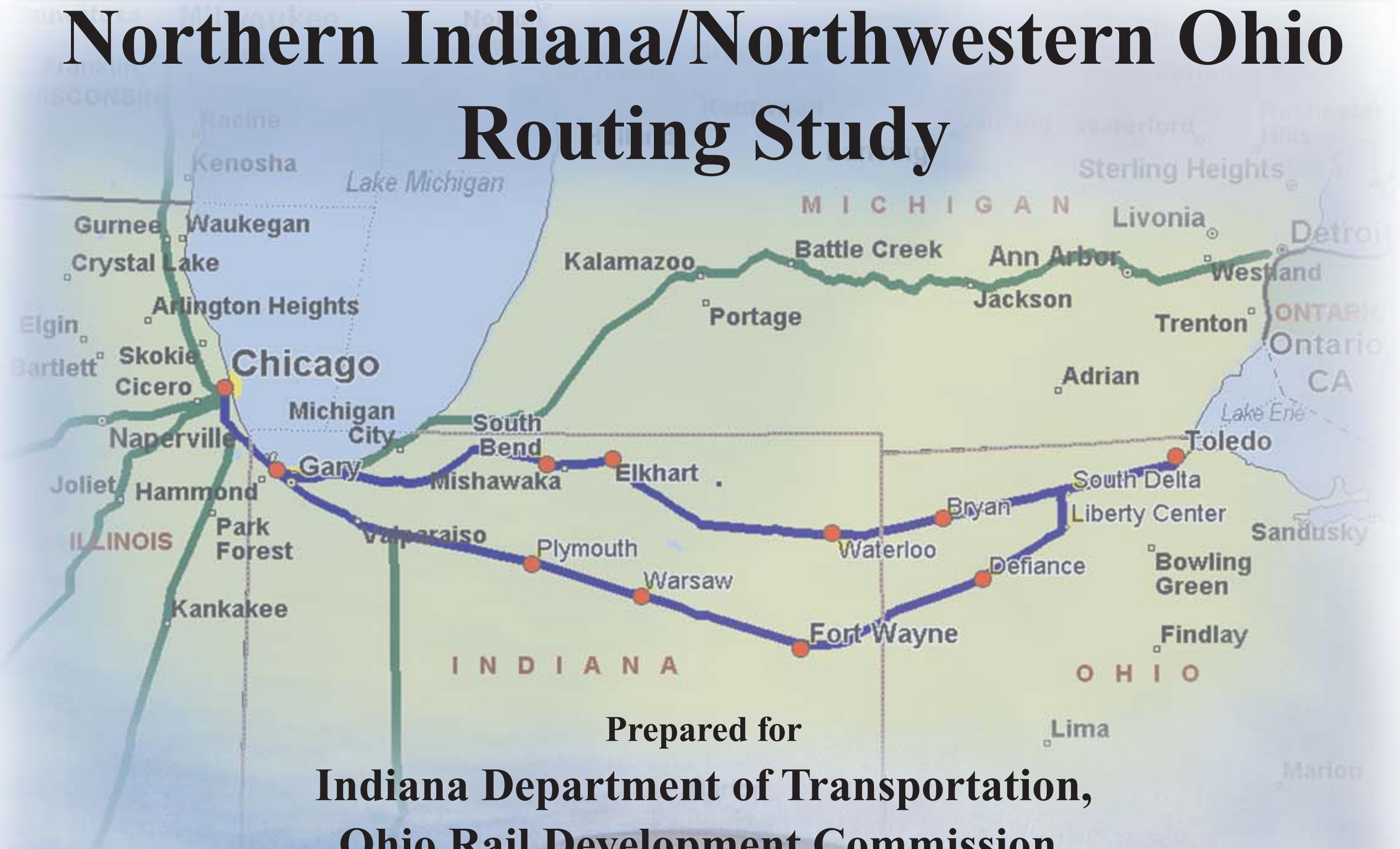
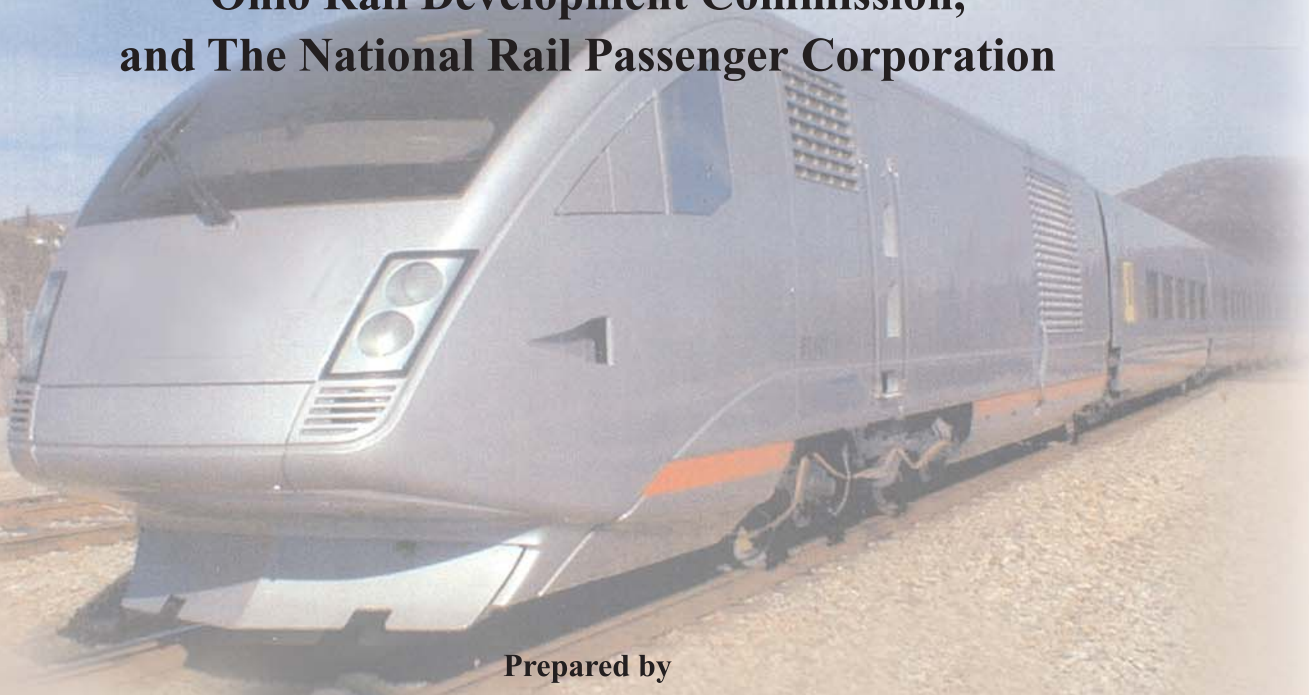
Northern Indiana/Northwestern Ohio Routing Study



Prepared for

Indiana Department of Transportation, Ohio Rail Development Commission, and The National Rail Passenger Corporation



Prepared by

TEMS

Transportation Economics & Management Systems, Inc.
116 Record Street • Frederick, MD 21701
301.846.0700 • fax 301.846.0740

in association with

HNTB

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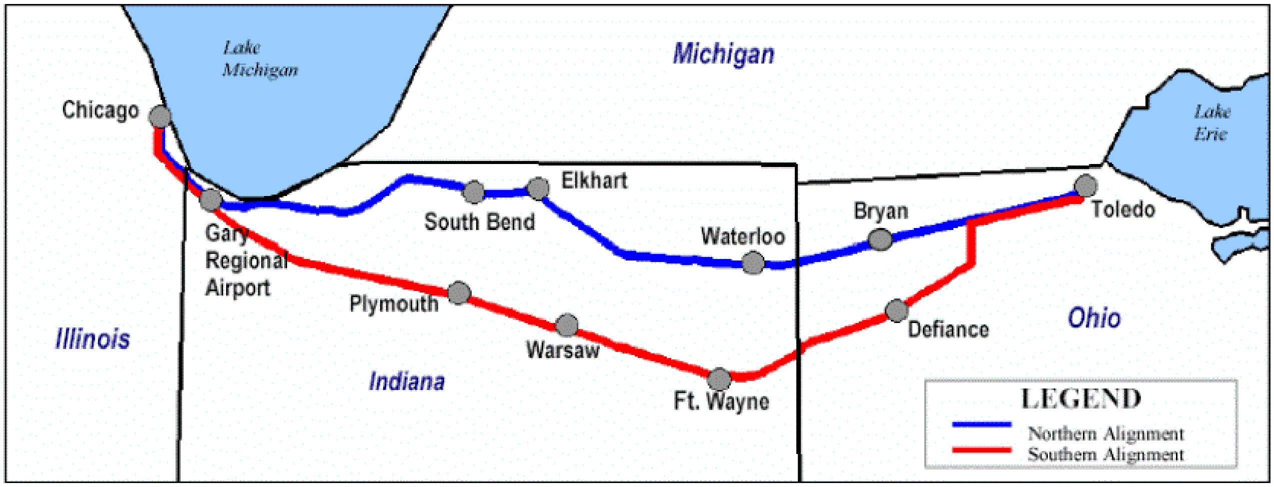
Executive Summary

Intercity passenger rail service through Northern Indiana and Ohio plays an important role in the Midwest Regional Rail Initiative (MWRRI). The MWRRI is an on-going effort involving nine Midwest states, Amtrak, and the Federal Railroad Administration to investigate and develop an improved and expanded passenger rail network in the Midwest. This study's goal is to determine, at a conceptual level, the financial and economic feasibility of alternative alignments in the Chicago-Cleveland corridor and to provide a recommended alternative for further analysis. The Chicago-Cleveland corridor serves as an integral part of the overall MWRRI network and Indiana and Ohio's intercity passenger rail system and two possible alignments are outlined in this report: a "Northern" Route and a "Southern" Route (See Exhibit 1). This cost-benefit study is being carried out prior to any negotiations with the freight railroads or the identification of specific funding sources. These issues will need to be addressed as part of any EIS Alternatives Analysis that will be needed should the states pursue the implementation of the project.

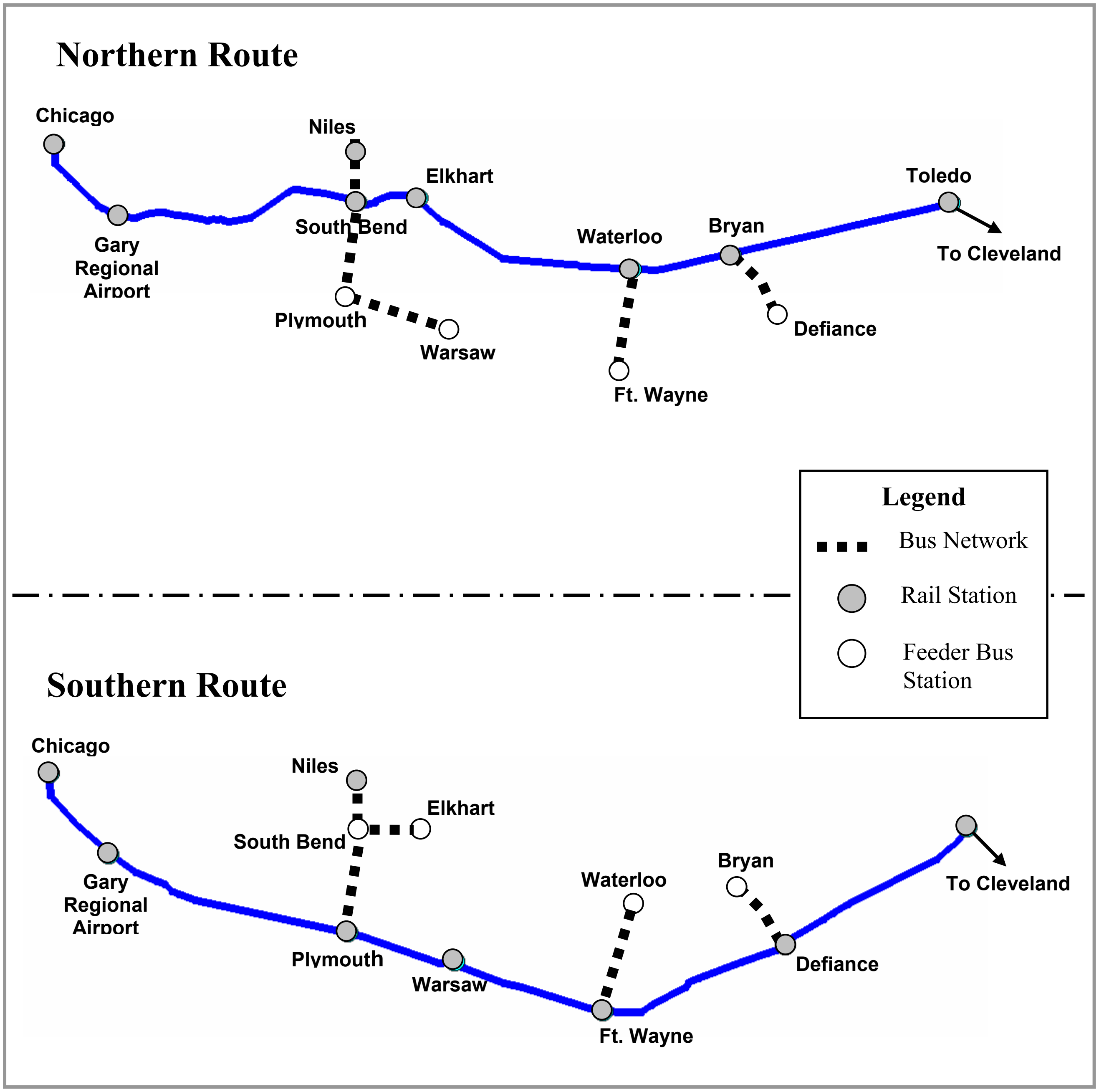
Exhibit 1: Alternative Alignments



A cost-benefit analysis of each alignment provides an assessment of the financial and economic returns and the basis by which to compare the routes. These assessments compare the sum of discounted revenue and benefits with the sum of discounted costs to determine the financial and economic feasibility of each alternative alignment. Discounted benefits and costs are the total dollar amounts over an extended time, discounted back to current dollar values. The total benefits include more than simply the revenues generated by riders. It also includes the Consumer Surplus and the benefits to other travel modes. Consumer Surplus measures the total benefit or value that travelers receive beyond what they pay for that service. For the financial and cost-benefit analysis, the Net Present Value (NPV) was computed for the 2013-2042 period. These dates were used for consistency with the rest of the MWRRI analysis. The assumption is that, by 2013, full development of the routes in the Midwest will have occurred allowing ridership numbers to represent all connected cities on the routes. While this is the assumption of this study, it is not meant to imply that the line will necessarily be operational by 2013. Much of the timing of the development of the system will depend on the rate at which funding programs become available.

The capital costs, operating expenses and revenues were estimated for both routes using MWRRI analysis methods for the 2013-2042 period, which corresponds to the 30-year life-cycle horizon of the project. To ensure an equal comparison of both routes, service levels for each were made the same. In other words, the operating strategies that were created for the alternatives have equal frequency and similar local and express stopping patterns. A system of express feeder buses was added to provide MWRRI service to towns not served directly by the rail system. The express feeder systems were made as mirror images of each other (See Exhibit 2).

Exhibit 2: Proposed Bus Feeder Routes



The Northern Route was the original route defined for the MWRRI, which was largely based on current Amtrak routes. A comparison of the travel distances, times and speeds for the two alternatives is given in Exhibit 3. Express stops for the Northern Route are in South Bend and Toledo, while the express stops for the Southern Route are in Ft. Wayne and Toledo. As detailed in the table below, the Southern route is 13 miles longer than the Northern route. Its travel time, however, is eight to nine minutes faster. Speed limitations through the urbanized portions of the Northern corridor are the primary reasons for the slower overall travel time. Very high freight train density (approximately 90 trains per day) on the Northern line mandated construction plans to show new, separate track for the proposed passenger rail operations. A separation of 26 feet between the center line of the passenger track and the nearest freight track was considered necessary by the owners of the freight line before they would consider supporting the plan for passenger trains reaching their maximum proposed speeds. This desired track separation was not economically or environmentally possible in all areas of the corridor due to limited additional right-of-way through much of the urbanized area described above. This necessitated lower speeds in those areas and slower travel times.

Exhibit 3: Travel Time and Distance Summary

Alternative Route	MWRRS Norfolk Southern- Northern Route	Alternative Southern Route	Difference
Travel Time – Local Stops	5:00	4:52	8 minutes
Travel Time- Express Stops	4:32	4:23	9 minutes
Effective Speed – Local Stops	68 mph	73 mph	5 mph
Effective Speed – Express Stops	75 mph	80 mph	5 mph
Total Mileage	341 miles	354 miles	13 miles

To help receive local input for this study, a steering committee was formed consisting of approximately 30 members. The committee included representatives of the railroads whose lines were being considered as well as officials from local communities. Prior to conducting this study, the Indiana Department of Transportation (INDOT) held a series of public meetings (including meetings in Gary, South Bend, and Fort Wayne) to receive public comment on passenger rail service. Participants at these meetings commented that without the MWRRI, Fort Wayne has no direct passenger rail access, whereas South Bend has direct passenger rail access to Chicago via the Northern Indiana Commuter Transportation District (NICTD). Additionally, comments were voiced expressing a desire to see rail improvements for both major population centers in Northern Indiana, as opposed to only one or the other.

In response to these public comments, two options were considered for the Southern Route. The first option is the base system (i.e., Southern Route and associated bus feeder system), which includes the current NICTD service to South Bend. This first option is used for the even comparison between the Northern and Southern Routes. A second option was created to add NICTD express service from South Bend to Chicago with a stop at Gary where passengers have the ability to transfer to MWRRI service. The additional costs to enhance the NICTD service are included in the costs for this Second Option for the Southern Route. The NICTD express service proposed in this second alternative reduces the travel time from South Bend to Chicago from approximately 2:30 (current) to 2:00 (express service).

Exhibit 4: Cost-Benefit Analysis for the 2013-2042 period

30-Year Net Present Value (in Millions of 2002$)			
Parameter	Northern Route	Southern Route	
		Without Express NICTD	With Express NICTD
Benefits			
Revenue	$1,045.57	$1,169.96	$1,198.88
Consumer Surplus	$1,003.85	$1,235.59	$1,240.14
Other Mode User Benefits			
Airport Congestion	$40.70	$49.08	$49.08
Highway Congestion	$70.21	$94.95	$96.59
Resources Benefits			
Airlines	$21.89	$26.40	$26.40
Emissions	$1.38	$1.65	$1.67
Total Benefits	**$2,183.59**	**$2,577.63**	**$2,612.76**
Total Costs*	**$2,373.43**	**$2,040.73**	**$2,134.99**
Ratio of Benefits to Costs	0.92	1.26	1.22
* Un-negotiated costs that show relative magnitude but may not show final dollar figures.			

Recommendations

The analysis shows that in financial and economic terms, the Southern Route will be more beneficial than the Northern Route. Given its stronger financial and economic performance, the Southern Route is the most cost efficient alternative. It is important to recognize that much of the benefit of the Northern Route is captured by providing express NICTD service to South Bend as part of the Southern Route buildout. This combination maximizes the benefits to travelers in Northern Indiana, Northwest Ohio and across the whole of the MWRRI system, and therefore, the "Southern Route with Express NICTD" is the routing plan recommended by this study.

By proceeding with development of the Southern Route, new direct rail passenger service can be restored to Fort Wayne on the more cost-effective of the two routes while the existing NICTD service to South Bend can be enhanced to ensure continued quality passenger rail service for that community. Direct rail access will be available from South Bend to downtown Chicago, with an additional express stop near the Gary/Chicago Airport where passengers can access high-speed trains to Indianapolis and the western MWRRI states. In addition, express bus service to Niles, MI, and Plymouth, IN, will allow South Bend area rail passengers to access high-speed trains to Cleveland, Detroit and points east. The Southern routing, with lower construction costs and faster travel times, is also beneficial to travelers in Toledo and Cleveland as well as other areas in the Midwest.

Access to the MWRRI network should also be provided to the population in neighboring Elkhart County. In the high-speed rail network, Elkhart has a feeder bus connection to South Bend where passengers can use NICTD service or continue on the bus to the Cleveland and Detroit rail corridors. An extension of NICTD's rail corridor should also be investigated as a possible way to improve future service to Elkhart.

Improvements to the Chicago-to-Cleveland corridor are proposed to occur during the middle phases of the MWRRI buildout plan. This point is made in order to clarify that, despite the recommendations in this report, the construction timetable for the route should not be expected to begin in the immediate future. Additional pre-construction steps would need to occur and, most importantly, a funding source for construction and operation must be established. As part of the proposed MWRRI implementation schedule, other corridors would be under construction before progress would be able to begin on this route.

1. Introduction

This study evaluates two alternative routings for passenger rail service between Chicago and Cleveland. The Midwest Regional Rail Initiative (MWRRI) originally considered only the existing route used by Amtrak that makes stops in Hammond, South Bend, Elkhart, Waterloo, Bryan, Toledo and Cleveland. Under the auspices of the MWRRI implementation program, the Indiana Department of Transportation (INDOT) requested a cost benefit analysis of an alternative route from Chicago via Gary, Plymouth, Warsaw, Ft. Wayne, Defiance, Toledo and Cleveland. The study is designed to identify the most cost effective route that best serves the overall transportation needs of Northern Indiana and Northern Ohio while remaining compatible with the greater MWRRI effort. The scope of the study assesses the potential benefits of this rail service by evaluating the capital and relative operating costs, the projected ridership and revenues, and the financial and economic returns, and compares the two routes.

Transportation Economics & Management Systems, Inc. (TEMS), in association with HNTB, is pleased to provide this cost benefit study report that details the analysis undertaken to assist INDOT and its study partners, the Ohio Rail Development Commission (ORDC) and Amtrak, in selecting the best performing corridor routing for the study region within the framework of the MWRRI. A steering committee has also assisted in providing critical input and review for this study. Of particular importance, on this committee there has been representation from the various railroads – the owners of the corridors being analyzed in the study. In addition, representation on the committee by a number of communities and regional entities located between Gary and Toledo has provided significant input on local issues and current development activities that could affect the analysis.

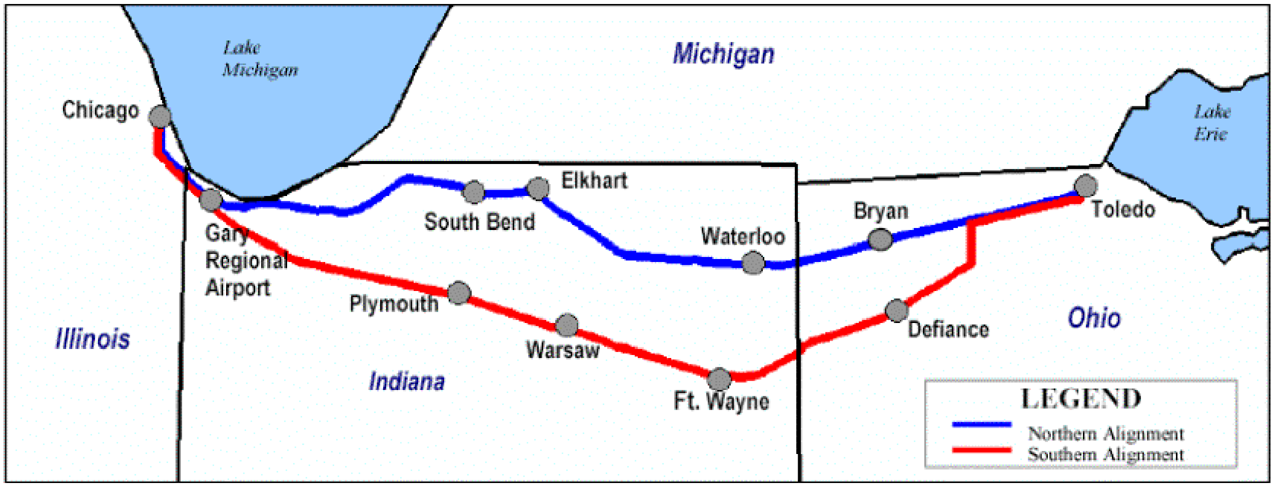
Although important input from the railroads has occurred, it must be stressed that the level of analysis in this study has not included any type of finalized, negotiated costing discussions with the freight railroads or the identification of specific funding sources. These issues will need to be addressed as part of any Environmental Impact Study (EIS) Alternatives Analysis that will be needed should Indiana and Ohio pursue the implementation of the project.

1.1 Study Context

The planned intercity passenger rail system in Indiana and Ohio serves as an integral part of the Midwest Regional Rail Initiative (MWRRI), an on-going effort involving nine Midwest states, Amtrak, and the Federal Railroad Administration to investigate and develop an improved and expanded passenger rail system in the Midwest. In 1998, the MWRRI released its MWRRI Business Plan, which recommended a Midwest Regional Rail System (MWRRS) with three of its eight designated corridors traveling through Indiana with two of these extending into Ohio. The MWRRS consists of a 3,000-mile rail network hubbed in Chicago, with trains operating at speeds up to 110-mph, and an associated feeder bus system.

Currently, the MWRRI is carrying out Phase 4B of the ongoing study process and has contracted TEMS to update its business plan by revisiting each of its corridors in the rail network. The Chicago-Cleveland corridor serves as an integral part of the overall MWRRI network and Indiana and Ohio's intercity passenger rail system. For this corridor, two possible alignments are being considered: a “Northern” Route and a “Southern” Route (See Exhibit 1-1). The Northern Route follows the alignment of the heavily used Norfolk Southern freight corridor from Chicago through Gary, South Bend, Toledo and Cleveland. The alternative Southern Route runs from Chicago through Gary, Ft. Wayne, Toledo and Cleveland. This route uses a CSX corridor and two short line railroads between Gary and Toledo as well as Norfolk Southern in the Ft. Wayne area. The segment west of Gary and east of Delta, Ohio, are the same for both alternatives. This study’s goal is to determine the financial and economic feasibility of the two potential alignments for the corridor.

Exhibit 1-1: Alternative Alignments



1.2 Approach and Methodology

Using the same methodology as used by the MWRRI to assess the Northern Corridor, TEMS evaluated the engineering, operations, ridership, revenue and financial and economic impacts of the Southern alignment via Ft. Wayne. TEMS used its *RightTrack System*©, which consists of a series of models for conducting an interactive analysis of track investment, train operations, ridership and revenue, financial performance, and economic analysis:

- *Trackman*© Track Management System analyzed the required track improvement costs and speeds of a corridor using the MWRRI “generic” 110-mph tilt train technology.

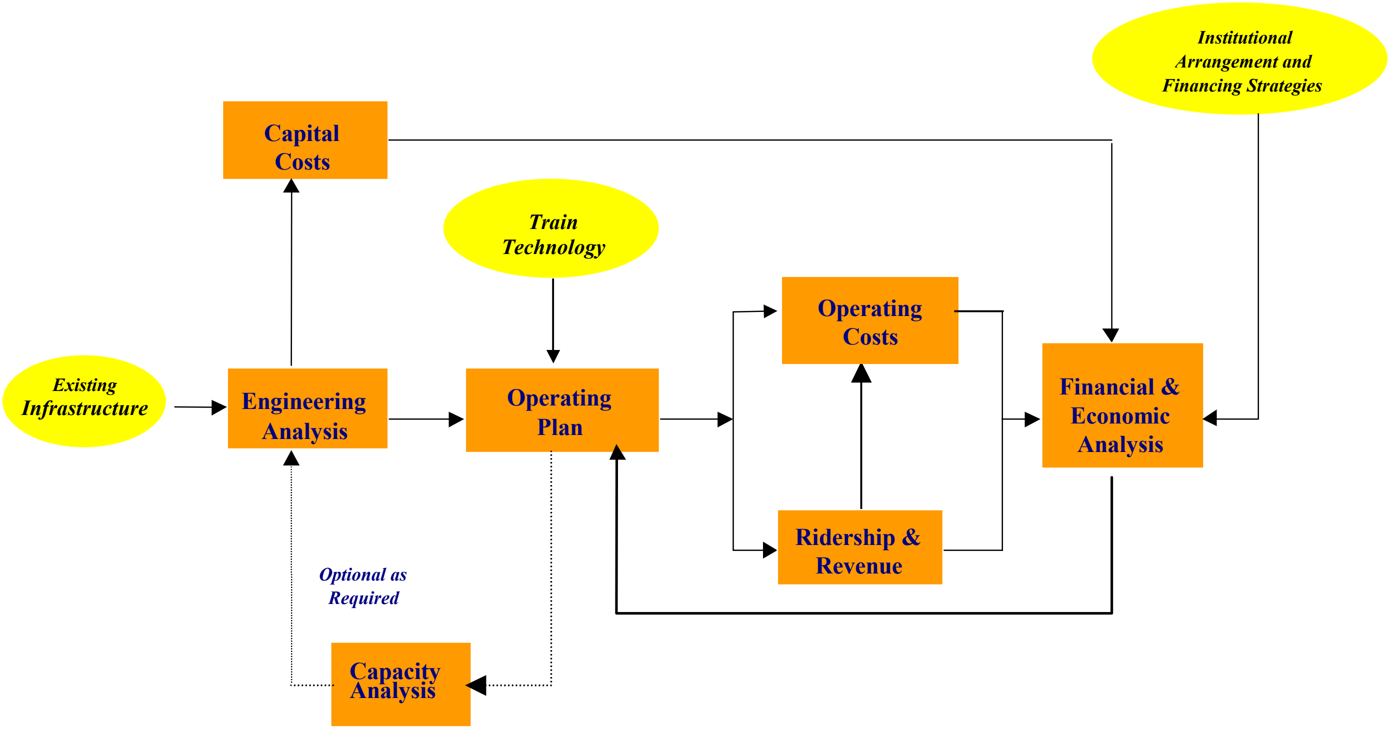
- The *Locomotion*© model assessed the most appropriate level for train service in terms of train frequency and stops for both alignments. To ensure an even comparison, the same number of stations and express and slow trains were adopted for both routes.

- Using the market database developed for Phase 4B of the MWRRI, the *Compass*© model was used to estimate ridership and revenues for both alignments.

- The *Rents*© model was used to assess the value of investment on both routes, taking into account both a comprehensive financial analysis and an economic analysis of user benefits.

Exhibit 1-2 depicts TEMS' approach and illustrates the integrated nature of the analysis and the corresponding feedback for the critical elements of the project.

Exhibit 1-2: TEMS' Interactive Analysis



The analysis takes an interactive approach that considers all factors that impact supply and demand-related issues to ensure a comprehensive analysis of return on investment.

1.3 Organization of Report

The report is organized into sections that address each of the study components.

- Chapter 2 presents the route and infrastructure analysis;
- Chapter 3 describes the operating plan, detailing the service proposed including train frequencies and schedules;
- Chapters 4 & 5 present the *Compass*© Demand Model database development and the results of the ridership and revenue analysis;
- Chapter 6 details the total costs for each routing alternative;
- Chapter 7 describes the economic analysis of total user benefits of the alternative routes along with the conclusions and recommendations;

- Chapter 8 details the NICTD Express Service option;
- Chapter 9 contains the report's conclusions and recommendations.

2. Infrastructure Analysis

This chapter presents the results of a cost comparison assessment of the Southern Route through Fort Wayne with the MWRRS' base Chicago to Cleveland corridor, the Northern Route through South Bend. This assessment supplements the work included in *Midwest Regional Rail Initiative* (*MWRRI*), *Phase 4B*.

Both the Southern and Northern Routes begin at Chicago Union Station and use an identical alignment between Chicago and Buffington Harbor, a distance of approximately 21.4 miles. This corridor is currently under study by Amtrak, the Michigan Department of Transportation, and the Indiana Department of Transportation and is commonly referred to as the South of the Lake (SOTL) Corridor.

For this assessment, the SOTL alternative from Chicago to Buffington Harbor continuing to Tolleston on the CSX right of way was utilized for comparison purposes. Similarly, for the Northern Alignment, the SOTL alternative from Chicago to Buffington Harbor continuing to Porter on the Norfolk Southern right of way was used.

HNTB, as a subconsultant to TEMS, conducted this analysis in cooperation with the Indiana Department of Transportation, the Ohio Rail Development Commission, and Amtrak as a part of the Northern Indiana/Northwestern Ohio Routing Study. The engineering assessment provided an evaluation of existing rail infrastructure conditions on the alternative alignments, which were then used to identify the types of capital investments and expenditures that would be required in order for the routes to support passenger train service.

2.1 Engineering Assessment Process

The engineering assessment was conducted at a *Feasibility Level* of accuracy and detail. This conceptual level of evaluation is not sufficient to support a formal EIS Alternatives Analysis. If a decision is made to advance one of the passenger rail alternatives analyzed in this study, the next step in the planning/engineering process would be to undertake a more detailed engineering assessment of the selected alternative to ensure more accurate capital costs or alternatives. A detailed review of the proposed improvements and costs with the host carrier railroads was not conducted.

Exhibit 2-1 highlights the typical development phases and levels of accuracy for engineering projects.

Exhibit 2-1: Engineering Project Development Phases and Levels of Accuracy

Development Phases	Approx. Engineering Design Level*	Approx. Level of Accuracy**
Feasibility Study	0%	+/- 30% or worse
Project Definition/Advanced Planning	1-2%	+/- 25%
Conceptual Engineering	10%	+/- 20%
Preliminary Engineering	30%	+/- 15%
Pre-Final Engineering	65%	+/- 15%
Final Design/Construction Documents	100%	+/- 10% or better

*Percent of Final Design.

**Percent of actual costs to construct.

The initial step in the engineering assessment conducted for this study was to segment the routes, as described in the following sections. The Southern Route engineering data were developed through field reviews of feasible routes. The field reviews involved walking short segments of the track at numerous crossing locations, switching yards, industrial sites with sidings and various other critical areas along the length of the route and taking photographs of these segments. A similar field inspection also occurred along the Northern corridor to reexamine conditions and update the information contained in the MWRRI Phase 4B assessment. The purpose of the field reviews was to determine the present condition of the track, assess its suitability to accommodate passenger train operations in accordance with Federal Railroad Administration (FRA) regulations and track safety standards, and gather sufficient data for estimating needed infrastructure improvements. Meetings also occurred with Class I railroad hosts to discuss these potential rail routing concepts.

The results of those reviews were then combined with data derived from the track charts of the affected railroads to determine recommended infrastructure improvements and cost estimates. Data were also taken from TEMS' trackfile reports, which were produced using the *TRACKMAN*© software. Trackfile data were used to estimate quantities, including track lengths, siding and spur locations, bridge locations, roadway and railroad grade crossings, curve data and station locations. Cost estimates were prepared using unit costs developed for the MWRRI Phase 4B Study.

Review of the proposed improvements and costs with the host carrier railroads was conducted only from a conceptual standpoint and requires considerably more discussion before being finalized and concurrence is reached. Moreover, further study is needed in large metropolitan areas such as Toledo and Cleveland. While the cost estimates for capital improvements include some placeholder costs in the immediate areas of Toledo and Cleveland, a final recommendation on how best to resolve these congestion points will depend on detailed operations analyses of these terminals as well as in-depth discussions with the host freight railroads.

2.2 Infrastructure Cost Breakdown and Route Description

The infrastructure improvements required for both alignments involve either building new capacity or upgrading/rebuilding existing capacity and represent the majority of capital investment. These improvements include track, positive train control (PTC) for high-speed rail, signaling, grade crossing eliminations and grade crossing improvements and other improvements. The degree of investment required is dependant on many factors. However, investment in track and signaling systems for capacity improvements is the most critical factor in creating higher speed, operationally reliable train services. In examining the corridors, a primary concern is to assure that design concepts for passenger rail do no hamper the freight railroads' ability to provide effective service to their customers or adversely impact their operational capacity.

It should be noted that while minimum basic station improvements are included in the capital costs for each route, it is likely that at many stations the opportunity will be taken to redevelop the terminals. This will probably be accomplished through public/private joint development projects that are not included in this analysis.

An assessment of each alignment and corresponding segments with major infrastructure unit cost items are described in the following sections. Additional details of the corridor costing estimates are provided in spreadsheet form in Appendix C.

2.2.1 The Northern Route

Between 1997 and 1999, a feasibility-level cost estimate was developed for the proposed Northern Route between Porter, Indiana, and Cleveland, Ohio. The infrastructure cost estimates were updated under MWRRI Phase 4B. This update included limited field views of South Bend, Indiana; Elkhart, Indiana; Toledo, Ohio; and Cleveland, Ohio; as well as review of inspection notes from 1997 to 1999. In 2002, another on-site corridor inspection occurred, re-examining infrastructure needs with an emphasis on right-of-way capacity, recent development along the corridor, and critical congested areas needing special design considerations to satisfy current and future needs. The infrastructure costs were updated to comply with 2002 assumptions as follows:

- Upgrade two tracks in two-track territory instead of one track (where applicable)
- Use 26-ft track center spacing instead of 14-ft spacing for installation of new high-speed main track in order to travel at speed greater than 90 mph
- Public grade crossings: upgrade to four quadrant gate (high ADT) and single arm gates (low ADT).
- Install precast concrete crossing panels at grade crossings
- Include an additional 5-mile passing siding every 25 miles (Note: It was determined that this has a similar effect as placing 10 miles of passing siding every 50 miles, the typical requirement for a system operating with 110^+ mph technology.)
- Assumes upgrade to Centralized Train Control system (CTC)

- Install fencing throughout the corridor
- Close 20% of all private crossings.

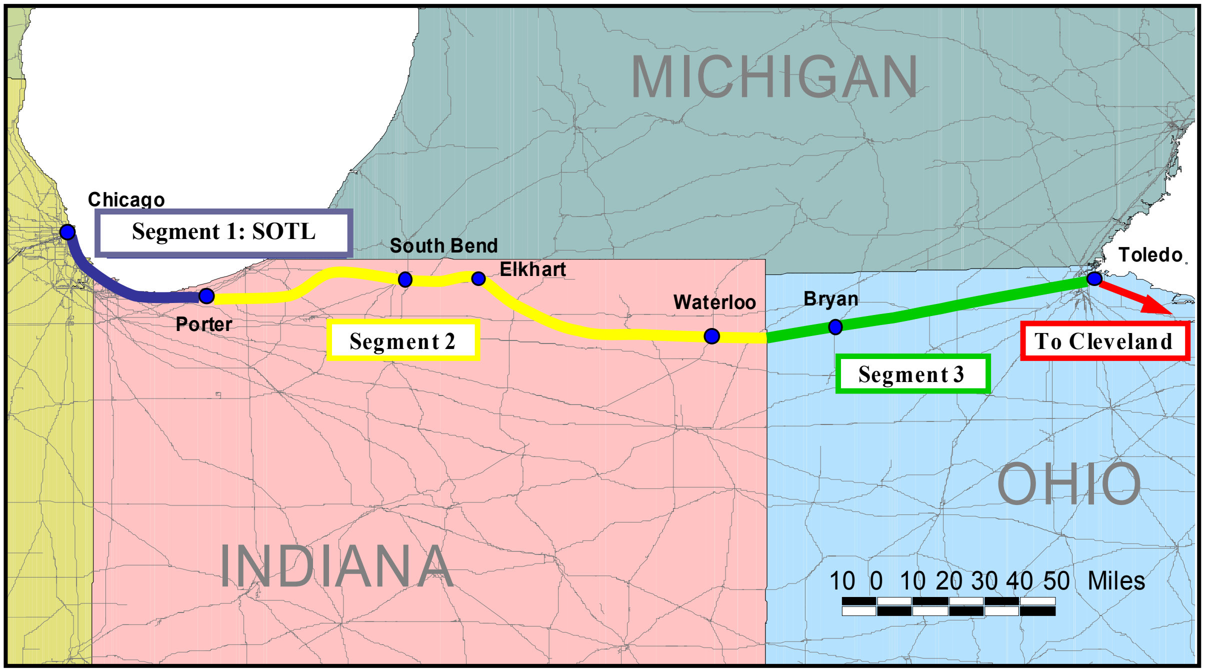
The Northern Route was segmented as described in Exhibit 2-2 and as shown in Exhibit 2-3:

Exhibit 2-2: Northern Alignment Segmentation

Segment	Description	Host Carrier	Length (miles)	Proposed Max. Passenger Speed (mph)
1	Chicago to Porter	varies	40.8*	
2	Porter to IN/OH State Line	NS	127.2	110
3	IN/OH State Line to Toledo	NS	66.5	110
4	Toledo to Berea	NS	94.5	110
5	Berea to Cleveland	NS	12.0	79
	Total		341.0*	

*This segment length may vary depending on the final routing decision made in the SOTL Study.

Exhibit 2-3: Northern Alignment (MWRRS Chicago to Cleveland Route) Segments



Previous assessment of this route in the MWRRI 4B studies concluded that the existing freight service requires separate track for passenger service. This separate track is required on the entire length of the track between Porter, Indiana, and Cleveland, Ohio, in order to minimize interference with the high-density freight operations and to permit passenger rail speeds up to

110 mph. Separation of a minimum of 26 feet between freight and passenger rail centerlines is required by host Class I railroads to permit passenger rail speeds above 90 mph. Where the track separation requirements can not be met, speed restrictions of 90 mph or less will be instigated.

The following sections summarize the proposed improvements to the Northern Route.

Segment 1: Chicago to Porter

This segment is a part of a South of the Lake (SOTL) Corridor alternative from Chicago to Buffington Harbor, continuing to Porter via one of several potential corridors being examined for its potential use. Among the issues affecting this corridor routing decision through Northwest Indiana are sensitive environmental concerns relating to the Dunes area along Lake Michigan. No further inspection or assessment of this segment was performed as a part of this study. The results of the SOTL study and its corridor cost estimates are being adopted for the purposes of this study.

Segments 2&3: Porter to Toledo

Starting in Porter and moving east, proposed track improvements include construction of a third track along the south side of the existing NS right-of-way to the Walnut Road crossing in New Carlisle. At Walnut Road, a flyover is proposed to be constructed to carry the tracks over to the north side and over lead tracks to the Intech steel facility. Construction of a third track on the north side is required since the stations in South Bend, Elkhart and Toledo are on the north side.

PHOTO 1: Looking east at Walnut Road crossing in New Carlisle, MP448.3 a proposed flyover location

PHOTO 2: Looking east at US 20 overbridge west of South Bend, MP 441.3

Construction of new track structure on new embankment is proposed in areas where the proposed speeds are in excess of 79-mph. It was assumed that the existing right-of-way could accommodate a 26-ft track center offset for the third track. Culvert extensions, new grade crossings, warning device installations and upgrades, and new bridges were included in the cost estimate. Five-mile passenger sidings were assumed every 25 miles and new turnouts and electric locks for industry leads were included.

Urban development in South Bend along with right-of-way limitations required the design for passenger track to be envisioned at 14-feet from the centerline of the adjacent freight line, thus requiring speed restrictions through South Bend and Mishawaka. In Elkhart, the previous proposal of a bypass was revised following field reviews conducted as a part of the MWRRI 4B project. It was determined that a bypass is not feasible, and that construction of a third track through the Elkhart area is needed, along with redesign of adjacent roadways and station area. Therefore, speed restrictions through the Elkhart Yard and the Elkhart Station area were assumed, and preliminary costs were included in the cost estimate for improvements.

PHOTO 3: At MP 434.4 in South Bend, looking east

PHOTO 4: MP 364 at CR 47 looking east

Urban congestion and right-of-way restrictions will continue to limit speeds through Goshen, Indiana. From Goshen to Toledo, the third track would continue along the north side of the right-of-way with embankment being provided as required. A second flyover is proposed in Butler to grade separate an existing NS at-grade crossing. Approaching Toledo, there is a major yard just west of the Toledo station called Airline Yard. The infrastructure cost estimates include a placeholder cost for improvements to this yard to add capacity. Through Airline Yard, passenger trains would need to co-mingle with freight traffic. Train speeds are therefore limited to 60-mph through this yard. The final engineering solution for routing trains into Toledo is still not firmly set. In this segment of the study area however, both routes are now using the same Norfolk Southern corridor. No matter the final cost estimate for improvements in this area, the same amount will be added or subtracted from both routes. This means that this costing issue will not change – in favor of one corridor or the other - the final routing recommendation of the study.

East of the Toledo Station, the existing two-track swing bridge over the Maumee River would be replaced with a new three-track movable span bridge, and the at-grade crossing with CSX at Vickers would be grade separated with the NS line crossing over CSX.

Segments 4&5: Toledo to Cleveland

Between Toledo and Cleveland, the third track on the north side of the right-of-way would continue where possible. The maximum speed would be 110 mph from Toledo to Berea, with exceptions where the 110-mph operation cannot be attained. Constraints include junctions with major railroads and restrictions at bridge crossings. The causeway between Sandusky and Port Clinton, the bridge over the Huron River, and Vermilion Bridge are some of the structures that cannot be expanded to accommodate a third track. In these sections, passenger train speeds will need to be restricted.

The segment from Berea to Cleveland has a maximum proposed speed of 79 mph due to a high volume of freight traffic. Passenger trains would co-mingle with freight trains. The right-of-way is also shared with Greater Cleveland Regional Transit Authority rapid transit trains in this segment, so improvements would need to include capacity for the rapid transit operations as well. The proposed improvements include the addition of both a third track for passenger use and a fourth track that would serve as multiple sidings to provide additional freight capacity. Placeholder costs for improvements at Brookpark near the Ford Plant and Rockport Yard were included in the cost estimates, as well as a new movable span bridge crossing over the Cuyahoga River in Cleveland.

2.2.2 The Southern Route

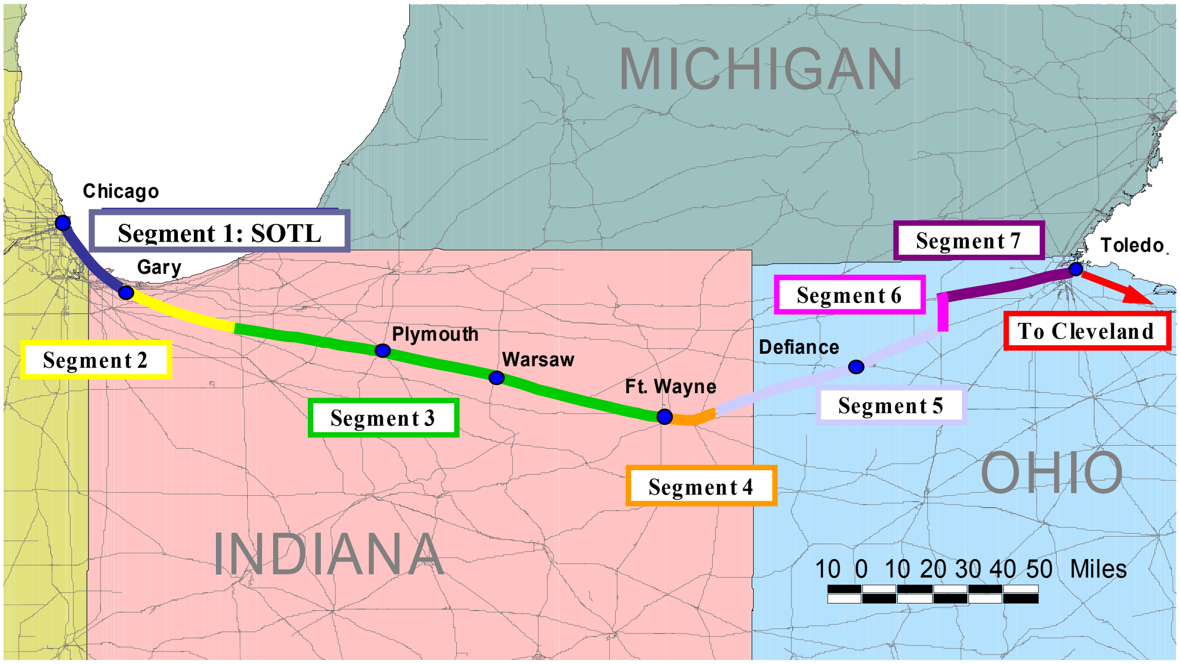
The Southern Route was developed following field reviews completed in December 2001 and April 2002. This alignment was segmented as described in Exhibit 2-4 and is illustrated in Exhibit 2-5.

Exhibit 2-4: Southern Alignment Segmentation

Segment	Description	Host Carrier	Length (miles)	Proposed Max. Passenger Speed (mph)
1	Chicago to Tolleston (SOTL)	varies	26.4*	
2	Tolleston to Wanatah	CSX	27.6	110
3	Wanatah to Mike Junction (Ft. Wayne)	CSX	95.6	110
4	Mike Junction (Ft. Wayne) to New Haven	NS	6.86	79
5	New Haven to Liberty Center	NS / M&W	56.94	110
6	Liberty Center to Delta	I&O	8.23	79
7	Delta to Toledo	NS	25.9	110
8	Toledo to Berea	NS	94.5	110
9	Berea to Cleveland	NS	12.0	79
	Total		354.0	

*This segment length may vary depending on the final routing decision made in the SOTL Study.

Exhibit 2-5: Southern Alignment Segments



The following sections describe the corridors, the field review findings, and proposed improvements by segment.

Segment 1: Chicago to Tolleston

This segment is the South of the Lake Corridor alternative from Chicago to Buffington Harbor (northwest of Gary) continuing to Tolleston on a short segment of the CSX right-of-way. The preliminary data and the analysis of the South of the Lake Study were adopted for this study. No further inspection or assessment of this segment was necessary as a part of this study.

Segments 2 & 3: CSX from Tolleston to Ft. Wayne

These two segments were inspected on a hi-rail vehicle on December 19, 2001.

Segment 2 starts at CSX MP 442.5 at Tolleston and ends at CSX MP 414.9 in Wanatah, along the CSX Fort Wayne Secondary Line. Segment 3 continues from Wanatah to Mike Junction in Fort Wayne, at NS MP 146.1, which is just east of the existing Fort Wayne Station. The proposed route follows the CSX Fort Wayne Secondary Line into Fort Wayne at CSX MP 320 then transfers to the NS Woodburn-New Haven line at NS MP 146.6.

In general, the line is mostly tangent with very few curves and minimal grades. The right-of-way formerly had two main tracks, but one was removed. The tracks are generally in FRA Class 3 or 4 condition with speeds limited to a maximum of 49 mph.

The rail varies between 131-lb and 136-lb continuously welded rail, for a total of about half of the length of the two segments.

Several approaches were considered to plan for passenger operations. The first assumed a co-mingling of passenger trains with the low volume of freight trains on the line, at a maximum passenger train speed of 90 mph, as required by the freight railroad. The second scenario assumed 110-mph operations on a new dedicated track. This additional track, on new embankment at a minimum offset of 26-foot track spacing with additional culverts and bridges was estimated to cost $147.8 million. To avoid the cost of building an additional track, a third scenario was considered; the freight line could be purchased by a government entity for a yet to be negotiated amount. This could allow both passenger and freight trains to use the same rail line and avoid unnecessary duplication of track on this lighter density corridor. By changing the ownership of the line, freight railroad operating policies pertaining to passenger services could be addressed, potentially allowing new track sharing flexibility.

The third approach is the plan recommended in this study. To facilitate this strategy, the proposed cost improvements are summarized as follows:

- 2/3 tie replacement
- Ballast resurfacing
- 5-mile high-speed siding every 25 miles (Note: It was determined that this has a similar effect as placing 10 miles of passing siding every 50 miles, the typical requirement for a system operating with 110^+ mph technology.)
- A 1000-ft siding for passenger station at Ft. Wayne
- Assumes upgrade to Centralized Train Control system (CTC)
- $200,000 rehabilitation at each underbridge
- Close 20% of all private crossings
- Public grade crossings: upgrade to four quadrant gate (high ADT) and single arm gates (low ADT) with new precast panels and approach roadway improvements
- Install fencing throughout the corridor.
- Placeholder for corridor acquisition

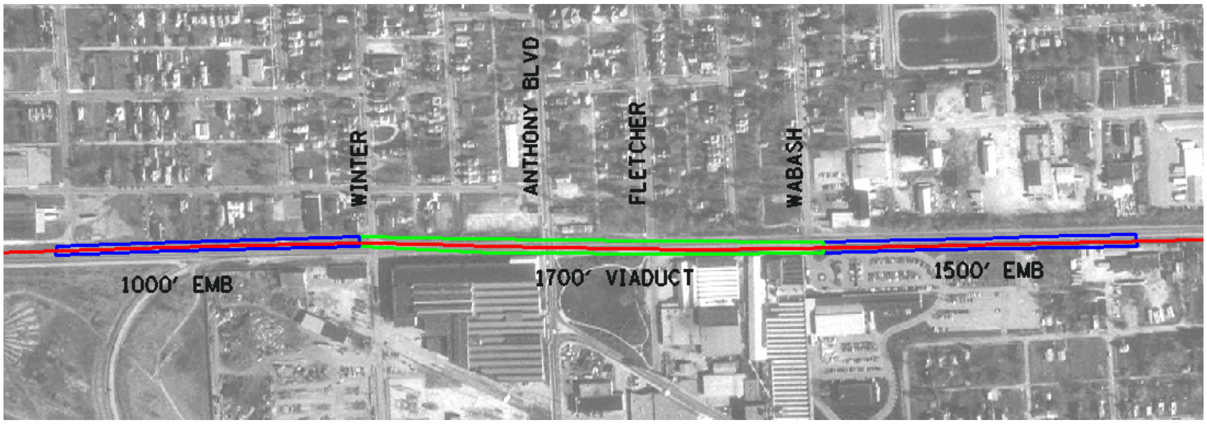
Segment 4: NS through Ft. Wayne & New Haven

Field review of this segment was done on March 15, 2002. The segment begins at Mike Junction, on the NS D-Line MP 146.1, and continues east to D-Line MP 140.6 where it connects to the NS B-Line MP 365.6. The segment continues east through New Haven. At the B-Line MP 363.94, it connects to the Maumee-Woodburn Branch TN-Line (Segment 5) at MP 87.19.

The segment is double track on the D-Line and single track on the B-line. The tracks are 131-lb or 132-lb welded rail. The corridor goes through downtown urban areas, and there are many track connections and spurs as well as a large yard in New Haven. The tracks are FRA Class 4, with current speeds limited to a maximum of 60 mph.

The proposed passenger service would be on new dedicated track through this segment. The new alignment would begin on the north side of the NS tracks from the Fort Wayne station, then climb an embankment structure for approximately 1000 feet to a 1700-ft long viaduct structure (see Exhibit 2-6). The tracks would cross over Winter Street, Anthony Boulevard, Fletcher Avenue and Wabash Avenue and connect to an embankment on the south side of the NS tracks. The proposed alignment would continue along the south side of the NS alignment to New Haven and through the New Haven yard area. The maximum proposed speed through this segment is 79 mph.

Exhibit 2-6: Alignment through Downtown Ft. Wayne, Showing Embankment and Viaduct Over Grade Crossings to Move from North Side to South Side



The proposed improvements are summarized as follows:

- New HSR on new roadbed (and some new embankment) along south side of existing NS alignment
- 2 viaduct/embankment structures at each end
- Ballast resurfacing & 2/3 tie replacement of existing NS track
- Assumes upgrade to Centralized Train Control system (CTC)
- $200,000 rehabilitation at each underbridge
- Closing of 20% of all private crossings
- Public grade crossings: upgrading to four quadrant gate (high ADT) and extended single arm gates (low ADT) with new precast panels and approaching roadway improvements
- Install fencing throughout the corridor.

In subsequent discussions with NS, it was learned that there is a capital improvement plan under consideration to add additional main line freight tracks through the Fort Wayne – New Haven area. This, effectively, could consume the right-of-way needed for a dedicated track footprint and may mandate that co-mingling of passenger and freight traffic occurs on an expanded infrastructure, but at a speed not exceeding 79 mph.

Segment 5: NS/M&W from New Haven to Liberty Center

Field review of this segment was done on March 14 and 15, 2002. The segment begins at MP 87.19 on the NS Maumee Woodburn Branch line and connects to the Maumee & Western Railroad alignment in Woodburn. The segment then continues along the Maumee & Western to Liberty Center, Ohio, at MP 30.25, where it connects to the Indiana & Ohio Railroad right-of-way (Segment 6).

The segment is single-track jointed rail, mostly 80-90 lbs. per yard. Most of the segment is through rural areas, with the exception of Defiance. The current maximum speed is 10 mph.

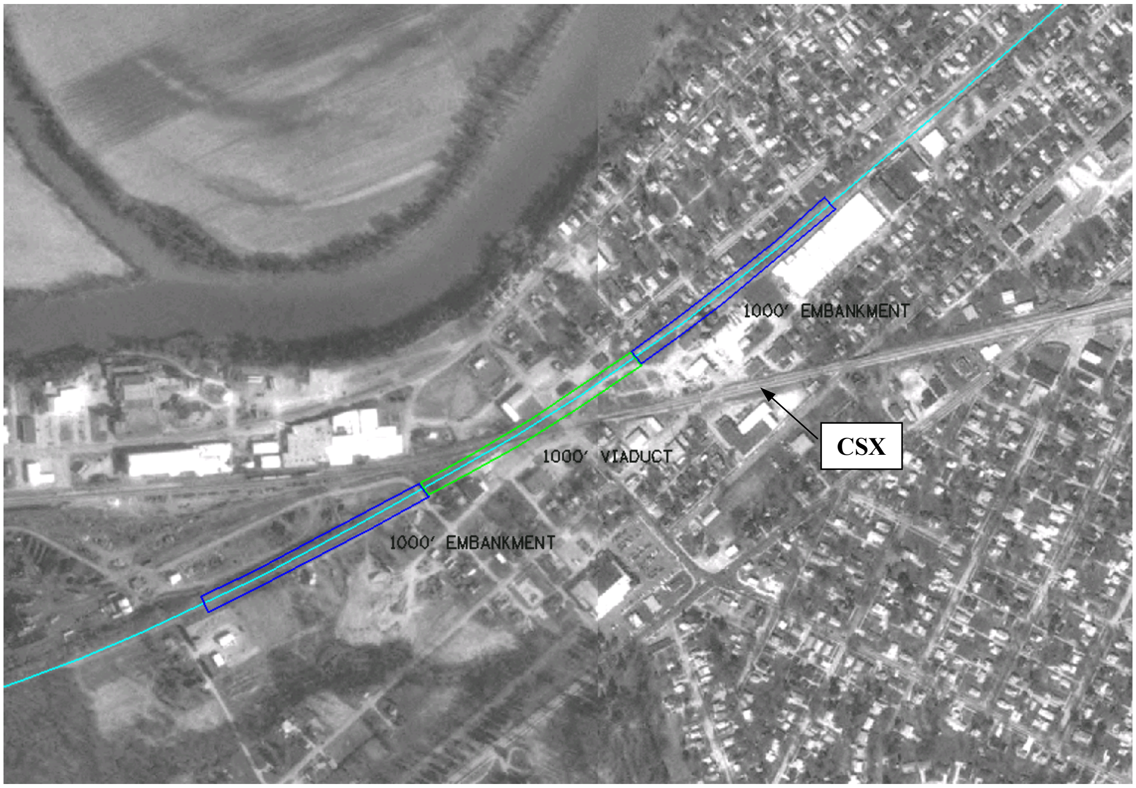
Photo 7: MP 78.7, at Center St. crossing in Woodburn, looking west

Photo 8: At Guston Rd. crossing near MP 77 east of Woodburn, looking east

Photo 9: At Wentworth Rd. crossing near MP 72 in Antwerp looking east

Proposed passenger service would require a complete re-build of the track structure. In Defiance, a flyover structure over the CSX railroad will be needed at the Defiance Junction due to the high volume of CSX traffic (see Exhibit 2-7). In addition, in Defiance, the railroad bridge over the Maumee River will require rehabilitation. East of Napoleon, grade separation of Route 24 will be required. With the exception of slower speeds through Defiance, the maximum proposed speed through this segment is 110 mph.

Exhibit 2-7: In Defiance, viaduct and embankment over CSX



The proposed improvements are summarized as follows:

- Replacement of existing track with new HSR on new roadbed with widened embankment along one side
- A viaduct/embankment structure at Defiance
- Assumes upgrade to Centralized Train Control system (CTC)
- Replacement of all underbridges, and rehabilitate major river crossing in Defiance
- Depression of Route 24 roadway under railroad east of Napoleon
- Installation of new culverts
- Closing 20% of all private crossings
- Public grade crossings: upgrading to four quadrant gate (high ADT) and extended single arm gates (low ADT) with new precast panels and approaching roadway improvements
- Install fencing throughout the corridor.

Segment 6: I&O from Liberty Center to Delta

Field review of this segment was done on March 14, 2002. The segment is along the Indiana & Ohio Railway (I & O), starting at the connection from the Maumee & Western Railroad in Liberty Center (MP 82.5) and ending at the connection with NS in Delta (MP 74.27), a distance of 8.23 miles.

This northward turn of the corridor to Delta became the recommended routing strategy after examining the potential use of an abandoned rail right-of-way. Previously, this alignment was a rail line that ran in a relatively straight alignment from Liberty Center into downtown Toledo. This corridor has been partially converted to a bicycle / pedestrian path with additional short term plans calling for the continued pathway conversion of the remaining portions of the abandoned right of way. With input from local citizens and community groups on the study steering committee, the option of reverting the corridor from a pathway back to a rail line for passenger use was recognized as highly unlikely and environmentally difficult and was eliminated as a routing option.

The I & O segment is single-track welded rail, 115 lbs. per yard. Most of the segment is on embankment. The current maximum authorized speed through this segment is 49 mph; it is FRA Class 4 track.

The proposed passenger service would co-mingle with the existing freight traffic since the traffic volumes are low. Infrastructure improvements would include 66% tie replacement, resurfacing of the ballast, and rehabilitation of all underbridge structures. A new at-grade connection track would be required in the northwest quadrant between the Maumee & Western line and the I&O line. On the north end, an embankment structure for track connection from the I&O to the NS is needed. The maximum proposed speed through this segment is 79 mph.

Photo 10: At County Line Road looking south

Photo 11: Looking east along the Indiana & Ohio Railway at County Road F

The proposed improvements are summarized as follows:

- 2/3 tie replacement

- Ballast resurfacing
- Flat track connection from M&W to I&O at Liberty Center
- Embankment connection from I&O to NS at Delta
- One 2-mile siding
- Assumes upgrade to Centralized Train Control system (CTC)
- $200,000 rehabilitation at each underbridge
- Close 20% of private crossings. For public grade crossings: upgrade to four quadrant gate (high ADT) and single arm gates (low ADT) with new precast panels and approach roadway improvements
- Install fencing throughout the corridor segment.

Segments 7, 8 and 9: NS from Delta to Cleveland

These segments are identical to the same locations on the Northern Route, so infrastructure improvements and costs are the same as described in that section.

3. Operating Plan

The alternative route and corresponding infrastructure requirement, combined with the rolling stock technology, determines the travel time between connecting stations and thus overall schedules. The MWRRS business plan has adopted a generic type of trainset technology to represent the vehicle operations on the rail corridors. This representative vehicle offers all the amenities of a modern train, including high-quality on-board facilities and services such as tilt (6 degrees) and steerable trucks. In addition, a low-cost loco-hauled train is well suited for the requirements of the Midwest rail system.

3.1 Operating Schedules

In the ultimate buildout, the MWRRS business plan includes service in the Chicago-Cleveland corridor along the Northern Route via South Bend, with eight daily corridor length frequencies plus an additional frequency between Toledo and Cleveland. This additional frequency is used to provide early morning service into Cleveland from Toledo. Operating this schedule would require eight trainsets. The corridor length frequencies from Chicago to Cleveland comprise of four local trains making eight intermediate stops and four express trains with a stop in South Bend, IN, and Toledo, OH. Scheduled trip times are 5:00 hours for the local service and 4:32 hours for the express service. In addition, intermediate length service includes one local express morning train from Toledo to Cleveland that takes 1:32 hours and an evening train with two intermediate stops from Cleveland to Toledo that takes 1:43 hours.

To ensure an appropriate comparison for this study, the alternative Southern Route adopts the same structure as the Northern Route. The Southern Route schedule, therefore, contains eight corridor length frequencies plus an intermediate length frequency between Toledo and Cleveland. The schedule similarly includes four local trains with eight intermediate stops and four express trains with a stop in Ft. Wayne, IN, and Toledo, OH. Average trip times are 4:52 hours for the local service and 4:23 for the express service. The complete operating time schedules for both Northern and Southern Routes are found in Appendix A. This draft schedule scenario represents the ultimate capital buildout.

3.2 Travel Times

Despite being approximately 13 miles longer, the Southern Route is up to nine minutes faster than the Northern Route. As stated earlier, the Northern Route would operate on new track that runs parallel to the existing track. Because the trains would operate on separate track, they would not be required to co-mingle with freight traffic. However, due to urban development, the new track proposed to be built alongside the existing track in the area between western South Bend and Goshen, IN is unable to be separated by the minimum 26 feet required; therefore, mandated speed restrictions must be followed. The maximum speed the Northern corridor trains are able to obtain in this 32-mile segment is 90 mph.

Exhibit 3-1 illustrates travel times and effective speeds for both Northern and Southern Routes and their differences. Each route is broken down into an express-stop service and local-stop service. By comparing both routes, the alternative southern express service is faster than that on the Northern Route by 9 minutes, while the local service is similarly faster by 8 minutes. The analysis shows that when operating an express schedule, trains are able to obtain an effective speed of 80 mph on the Southern Route while only reaching an effective speed of 75 mph on the Northern Route in the ultimate buildout.

Exhibit 3-1: Travel Time and Effective Speeds – Ultimate Buildout

Alternative Route	MWRRS Norfolk Southern Northern Route	Alternative Southern Route	Difference
Travel Time – Local Stops	5:00	4:52	8 Minutes
Travel Time – Express Stops	4:32	4:23	9 Minutes
Effective Speed – Local Stops	68 mph	73 mph	5mph
Effective Speed – Express Stops	75 mph	80 mph	5 mph
Total Mileage	341 miles	354 miles	13 miles

3.3 Summary

Despite being approximately 13 miles longer in length, the Southern Route has faster travel times between Chicago and Cleveland. The primary reason for the lower speeds displayed on the Northern Route is due to the inability to build the adjacent passenger corridor the required 26 feet from the freight line on several segments of the route. This factor results in speeds of less than 110 mph for most of the corridor from west of South Bend to Goshen.

4. *COMPASS*© Demand Model Database Development

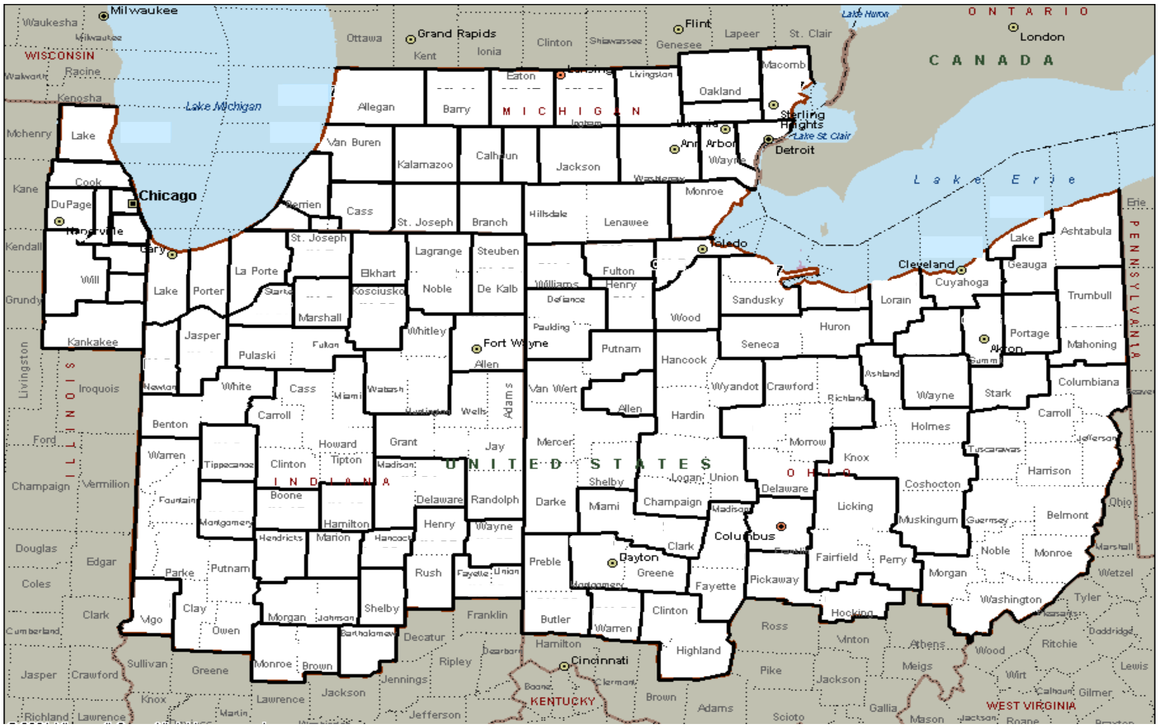
The *COMPASS*© Modeling System measured the ridership and revenue benefit of each passenger rail routing. *COMPASS*© uses an advanced market research technique, known as Abstract Mode Trade-Off Analysis; these travel characteristics are formulated as preference utilities or demand elasticities, yielding a measurement of the responsiveness of travel demand to improvements in service and the relative competitive position of alternative modes. The system computes competitive mode market shares based on levels of service, fares or costs, and attractiveness or bias for each mode.

Chapters 4 and 5 of this report provide an overview of the steps that were taken to estimate the demand of travel for the two alternative routes involved with the MWRRS. Chapter 4 describes some inputs into the *COMPASS*© demand model, such as the study area zone system, origin-destination data, transportation network data, stated preference survey data, and socioeconomic data. Chapter 5 details the ridership and revenue forecasts prepared for the two passenger rail options on the Chicago to Cleveland corridor of the MWRRS. An overview of the *COMPASS*© demand model is given in Appendix B of this report.

4.1 Zone System

One of the first steps in generating ridership and revenue forecasts for the study was to delineate geographic units ("zones") that are relatively homogenous with regard to their socioeconomic characteristics and likely access/egress points to the MWRRS rail system. The MWRRI zone system provided a base for the system used in this study. Changes in the MWRRI Phase 4B zone system were made in places where new rail or bus feeder stations were added. Exhibit 4-1 displays the zone system used to model the study area.

Exhibit 4-1: Northern Indiana / Northwest Ohio Study Area Zone System



4.2 Origin – Destination Data

The origin-destination (O-D) travel data were based on annual passenger trips between zone pairs for each mode (i.e., air, rail, bus and auto) and trip purpose (i.e., business and non-business). The base year for the data is the year 2000, and the primary source of trip data was the MWRRI database. In a few instances, the data from these sources had to be modified (aggregated, disaggregated, and/or synthesized) in order to make the trip file specific for the zone system used in this study. Sources for origin-destination data are shown in Exhibit 4-2.

Exhibit 4-2: Sources of Origin-Destination Data

Mode	Source
Air	Federal Aviation Administration (FAA): *10% Ticket Sample*
Rail	Amtrak: Ticket Count Data Northern Indiana Commuter Transportation District (NICTD): Corridor Data
Bus	Greyhound Lines: Passenger O-D Data
Auto	Statewide Travel Models & Trip Generation/Distribution Modeling

4.3 Network Data

Transportation networks for base (i.e., year 2000) and forecast years were developed for auto, air, rail and bus based on data from the MWRRI database. In order to evaluate the perceived competitiveness of the four modes, the *COMPASS*© model requires travel times, travel costs, and levels of service (e.g., reliability, schedules) for the base year. The transportation network characteristics that are considered are outlined in Exhibit 4-3.

Exhibit 4-3: Parameters Used in the Demand Estimation Model

	Public Modes	Auto
Time	In-vehicle Time Access/Egress Times Number of Interchanges Connection Wait Times Terminal Wait Times	Travel Time
Cost	Fare Access/Egress Costs	Operating Cost Tolls Parking (all divided by occupancy)
Reliability	On-time performance	
Schedule	Frequency of Service Convenience of Times	

Two trip purposes were used during this study: Business and Non-Business. Trips that are denoted as *Business* refer to trips that are paid by an employer, and trips that are referred to as *Non-Business* (e.g., Commuter, Social, Recreation, etc.) are ones not paid by an employer.

4.4 Stated-Preference Surveys

To forecast ridership accurately, stated-preference surveys were conducted throughout the Midwest states, including Ohio and Indiana, in a manner designed to reach a broad sample of potential users of the proposed passenger system. The travel survey was conducted as part of the MWRRI. Approximately 1,500 surveys were completed using a self-administered approach. Each form collected information on origin-destination, trip purpose, demographics, value of time (VOT), value of access time (VOAT), value of frequency (VOF) and various modal bias coefficients.

The attitudinal parameters calculated from the stated preference surveys are components of the generalized cost aspect of the model. Appendix B illustrates how the attitudinal parameters (e.g. VOT and VOF) are used in the model formulation. Exhibit 4-4 illustrates values of time and frequency for different modes of travel and trip purposes.

Exhibit 4-4: Summary of Attitudinal Parameters Used in the Analysis

a)Values of Time ($/hr)

Trip Purpose	Mode			
	Auto	Bus	Rail	Air
Business	$22.40	$16.20	$25.90	$54.20
Non-Business	$16.00	$13.90	$15.10	$26.71

b) Values of Frequency ($/hr)

Trip Purpose	Mode		
	Bus	Rail	Air
Business	$15.90	$16.00	$26.80
Non-Business	$13.40	$14.20	$17.60

4.5 Socioeconomic Data

Another step in the process of forecasting ridership and revenue involved establishing a socioeconomic database for the study area. The variables used to forecast potential ridership in this study were population, employment, and per capita income. A socioeconomic database for the base and forecast years was established using data from the United States Bureau of the Census and the Bureau of Economic Analysis. As with the trip database, the year 2000 was used as the base year.

5. Ridership and Revenue Forecasts

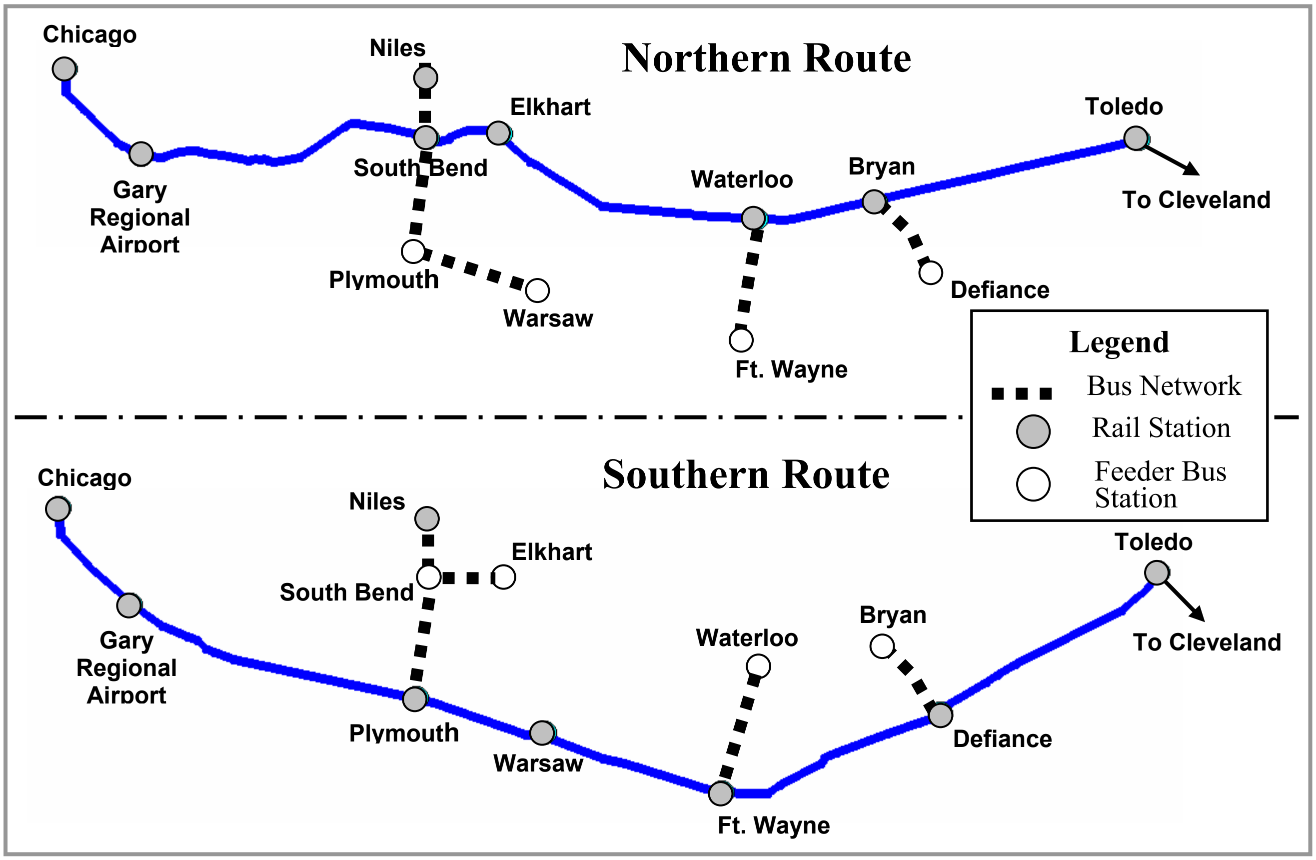
Ridership and revenue forecasts were prepared for the northern and southern Indiana MWRRI routings using the *COMPASS*© model with inputs described in Section 4 and the operating plans described in Section 3. A detailed description of the *COMPASS*© model is provided in Appendix B.

5.1 Bus Feeder Network

A bus feeder system was developed as part of the MWRRI to increase the accessibility of the Midwest rail system to additional areas. The design of the feeder bus network is based on past studies and recommendations from the Indiana Department of Transportation and the Ohio Rail Development Commission. Feeder bus scheduling was coordinated with passenger rail schedules to provide essentially "seamless" travel throughout the Midwest. Additionally, this system aids in making the cities not served by the alternate routing more accessible to the Midwest rail network.

In order to be consistent with the MWRRI, the concept of the feeder bus was applied to the Northern and Southern routings. All cities have either rail service or bus feeder service for the two different routes. The bus feeder system developed for the study area of this project is shown in Exhibit 5-1.

Exhibit 5-1: Rail Networks with Bus Feeder Routes (Not Drawn to Scale)



5.2 Forecasts

Ridership and revenue forecasts were developed for the Chicago to Cleveland corridor of the MWRRI for the two different routes between Chicago and Toledo. Forecasts are based on the premise that the first phase of the MWRRI will take place in 2006. The Chicago-to-Cleveland corridor of the project is due to improve its existing service under Phases 4, 5, and 6 of the six-phase implementation process. These phases could potentially occur between 2010 and 2012. However, depending on the availability of funding and relative progress on building Phases 1, 2 and 3, this potential start date could be moved to a later year. Exhibit 5-2 shows the annual ridership and revenue forecasts for the two routes for various forecast years.

The annual ridership for the Northern Route is forecasted to be 908,907 in the year 2020. Meanwhile, the Southern Route is forecasted to have an annual ridership of 1,067,194 in the year 2020 – 158,287 more passengers per year than the Northern Route.

The annual fare box revenue in 2002 dollars for the Northern Route is forecasted to be $52,950,000 in the year 2020. Meanwhile, the Southern Route is forecasted to have annual fare box revenue in 2002 dollars of $59,284,000 in the year 2020 — approximately $6,334,000 more than the Northern Route.

Exhibit 5-2: Ridership and Revenue Forecast Summary

Year	Ridership (Annual Trips)		Fare Box Revenue (Millions of 2002$)		Yield Per Passenger Mile (2002$ per mile)	
	Northern Route	Southern Route	Northern Route	Southern Route	Northern Route	Southern Route
2010 (Phase 4)	741, 266	866,859	$44.540	$49.770	0.27	0.23
2011 (Phase 5)	795,877	931,156	$46.780	$52.303	0.27	0.23
2012 (Phase 6)	821,621	961,687	$47.950	$53.627	0.26	0.23
2015*	854,354	1,001,252	$49.830	$55.748	0.26	0.23
2020*	908,907	1,067,194	$52.950	$59.284	0.26	0.23
2023*	949,256	1,114,517	$55.284	$61.885	0.26	0.23
2033*	1,083,756	1,272,259	$63.842	$70.553	0.27	0.22
2040*	1,117,905	1,382,679	$68.520	$76.621	0.26	0.22
2042*	1,205,262	1,414,585	$70.102	$78.396	0.26	0.22

*MWRR system fully implemented

The ridership estimate from the *COMPASS*© model also generated station volumes in the corridor – as illustrated in Exhibits 5-3 and 5-4. The station volumes that are calculated here refer to the annual boardings and alightings at the specific rail stations along the corridor. An analysis of the station volumes on the Southern Route shows that significant ridership comes from the stop in Ft. Wayne, Indiana. Additionally, Exhibit 5-3 shows that the Southern Route benefits from the reduced travel time along the corridor. More specifically, the decrease in travel time on the Southern Route increases the station volumes to Toledo and stations to the east (i.e., Sandusky, Elyria and Cleveland).

Exhibit 5-3: Annual Station Volumes by Trip Purpose (Southern Route, 2020)

Stations	Business	Non-Business	Total
Gary/Hammond-Whiting *	22,593	66,680	89,273
Plymouth	7,454	42,258	49,712
Warsaw	4,223	24,023	28,246
Ft. Wayne	48,491	95,884	144,375
Defiance	8,039	39,212	47,251
Toledo	53,320	201,520	254,840
Sandusky	6,230	33,666	39,896
Elyria	6,838	51,638	58,476
Cleveland	80,071	313,368	393,439

* Gary/Hammond-Whiting Station shared by multiple corridors therefore all station volumes cannot be attributed to Chicago-Cleveland corridor.

Exhibit 5-4: Annual Station Volumes by Trip Purpose (Northern Route, 2020)

Stations	Business	Non-Business	Total
Gary/Hammond-Whiting *	21,104	62,584	83,688
South Bend	12,350	60,170	72,520
Elkhart	5,864	40,054	45,918
Waterloo	10,212	41,009	51,221
Bryan	3,600	20,990	24,590
Toledo	51,933	190,780	242,713
Sandusky	6,599	31,642	38,241
Elyria	6,692	50,155	56,847
Cleveland	79,722	301,274	380,996

* Gary/Hammond-Whiting Station shared by multiple corridors therefore all station volumes cannot be attributed to Chicago-Cleveland corridor.

5.3 Summary

With respect to ridership and revenue, the Southern Route has produced greater values. The fundamental reasons for the additional ridership and revenue for the Southern Route are the contribution from a station in Fort Wayne and the effect of the ultimate reduced corridor travel time associated with the Southern Route.

6. Total Costs

There are two cost considerations when evaluating alternative service levels. The first is a fixed capital investment in infrastructure and rolling stock, which will be incurred during construction as up-front costs. The second is the ongoing variable and fixed costs of operations. A discussion of these cost issues is presented below.

6.1 Capital Investment Costs

The capital costs associated with passenger rail corridor development have two major components: infrastructure and rolling stock costs. The infrastructure cost items for both the Southern Route and the Norfolk Southern Northern Route are described in detail in Chapter 2. Other capital investments include the purchase of track and Right-of-Way (R.O.W.) along the Southern Route between Tolleston and Ft. Wayne to allow passenger operations up to 110 mph.

6.1.1 Infrastructure Costs

Infrastructure costs represent the majority of all capital costs and vary with each alignment and section. To ensure a balanced comparison between northern and southern alignments, this study's infrastructure costs assessment encompasses the entire Chicago-Cleveland corridor for each and is broken down into segments outlined in Chapter 2. Exhibit 6-1 outlines the segments for each alignment and corresponding infrastructure costs required to fulfill the ultimate operating plan prepared for this project. A more detailed breakout of cost items by segment for both corridors is provided at the end of this report in Appendix C.

Exhibit 6-1: Infrastructure Costs, Chicago to Cleveland

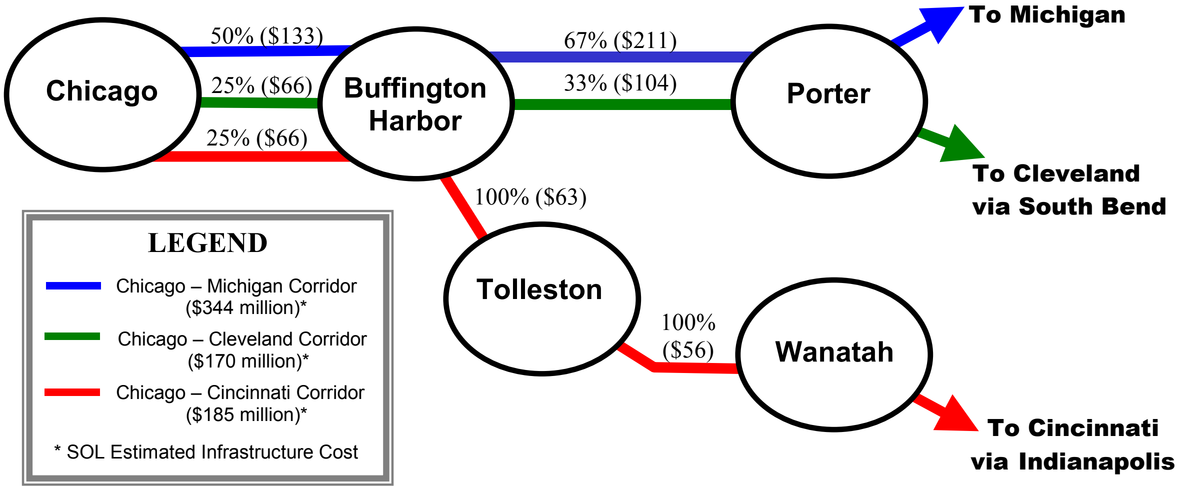
Alignment and Segment	Total Cost
Northern Alignment	
Segment 1: Chicago to Porter*	$170,000,000
Segment 2: Porter to IN/OH Line	$601,623,000
Segment 3: IN/OH Line to Toledo	$298,190,000
Segment 4: Toledo to Berea	$337,013,000
Segment 5: Berea to Cleveland	$142,749,000
Total	*$1,549,575,000*
Southern Alignment	
Segment 1: Chicago to Tolleston*	$98,000,000
Segment 2: Tolleston to Wanatah*	$28,000,000
Segment 3: Wanatah to Mike Junction(Ft. Wayne)	$174,521,000
Segment 4: Mike Junction (Ft. Wayne) to New Haven	$45,643,000
Segment 5: New Haven to Liberty Center	$211,122,000
Segment 6: Liberty Center to Delta	$17,651,000
Segment 7: Delta to Toledo	$131,577,000
Segment 8: Toledo to Berea	$337,013,000
Segment 9: Berea to Cleveland	$142,749,000
*Total**	*$1,186,276,000*

Does not include cost of ROW
Note: Costs are in 2002 dollars.
* Represents a portion of the segment's cost, as explained in Exhibit 6.2.

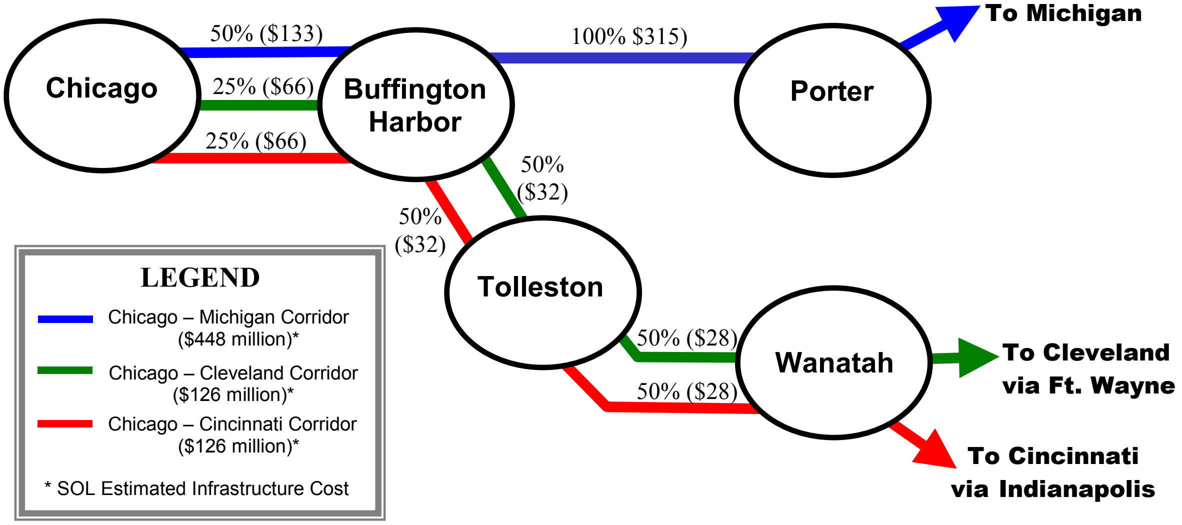
The total infrastructure cost for the Northern Route is approximately $1.550 billion and $1.186 billion for the Southern Route, a difference of $364 million. The costs for Segment 1 for both alignments are referenced from the South of the Lake Corridor Study and are only a portion of a larger cost for the entire MWRRS system. Exhibit 6-2 illustrates how the total infrastructure costs developed in the South of the Lake Corridor Study are proportioned to the Chicago-Cleveland corridor assuming a segment train frequency basis for the allocation.

Exhibit 6-2: Costs for Both Alignments (in $Millions)

Northern Alignment



Southern Alignment



From Exhibit 6-2 it can be seen that the alignments for both alternatives break apart at Buffington Harbor (Indiana). The Infrastructure costs from Chicago to Buffington Harbor are distributed amongst the three corridors based on the level of frequency offered. At Buffington Harbor the Northern Route continues on to Porter, while the Southern Route goes to Tolleston before continuing on to Wanatah. The Infrastructure Costs are distributed amongst the corridors based on proposed levels of frequency on the various corridors. The South-of-the-Lake Infrastructure Cost estimate for the three corridors is provided in Exhibit 6-2.

6.1.2 Capital Investment Summary

The other major capital investment is in acquiring rolling stock. The operating plans for the Northern and Southern Routes have the same rolling stock requirements for intercity travel of eight trainsets, with each having a seating capacity of approximately 192 riders. The total capital cost for the rolling stock required for the operating schedule used here is $75.6 million. Other capital expenditures for the Southern Route include a placeholder for the purchase of track and right-of-way (R.O.W) between Tolleston and Ft. Wayne to allow passenger operations up to 110 mph. No negotiations have occurred with the freight railroad to finalize a price associated with such an agreement. Exhibit 6-3 summarizes the capital investment costs for each alternative route, with a total capital cost of $1.625 billion for the Northern Route and $1.282 billion for the Southern Route, a difference of $343 million. The difference in the total capital cost is due mainly to the difference in the infrastructure costs of the two routes. Other capital expenditures for the Southern Route are small in proportion and have little bearing on the total capital cost, which remains lower than the Northern Route.

Exhibit 6-3: Total Capital Investment by Alternative Route

Service	Total Cost	
	Northern Route	Southern Route
Infrastructure, Track and R.O.W.	$1,549,575,000	$1,206,276,000
Rolling Stock for Intercity Service	$75,600,000	$75,600,000
Total	$1,625,175,000	$1,281,876,000
Note: Costs are in 2002 dollars.		

6.2 Operating Costs

The operating costs for the MWRRS system are highly dependent on the level of service offered, the train technology selected, and the character and size of the proposed operating plan and include costs that are either fixed or variable. During the MWRRS Phase 3B, operating costs were developed for the entire MWRRS system and have been adopted for this study for a direct comparison between both Northern and Southern Routes. Using the MWRRS Phase 3B figures, the annual operating costs for both the Northern and Southern Routing alternatives were similar, differing by a factor of only 2%. Given that at this time the operating costs are simply estimates and have not been negotiated with the railroads that own the lines, this study assumes that operating costs will be the same for both alternatives and therefore will neither bias nor favor one route or the other. Additional discussion must occur before rates for operations are finalized. Because the study used the same unit costs for both corridors, namely an "apples to apples" comparison, the study's recommendations are not effected. While the final cost numbers may differ, any change will only be in terms of a relative level of magnitude and will affect both routes equally. They will therefore not change the overall findings of this report in terms of the recommended routing.

7. Benefit-Cost Analysis

The economic analysis of the alternative route options provides us with all financial and non-financial returns and associated costs from an initiative. The comparison of the sum of discounted benefits to the sum of discounted costs determines the feasibility of a project.

The benefits to the users of the High-Speed Rail (HSR) project are equal to the sum of the consumer surplus and the revenues generated by the rail system. In addition to the rail-user benefits, travelers using other modes will also benefit from the improvement in rail service along the corridor. More specifically, the improvement of rail services along this corridor and the diversion of passengers to the high-speed rail alternative would contribute to relieving highway congestion, reducing tailpipe emissions and decreasing travel times for users taking other modes.

Consumer surplus also measures user benefits. A transportation improvement is seen as providing user benefits in terms of time and costs savings, as well as convenience, comfort and reliability to users of the mode. For example, when considering high-speed rail, trips will be either induced (i.e., users who previously did not make a trip) or diverted (users who previously used a different mode).

For the benefit-cost analysis, we compute the Net Present Value (NPV) for the 2013-2042 period, which corresponds to the 30-year life-cycle horizon of the rolling stock and infrastructure. The results show that only the Southern Route has a positive benefit-cost ratio, with 1.26, while the Northern Route has a benefit-cost ratio of 0.92. This means that for a life cycle of 30 years of the railroad, the rail service with the Southern Route will generate more benefits than its costs. But with the Northern option, the service will be losing money because the total costs will be slightly higher than the total benefits (operating revenues and social benefits). Exhibit 7-1 shows the economic and financial results with respect to operating revenues, consumer surplus, the other mode user benefits, the resources benefits, and the total costs.

Exhibit 7-1: Chicago to Cleveland Alternative Route Option: Cost-Benefit Analysis for the 2013-2042 Period

Cost Benefit Parameters	**30-Year Net Present Value (in Millions of $2002)**	
	Northern Route	**Southern Route**
Benefits		
Revenue	$1,045.57	$1,169.96
Consumer Surplus	$1,003.85	$1,235.59
Other Mode User Benefits		
Airport Congestion	$40.70	$49.08
Highway Congestion	$70.21	$94.95
Resources Benefits		
Airlines	$21.89	$26.40
Emissions	$1.38	$1.65
Total Benefits	**$2,183.59**	**$2,577.63**
Total Costs	**$2,373.43**	**$2,040.43**
Ratio of Benefits to Costs	**0.92**	**1.26**

8. Comparison of the Southern Route and Option with Express NICTD Service

This study has shown that there are significant financial as well as travel-time reasons for selecting the Southern corridor as the designated high-speed rail route between Chicago and Cleveland. Throughout the discussions about this study, however, a goal has been expressed by the Indiana Department of Transportation that the recommendations should propose ideas for rail transportation improvements that would be beneficial to all of the major population centers in the northern part of the state. Unfortunately, the recommended southern corridor through Ft. Wayne does not connect directly with other major markets in Northern Indiana such as the South Bend / Elkhart region, so other types of improvements are being considered in this chapter as ways to serve these areas better. New express NICTD service was investigated for its costs and benefits.

South Bend is currently connected to Chicago via the NICTD service. Seven daily trains run in each direction between these two cities. Each of these trains stops at as many as sixteen of the stations along the route to Chicago, making the total travel time approximately 2:30. A recommendation to provide new express trains has been suggested as a way to provide travel benefits to South Bend. Two additional express trains in each direction would be added to the current service levels. These trains would stop only once on their way to downtown Chicago (near Gary) bringing the total travel time down to two hours. Along with providing faster service to Chicago, the stop near Gary would provide travelers from South Bend a connection to the MWRRI system, allowing links to other Midwest destinations beyond Chicago. If warranted, a future rail extension of the NICTD service from South Bend to Elkhart might also occur and should be further studied by INDOT.

Along with these proposed improvements, feeder buses would provide connections to eastward-running trains. The preliminary plan for feeder bus service envisions a bus originating in Elkhart and running into downtown South Bend. From there, it would connect to Niles, MI, on the route to Detroit as well as to Plymouth, IN, on the Cleveland corridor. Other feeder bus alignments might also be possible, with additional review needed to determine the most cost-effective routing and level of service for this market.

8.1 Ridership

By connecting the NICTD express service into the MWRRI network, NICTD serves as both a commuter service and a rail feeder to the MWRRI system. Although the number of riders on the Southern route shows a slight decline when the NICTD express service is added, by being able to connect to the MWRRI network at Gary, overall there is an increase in riders feeding into the MWRRI system (in other words, more people have direct access to passenger train service). The decrease in passengers on the Southern Route occurs because, with NICTD express service, people from the South Bend area are less likely to drive or use the feeder bus connections to ride MWRRI trains to Chicago. The slight decline in the riders on the Southern Route is substantially offset by the increase in passengers using the NICTD express service. Because the costs for the NICTD express service are included in the calculations for this option, the revenue from the express trains is also included in this analysis, as shown in the increased revenue amounts listed in Exhibit 8-1.

The addition of express NICTD service decreases the annual ridership on the Southern Route by 6,386 passengers. However, since the NICTD express service allows direct access between the South Bend area and the rest of the Midwest Regional Rail System, TEMS ridership models estimate NICTD ridership increasing by 186,000 passengers per year. Overall, the additional NICTD express service increases the total number of passenger rail riders in Northern Indiana because these additional passengers will have direct rail access to other Midwestern destinations via Gary or downtown Chicago. The annual fare box revenue for the Southern Route increases by $2,187,000 in the year 2020 due to the inclusion of the NICTD express revenue. These comparisons discussed here between the Southern Route numbers and the Southern Route with NICTD numbers can be seen by examining Exhibit 5-2 earlier in this report with the numbers shown in Exhibit 8-1.

Exhibit 8-1: Southern Route Ridership and Revenue Forecast

With Improved NICTD Service

Year	Southern Route Ridership (Annual Trips)	Express NICTD Ridership (Annual Trips)	Farebox Revenue (Millions of 2002$)
2010 (Phase 4)	859,059	186,150	$52.052
2011 (Phase 5)	930,924	186,150	$54.560
2012 (Phase 6)	954,047	186,150	$55.871
2015*	999,208	186,150	$57.971
2020*	1,060,808	186,150	$61.471
2023*	1,107,795	186,150	$64.046
2033*	1,264,420	186,150	$72.628
2040*	1,374,057	186,150	$78.635
2042*	1,405,660	186,150	$80.392

* MWRR system fully implemented

Note: Fare box revenues include additional NICTD revenue, but exclude on-board services and express parcels.

8.2 Capital and Operating Costs

To operate additional NICTD service, the Southern Route bears an annual cost of approximately $3.726 million by operating 136,024 annual train miles of express NICTD service, which uses a rate of $29.6 dollars per trainmile based on its 1999 annual operations. Additional capital infrastructure costs would be necessary to increase the capacity of the track for the additional NICTD express service. Estimates for an additional passing siding, new catenary and other track improvements are approximately $30 million. The Southern Route also acquires an additional trainset to serve South Bend and Elkhart at a total cost of $9.8 million. Exhibit 8-2 illustrates the costs of starting up the extra NICTD service along with intercity service on the Southern Route.

Exhibit 8-2: Total Capital Costs

Service	Total Cost	
	Southern Route	Southern Route with NICTD
Infrastructure, Track and R.O.W.	$1,206,276,000	$1,206,276,000
Rolling Stock for Intercity Service	$75,600,000	$75,600,000
Rolling Stock for NICTD Commuter Service		$9,809,620
Additional NICTD Infrastructure		$30,000,000
Total	$1,281,876,000	$1,321,685,620
Note: Costs are in 2002 Dollars		

8.3 Economic Analysis

An economic analysis was performed for the two options. For the benefit-cost, we compared the sum of discounted benefits to the sum of discounted costs in a Net Present Value (NPV) analysis for the 2013-2042 periods.

While the Southern Route outperforms the Southern Route with express NICTD on an economic basis, the benefit-cost ratio for both scenarios is positive. In other words, both options will generate more benefits than their respective costs. Exhibit 9-1 shows the economic results with respect to operating revenues, consumer surplus, the other mode user benefits, the resources benefits, and the total costs.

9. Conclusions and Recommendations

For this study, the Northern Route option has been compared to the two alternative Southern Route options (i.e., with and without express NICTD service to South Bend, Indiana). Exhibit 9-1 summarizes the results for the total costs and total benefits associated with each alternative.

Exhibit 9-1: Fort Wayne Alternative Route Option:

Cost-Benefit Analysis for the 2013-2042 Period

30-Year Net Present Value (in Millions of 2002$)			
Parameter	**Northern Route**	**Southern Route**	
		Without Express NICTD	**With Express NICTD**
Benefits			
Revenue	$1,045.57	$1,169.96	$1,198.88
Consumer Surplus	$1,003.85	$1,235.59	$1,240.14
Other Mode User Benefits			
Airport Congestion	$40.70	$49.08	$49.08
Highway Congestion	$70.21	$94.95	$96.59
Resources Benefits			
Airlines	$21.89	$26.40	$26.40
Emissions	$1.38	$1.65	$1.67
Total Benefits	**$2,183.59**	**$2,577.63**	**$2,612.76**
Total Costs*	**$2,373.43**	**$2,040.73**	**$2,134.99**
Ratio of Benefits to Costs	0.92	1.26	1.22
* Un-negotiated costs that show relative magnitude but may not show final dollar figures.			

The analysis shows that the Southern Routes, both with and without express NICTD service, outperform the Northern Route.

Given its stronger economic performance, the Southern Route is the most cost effective alternative. Much of the benefit of the Northern Route is captured by providing express NICTD service to South Bend as part of the Southern Route. This combination maximizes the benefits to travelers in Northern Indiana and across the whole of the MWRRI system and therefore the Southern Route with Express NICTD service is the strategy recommended for implementation as a result of this study.

Other considerations provide additional reasons to support the recommendations in this study. One issue is that it would be less than ideal to have two publicly provided passenger rail operations in the South Bend region competing against each other for customers. Increased subsidy needs for both services could be a result of such a situation. An additional issue is that the Ft. Wayne region is not served by a direct East – West interstate highway to connect it with Chicago and Cleveland. High-speed rail would therefore provide a very competitive modal alternative to the automobile.

The recommendations in this report have defined the most cost-efficient routing for this Chicago-to-Cleveland corridor. However, actual implementation of such recommendations could still be relatively far into the future. Certain tasks such as environmental review for all or portions of the corridor as well as other pre-construction activities would first need to be initiated. Modifications to the findings could occur as these additional steps are taken. Adequate funding sources for the improvements also need to be identified before real progress on the Midwest corridors is likely to begin. Discussions and negotiations with the freight railroads obviously must also continue, to assure that the operating plans are developed in a mutually satisfactory way that offers benefits for all parties. In addition, it must be assured that the design concepts for passenger rail do not hamper the freight railroads' ability to provide effective service to their customers or adversely impact their operational capacity.

The implementation plan for the MWRRS calls for the Cleveland corridor to be constructed in phases three, four and five of the six-phase buildout plan. This is later than several other segments that are proposed. In Indiana, for example, the Chicago-Indianapolis-Cincinnati segments would begin construction earlier than the Chicago to Toledo segment would. Although construction on this route may not begin in the near future, this corridor, as evidenced by the benefit-cost ratio, does offer excellent opportunities to be a strong and beneficial transportation corridor for the residents of this region of the Midwest.

By recommending development of the Southern Route, new direct rail passenger service can be extended to Fort Wayne on the more cost-effective of the two routes while the existing NICTD service to South Bend can be enhanced to ensure continued quality passenger rail service for that community. Direct rail access will be available from South Bend to downtown Chicago with one stop near the Gary/Chicago airport where passengers can access high-speed trains to Indianapolis and the western MWRRI states. In addition, express bus service to Niles, MI, and Plymouth, IN, will allow South Bend area rail passengers to access high-speed trains to Cleveland, Detroit and points east.

Appendix A:

Scenario Timetables

Appendix A: Scenario Timetables

Northern Alignment

Station	Train Number		250	200	202	204	206	208	210	212	214
	Milepost	Schedule Time	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily
Chicago, IL - Union Station	0.0	0:00		6:00	8:55	9:45	11:10	13:30	15:30	18:00	20:20
Gary Airport (IN)	23.0	0:24			9:19		11:34		15:54		20:44
South Bend, IN	84.5	1:14		7:09	10:09	10:54	12:24	14:39	16:44	19:09	21:34
Elkhart, IN	101.0	1:32			10:27		12:42		17:02		21:52
Waterloo, IN	156.0	2:15			11:10		13:25		17:45		22:35
Bryan, OH	181.0	2:35			11:30		13:45		18:05		22:55
Toledo, OH	234.5	3:17	6:30	8:59	12:12	12:44	14:27	16:29	18:47	20:59	23:37
Sandusky, OH	281.5	4:00			12:55		15:10		19:30		0:20
Elyria, OH	316.5	4:35			13:30		15:45		20:05		0:55
Cleveland, OH	341.0	5:00	8:02	10:32	13:55	14:17	16:10	18:02	20:30	22:32	1:20

Station	Train Number		201	203	205	207	209	211	213	215	251
	Milepost	Schedule Time	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily
Cleveland, OH	0.0	0:00	5:06	6:59	8:27	10:29	13:52	14:39	16:08	18:29	20:52
Elyria, OH	24.5	0:25		7:24		10:54		15:04		18:54	21:17
Sandusky, OH	59.5	1:00		7:59		11:29		15:39		19:29	21:51
Toledo, OH	106.5	1:43	6:39	8:42	10:00	12:12	15:25	16:22	17:41	20:12	22:35
Bryan, OH	160.0	2:25		9:24		12:54		17:04		20:54	
Waterloo, IN	185.0	2:46		9:45		13:15		17:25		21:15	
Elkhart, IN	240.0	3:28		10:27		13:57		18:07		21:57	
South Bend, IN	256.5	3:46	8:29	10:45	11:50	14:15	17:15	18:25	19:31	22:15	
Gary Airport (IN)	318.0	4:37		11:36		15:06		19:16		23:06	
Chicago, IL - Union Station	341.0	5:01	9:39	12:00	13:00	15:30	18:25	19:40	20:41	23:30	

Southern Alignment

Station	Train Number		250	200	202	204	206	208	210	212	214
	Milepost	Schedule Time	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily
Chicago, IL - Union Station	0.0	0:00		6:00	8:55	9:45	11:10	13:30	15:30	18:00	20:20
Gary Airport (IN)	23.0	0:24			9:19		11:34		15:54		20:44
Plymouth, IN	84.7	1:08			10:03		12:18		16:38		21:28
Warsaw, IN	109.8	1:27			10:22		12:37		16:57		21:47
Ft. Wayne, IN	148.8	1:57		7:43	10:52	11:28	13:07	15:13	17:27	19:43	22:17
Defiance, OH	192.4	2:35			11:30		13:45		18:05		22:55
Toledo, OH	247.1	3:22	6:30	9:03	12:17	12:48	14:32	16:33	18:52	21:03	23:42
Sandusky, OH	294.1	4:03			12:58		15:13		19:33		0:23
Elyria, OH	329.1	4:30			13:25		15:40		20:00		0:50
Cleveland, OH	353.6	4:52	7:50	10:23	13:47	14:08	16:02	17:53	20:22	22:23	1:12

Station	Train Number		250	200	202	204	206	208	210	212	214
	Milepost	Schedule Time	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily
Cleveland, OH	0.0	0:00	5:17	7:09	8:38	10:39	14:03	14:49	16:19	18:39	21:08
Elyria, OH	24.5	0:20		7:29		10:59		15:09		18:59	21:28
Sandusky, OH	59.5	0:46		7:55		11:25		15:35		19:25	21:54
Toledo, OH	106.5	1:27	6:35	8:36	9:56	12:06	15:21	16:16	17:37	20:06	22:35
Defiance, OH	161.2	2:11		9:20		12:50		17:00		20:50	
Ft. Wayne, IN	204.8	2:50	7:52	9:59	11:13	13:29	16:38	17:39	18:54	21:29	
Warsaw, IN	243.8	3:20		10:29		13:59		18:09		21:59	
Plymouth, IN	268.9	3:39		10:48		14:18		18:28		22:18	
Gary Airport (IN)	330.6	4:23		11:32		15:02		19:12		23:02	
Chicago, IL - Union Station	353.6	4:51	9:39	12:00	13:00	15:30	18:25	19:40	20:41	23:30	

Appendix B: Description of the

COMPASS© Model System

Appendix B: Description of the *COMPASS*© Model System

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.

COMPASS© is structured on two principal models: a Total Demand Model and a Hierarchical Modal Split Model. For this study, these two models were calibrated separately for two trip purposes, i.e., business and non-business (commuter, personal, and social). Moreover, since the behavior of short-distance trip making is significantly different from long-trip-making, the database was segmented by distance and independent models were calibrated for both long and short trips. For each market segment, the models were calibrated on origin-destination trip data, network characteristics, and base year socioeconomic data.

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

Total Demand Model

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

Equation 1. $T_{ijp} = e^{\beta 0p}(SE_{ijp})^{\beta 1p} e^{\beta 2p\ Uijp}$

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 and non-business, and 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.

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	$E_iE_j(I_i+I_j)/2$
Non-Business	$P_iP_j(I_i+I_j)/2$

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 non-business formulation 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. Non-business 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.

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 airports, 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, additional wait times are incurred at connecting stations. 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 non-business 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 *non-business* generalized cost. For bus travel, the interchange penalties are 20 minutes and 15 minutes for business and non-business, 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 be some double counting because the station wait time in the first term of the generalized cost function is included in this headway measure, the headway time itself is not 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.

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

This provides the linear specification of the model necessary for regression analysis.

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 trips. This cutoff was chosen because travel behavior switches significantly around this level, with travelers considering faster modes such as air and high-speed rail over the automobile. In the base data, the average trip length for the short-distance model is approximately 80 miles, while the average trip length for the long-distance model is approximately 310 miles. The results of the calibration for the Total Demand Models are displayed in Exhibit C-1.

In evaluating the validity of a statistical calibration, there are two key statistical measures: *t*-statistics and R^2. *T*-statistics are a measure of the significance of the model's coefficients; values of 1.95 and above are considered "good" and imply that the variable has significant explanatory power in estimating the level of trips. 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 excellent. The *t*-statistics are very high, aided by the large size of the Midwest data set. There are roughly five times as many long-distance observations as short-distance observations, resulting in higher *t*-statistics for the long-distance models. R^2 values imply "very good" fits of the equations to the data.

As shown in Exhibit B-1, the socioeconomic elasticity values for the Total Demand Model are close to 0.4, meaning that each 1 percent growth in the socioeconomic term generates approximately a 0.4 percent growth in trips. Since each component of the socioeconomic term will have this elasticity, a one percent increase in population (or employment) of every zone combined with a one percent increase in income will result in a 0.8 percent growth in trips.

The coefficient on the utility term is not exactly elastic, but it can be used as an approximation. Thus, the transportation system or network utility elasticity is higher for short distance-trips than long-distance trips, with each 1 percent improvement in network utility or quality as measured by generalized cost (i.e., travel times or costs), generating approximately a 0.7 percent increase for long trips and a 1.3 percent increase for short trips. The 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 trips, reflecting in the higher elasticity on the short-distance model.

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

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

$$\begin{array}{lllllllll} \text{Business:} & \log(T_{ij}) & = & -2.41 & + & 0.421\,SE_{ij} & + & 0.987\,U_{ij} & R^2=0.71 \\ & & & & & (91) & & (65) & \end{array}$$

Where

$$U_{ij} = \text{og}[\exp(-0.437 + 3.718\,U_{Pub}) + \exp(-0.00166\,GC_{Car})]$$

$$\begin{array}{lllllllll} \text{Non-Business:} & \log(T_{ij}) & = & -2.44 & + & 0.403\,SE_{ij} & + & 0.539\,U_{ij} & R^2=0.70 \\ & & & & & (125) & & (76) & \end{array}$$

Where

$$U_{ij} = \log[\exp(-0.532 + 3.415\,U_{Pub}) + \exp(-0.00219\,GC_{Car})]$$

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

$$\begin{array}{lllllllll} \text{Business:} & \log(T_{ij}) & = & -0.47 & + & 0.396\,SE_{ij} & + & 1.388\,U_{ij} & R^2=0.72 \\ & & & & & (19) & & (19) & \end{array}$$

Where

$$U_{ij} = \log[\exp(-4.482 + 2.765\,U_{Pub}) + \exp(-0.00787\,GC_{Car})]$$

$$\begin{array}{lllllllll} \text{Non-Business:} & \log(T_{ij}) & = & -0.44 & + & 0.390\,SE_{ij} & + & 1.262\,U_{ij} & R^2=0.70 \\ & & & & & (15) & & (13) & \end{array}$$

Where

$$U_{ij} = \log[\exp(-2.852 + 1.430\,U_{Pub}) + \exp(-0.00380\,GC_{Car})]$$

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

The utility functions are functions of the generalized costs of the modes of travel. In deriving the total utility term, a special "logsum" approach is used in which utilities are built up from individual modes in a recursive fashion. Further details are provided later in this report. Thus, the total utility is derived from the *auto* generalized cost and the public mode utility, which itself is derived from the generalized costs of its constituent modes (i.e., air, rail, bus). The exact form for the public mode utility function is determined from the calibration process for the modal split models and is described in the next section.

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, income and 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.

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

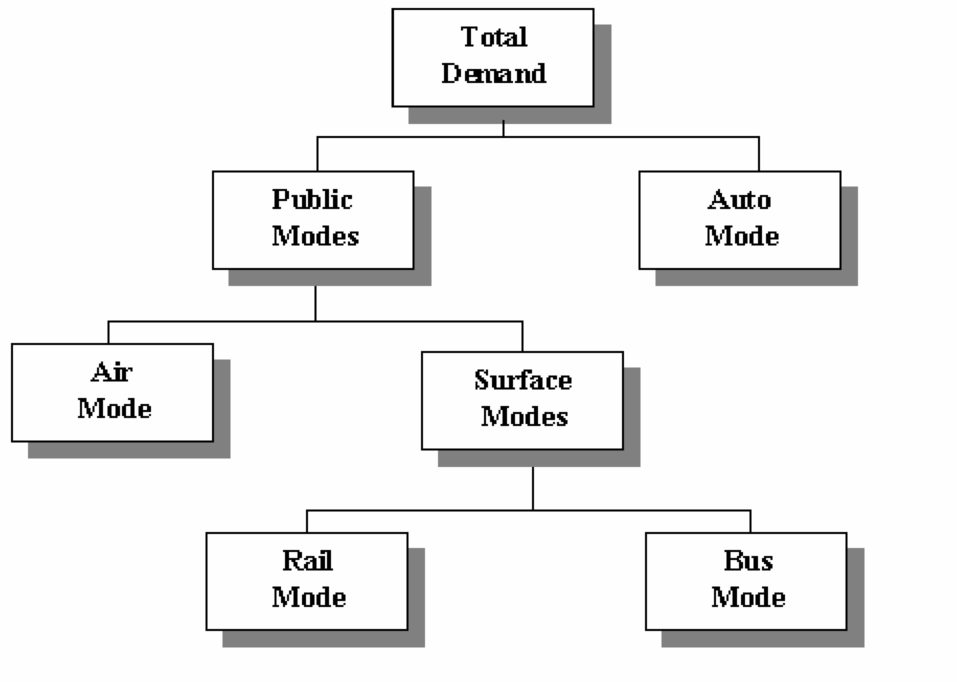
Where
T^{f}_{ijp} = Number of Trips between zones i and j for trip purpose p in forecast year f
T^{b}_{ijp} = Number of Trips between zones i and j for trip purpose p in base year b
SE^{f}_{ijp} = Socioeconomic variables for zones i and j for trip purpose p in forecast year f
SE^{b}_{ijp} = Socioeconomic 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.

Modal Split Model

The role of the Modal Split Model is to estimate relative modal shares, given the Total Demand Model estimate of the total market. Relative modal shares are derived by comparing the relative levels of service offered by each of the travel modes. The *COMPASS*© 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.

Form of the Modal Split Model

To assess modal split behavior, the logsum utility function, which is derived from travel utility theory, has been adopted. As the modal split hierarchy ascends, the logsum utility values are derived by combining the generalized costs of travel. Advantages of the logsum utility approach are 1) the introduction of a new mode will increase the overall utility of travel, and 2) a new mode can readily be incorporated into the Modal Split Model, even if it were not included in the base-year calibration.

As only two choices exist at each level of the modal split hierarchical structure, a Binary Logit Model is used, as shown in Equation 6:

Equation 6.

$$P_{ijmp} = \frac{\exp(U_{ijmp} / \rho)}{\exp(U_{ijmp} / \rho) + \exp(U_{ijnp} / \rho)}$$

Where

P_{ijmp} = Percentage of trips between zones i and j by mode m for trip purpose p

U_{ijmp}, U_{ijnp} = Utility functions of modes m and n between zones i and j for trip purpose p

ρ is called the "nesting" coefficient

In Equation 6, the utility of travel between zones *i* and *j* by mode *m* for trip purpose *p* is a function of the generalized cost of travel. Where mode *m* is a composite mode (e.g., the surface modes in the third level of the Modal Split Model hierarchy, which consist of the rail and bus modes), the utility of travel, as described below, is derived from the utility of the two or more modes it represents.

Utility of Composite Modes

Where modes are combined, as in the upper levels of the modal split hierarchy, it is essential to be able to measure the "inclusive value" of the composite mode, e.g., how the combined utility for bus and rail compares with the utility for bus or rail alone. The combined utility is more than the utility of either of the modes alone, but it is not simply equal to the sum of the utilities of the two modes. A realistic approach to solving this problem, which is consistent with utility theory and the logit model, is to use the logsum function. As the word *logsum* suggests, the utility of a composite mode is defined as the natural logarithm of the sum of the utilities of the component modes. In combining the utility of separate modes, the logsum function provides a reasonable proportional increase in utility that is less than the combined utilities of the two modes but reflects the value of having two or more modes available to the traveler. For example:

Suppose

Utility of Rail, or

U_{rail} = á + âGC_{rail}

Utility of Bus, or

U_{bus} = ãGC_{bus}

Then

Inclusive Utility of Surface Modes, or

$U_{surface} = \log(e^{U_{rail}} + e^{U_{bus}})$

Improvements in either rail or bus would result in improvements to the inclusive utility of the surface modes.

In a nested binary logit model, the calibrated coefficients associated with the inclusive values of composite modes are the *nesting coefficients* and take on special meaning. If one of these coefficients is equal to 1, then that level of the hierarchical model collapses and two levels of the hierarchy essentially become one. At this point, the Modal Split Model is a multinomial logit model that is analyzing three or more modes, i.e., all the modes comprising the composite mode as well as the other modes in that level of the hierarchy. If one of the coefficients is greater than

1, then the hierarchy has been incorrectly specified and counterintuitive forecasts will result. Because of the assumptions behind the Modal Split Model, the coefficients must decrease as the modal split hierarchy is ascended or counterintuitive results will occur. Thus, the coefficients provide a check on whether the Modal Split Model hierarchy has been specified correctly.

Calibration of the Modal Split Model

Working from the bottom of the hierarchy to the top, the first analysis is that of the rail mode versus the bus mode. As shown in Exhibit B-3, the model was effectively calibrated for the two 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. Rail travelers are more sensitive than bus travelers are to time and cost. This is as expected, given the general attitude that travelers, and in particular business travelers, have toward the bus mode. The higher coefficients on the short-distance models are partly due to the scale effect where the same time or cost improvements would be more meaningful on shorter trips.

Exhibit B-3: Rail versus Bus Modal Split Model Coefficients[*]

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

Business:	$\log(P_{Rail}/P_{Bus})$	=	1.340	- 0.00109 GC_{Rail}	+	0.000451 GC_{Bus}	R^2=0.44
				(37)		(16)	
Non-Business:	$\log(P_{Rail}/P_{Bus})$	=	0.675	- 0.00136 GC_{Rail}	+	0.000494 GC_{Bus}	R^2=0.55
				(66)		(27)	

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

Business:	$\log(P_{Rail}/P_{Bus})$	=	2.295	- 0.00224 GC_{Rail}	+	0.000592 GC_{Bus}	R^2=0.50
				(18)		(6)	
Non-Business:	$\log(P_{Rail}/P_{Bus})$	=	1.098	- 0.00230 GC_{Rail}	+	0.000165 GC_{Bus}	R^2=0.46
				(17)		(3)	

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

The constant term in each equation indicates the degree of bias towards one mode or the other. Since the terms are positive in all the market segments, 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. As expected, this bias is larger for business travelers who tend to have very negative perceptions of intercity bus.

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-4, 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 air coefficients, short-distance travelers are less sensitive to changes in the air costs than long-distance travelers. One explanation is some short-distance air trips are special trips responding to personal or business emergencies and, thus, are cost insensitive. As indicated by the constant terms, there is a large bias towards air travel for long-distance trips. However, for short trips, there is only a small bias towards air for both business and non-business travelers.

Exhibit B-4: Surface versus Air Modal Split Model Coefficients*

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

Business:

$$\log(P_{Surf}/P_{Air}) = -3.260 + \underset{(78)}{2.786\ U_{Surf}} + \underset{(79)}{0.00184\ GC_{Air}} \qquad R^2=0.56$$

Where

$$U_{Surf} = \log[\exp(1.340 - 0.00109\ GC_{Rail}) + \exp(-0.000451\ GC_{Bus})]$$

Non-Business:

$$\log(P_{Surf}/P_{Air}) = -1.520 + \underset{(102)}{3.284\ U_{Surf}} + \underset{(97)}{0.00210\ GC_{Air}} \qquad R^2=0.56$$

Where

$$U_{Surf} = \log[\exp(0.675 - 0.00136\ GC_{Rail}) + \exp(-0.000494\ GC_{Bus})]$$

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

Business

$$\log(P_{Surf}/P_{Air}) = -1.450 + \underset{(21)}{3.981\ U_{Surf}} + \underset{(4)}{0.000418\ GC_{Air}} \qquad R^2=0.62$$

Where

$$U_{Surf} = \log[\exp(2.295 - 0.00224\ GC_{Rail}) + \exp(-0.000592\ GC_{Bus})]$$

Non-Business

$$\log(P_{Surf}/P_{Air}) = -0.927 + \underset{(19)}{6.853\ U_{Surf}} + \underset{(9)}{0.000990\ GC_{Air}} \qquad R^2=0.55$$

Where

$$U_{Surf} = \log[\exp(1.098 - 0.00230\ GC_{Rail}) + \exp(-0.000165\ GC_{Bus})]$$

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-5, the model calibrations for both trip purposes are all statistically significant, with good R^2 and *t* values and reasonable parameters in most cases. A reason why the R^2 value for the non-business, short-distance model is a bit lower than in the rest of the model is because local transit trips are not included in the public trip database, causing some of the observations to deviate significantly from the model equation. The constant terms show that there is a bias towards the auto mode, with the bias increasing with shorter trip length.

Exhibit B-5: Public versus Auto Modal Split Model Coefficients[*]

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

Business:
$$\log(P_{Pub}/P_{Auto}) = -0.437 + \underset{(110)}{3.718\,U_{Pub}} + \underset{(96)}{0.00166\,GC_{Auto}} \qquad R^2=0.71$$

Where
$$U_{Pub} = \log[\exp(-3.26 + 2.786\,U_{Surf}) + \exp(-0.00184\,GC_{Air})]$$

Non-Business:
$$\log(P_{Pub}/P_{Auto}) = -0.532 + \underset{(106)}{3.415\,U_{Pub}} + \underset{(107)}{0.00219\,GC_{Auto}} \qquad R^2=0.54$$

Where
$$U_{Pub} = \log[\exp(-1.52 + 3.284\,U_{Surf}) + \exp(-0.00210\,GC_{Air})]$$

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

Business:
$$\log(P_{Pub}/P_{Auto}) = -4.482 + \underset{(9)}{2.765\,U_{Pub}} + \underset{(19)}{0.00787\,GC_{Auto}} \qquad R^2=0.55$$

Where
$$U_{Pub} = \log[\exp(-1.45 + 3.981\,U_{Surf}) + \exp(-0.000418\,GC_{Air})]$$

Non-Business:
$$\log(P_{Pub}/P_{Auto}) = -2.852 + \underset{(10)}{1.430\,U_{Pub}} + \underset{(13)}{0.00380\,GC_{Auto}} \qquad R^2=0.44$$

Where
$$U_{Pub} = \log[\exp(-0.927 + 6.853\,U_{Surf}) + \exp(-0.00099\,GC_{Air})]$$

t-statistics are given in parentheses.

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 Midwest Regional Rail 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 modal split models is used:

Equation 7.

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

where

P_A^f = Percentage of trips using mode *A* in the forecast year *f*

P_A^b = Percentage of trips using mode *A* in the base year *b*

GC_A^f = Generalized cost for mode *A* in the forecast year *f*

GC_A^b = Generalized cost for mode *A* in the base year *b*

β,γ = Estimated coefficients

For 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 changes in generalized cost from base conditions.

Another consequence of the pivot point method is that extreme changes from current trip-making levels and current modal shares are rare. Thus, since very few short-distance commuter trips are currently being made on Amtrak, the forecasted growth in these trips will be limited despite the huge auto market.

These calibrated models maximize the use of available local origin-destination data for the study area. The calibrated Total Demand and Modal Split Models appear very reasonable and compare well with models constructed for other transportation projects.

Appendix C: Detailed Infrastructure Cost Estimates