.04*GC_{Bus}})$ for Commuter	
Casino	$\log(P_{Surf}/P_{Air}) = -6.23 + 0.98U_{Surf} + 0.02\,GC_{Air}$ t: (10) (4)	R^2=0.94
	where $U_{Surface} = Log(e^{-1.41-0.01*GC_{Rail}} + e^{-0.01*GC_{Bus}})$ for Casino	
Other	$\log(P_{Surf}/P_{Air}) = -1.99 + 0.96\,U_{Surf} + 0.01\,GC_{Air}$ t: (149) (42)	R^2=0.92
	where $U_{Surface} = Log(e^{2.49-0.02*GC_{Rail}} + e^{-0.03*GC_{Bus}})$ for Other	

(1) t-statistics are given in parentheses.

The analysis for the top level of the hierarchy is of auto versus the public modes. The utility of the public modes is obtained by deriving the logsum of the utilities of the air, rail and bus modes.

As shown in Exhibit B-6, the model calibrations for both trip purposes are all statistically significant, with good R^2 and *t* values and reasonable parameters in most cases. The constant terms show that Business, Commuter trips have a bias toward for public mode, while Casino and Other trips prefer auto mode. A reason for why the R^2 value for the short-distance model is a bit lower than in the rest of the model is due to the fact that local transit trips are not included in the public trip database, causing some of the observations to deviate significantly from the model equation.

Exhibit B-6: Public versus Auto Hierarchical Modal Split Model Coefficients [(1)]

Long-Distance Trips (trip length greater than 170 miles)

Business (298) $\log(P_{Pub}/P_{Auto}) = 2.59\ (28) + 0.89\ U_{Pub} + 0.01\ GC_{Auto}$ $R^2=0.95$

where $U_{Public} = Log(e^{-0.30+0.99*U_{Surface}} + e^{-0.01*GC_{Air}})$

Commuter (110) $\log(P_{Pub}/P_{Auto}) = 1.46\ (44) + 0.99\ U_{Pub} + 0.02\ GC_{Auto}$ $R^2=0.94$

where $U_{Public} = Log(e^{-8.83+0.99*U_{Surface}} + e^{-0.01*GC_{Air}})$

Other (1265) $\log(P_{Pub}/P_{Auto}) = -5.24\ (47) + 0.97\ U_{Pub} + 0.01\ GC_{Auto}$ $R^2=0.96$

where $U_{Public} = Log(e^{-2.12+0.99*U_{Surface}} + e^{-0.03*GC_{Air}})$

Short-Distance Trips (trip length less than 170 miles)

Business (2652) $\log(P_{Pub}/P_{Auto}) = 1.56\ (32) + 0.93\ U_{Pub} + 0.01\ GC_{Auto}$ $R^2=0.94$

where $U_{Public} = Log(e^{-0.20+0.98*U_{Surface}} + e^{-0.01*GC_{Air}})$

Commuter (119) $\log(P_{Pub}/P_{Auto}) = 1.57\ (45) + 0.98\ U_{Pub} + 0.03\ GC_{Auto}$ $R^2=0.85$

where $U_{Public} = Log(e^{-8.23+0.99*U_{Surface}} + e^{-0.03*GC_{Air}})$

Casino (303) $\log(P_{Pub}/P_{Auto}) = -2.32\ (2) + 0.88\ U_{Pub} + 0.04\ GC_{Auto}$ $R^2=0.86$

where $U_{Public} = Log(e^{-6.23+0.98*U_{Surface}} + e^{-0.02*GC_{Air}})$

Other (1212) $\log(P_{Pub}/P_{Auto}) = -7.07\ (45) + 0.95\ U_{Pub} + 0.02\ GC_{Auto}$ $R^2=0.84$

where $U_{Public} = Log(e^{-1.99+0.96*U_{Surface}} + e^{-0.01*GC_{Air}})$

[(1)] *t-statistics are given in parentheses.*

B.4 INCREMENTAL FORM OF THE MODAL SPLIT MODEL

Using the same reasoning as previously described, the modal split models are applied incrementally to the base data rather than imposing the model estimated modal shares. Different regions of the corridor may have certain biases toward one form of travel over another and these differences cannot be captured with a single model for the entire system. Using the "pivot point" method, many of these differences can be retained. To apply the modal split models incrementally, the following reformulation of the hierarchical modal split models is used (Equation 6):

Equation 6:

$$\frac{\left(\frac{P_A^f}{P_B^f}\right)}{\left(\frac{P_A^b}{P_B^b}\right)} = e^{\beta(GC_A^f - GC_B^b) + \gamma(GC_B^f - GC_B^b)}$$

For hierarchical modal split models that involve composite utilities instead of generalized costs, the composite utilities would be used in the above formula in place of generalized costs. Once again, the constant term is not used and the drivers for modal shifts are changed in generalized cost from base conditions.

Another consequence of the pivot point method is that it prevents possible extreme modal changes from current trip-making levels as a result of the calibrated modal split model, thus that avoid over- or under- estimating future demand for each mode.

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