7. Financial and Economic Viability

The analysis uses the same criteria and structure as the 1997 FRA *Commercial Feasibility Study*[48]. In that study, costs and benefits were quantified in terms of passenger rail system user benefits, other-mode user benefits and resources benefits. The study described two conditions that were considered essential for receiving federal funding support for proposed intercity passenger rail projects:

- An operating cost ratio of at least 1.0, defined as a pre-condition for an effective public/private partnership, so that once the system has been constructed, a private operator could operate the system on a day-to-day without financial loss49, and
- A benefits/cost ratio greater than 1.0, to ensure that the project makes an overall positive contribution to the economy, at both the regional and national levels.

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

The operating performance and financial analysis for the Ohio and Lake Erie Regional Rail - Ohio Hub system reflects economies of scale inherent in construction and operation of a large regional passenger rail service. This chapter discusses the operating performance of each corridor alternative and presents the financial analysis of the system's construction and operation. This analysis integrates capital, operating and maintenance costs and revenue projections. It was prepared at the system level for various selected route configuration options to provides insight into the viability of the overall proposed Ohio Hub system.

7.1 Financial Performance Measures

Financial performance was evaluated by analyzing the operating cash flows for each corridor. Two criteria have been identified by the Federal Railroad Administration[50] as critical to the evaluation of proposed high-speed rail projects: the operating ratio and benefit/cost ratio. The ratio of operating revenues to operating costs (i.e., operating cost ratio) provides a key indicator of the financial viability of the Ohio Hub System. The operating ratio is calculated as follows:

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

The benefit/cost ratio is a calculation that is based on a summation of the value of project benefits and costs, over the entire lifetime of a project. This financial measure uses a discounted

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

[49] As defined in the Commercial Feasibility Study, a positive operating ratio does not imply that a passenger service can attain "commercial profitability." Since "operating ratio" as defined here does not include any capital-related costs, this report shows that the proposed Ohio Hub network meets the requirements of the Commercial Feasibility Study by covering at least its direct operating costs and producing a cash operating surplus.

[50] Federal Railroad Administration *Commercial Feasibility Study*

cash flow, or interest-rate based, approach using the standard financial formula for calculating Present Values:

$$PV = \Sigma \ C_t / (1 + r)^t$$

Where:

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

For this analysis, the discount rate, or the opportunity cost of capital was set at 3.9 percent[51]. The calculation of the benefit/cost ratio is addressed fully in Chapter 8. This chapter will focus on the operating ratio criteria.

7.2 The Three-Layered Analysis

The earlier 2004 Ohio Hub study relied upon complex allocations of capital and operating cost, as well as of revenue between routes to separate Ohio Hub financials from those of the MWRRS system, and to eliminate double counting of ridership, revenues, costs, or benefits. However, this allocations-based approach also made the Ohio Hub dependent on the MWRRS to pay its share of the costs. More recently, proposed development of a direct Columbus to Chicago service substantially increased the overlap between Ohio Hub and the MWRRS system:

- Given this increased overlap, the allocations would have become even more complicated. Instead of perpetuating the dependency of Ohio Hub on MWRRS in the 2007 update, a new approach was developed for eliminating the dependency, and making it possible to develop critical line segments on Ohio's own timetable.
- In addition, planning MWRRS and Ohio Hub separately resulted in suboptimal operations – in the 2004 plan for example, from Toledo to Cleveland, both systems operated 8 round-trips per day, a total of 16 combined round-trip frequencies – which provided more trains than the market really needed or could support, and led to poor financial performance of both routes. This deficiency has been rectified in the 2007 update by planning the services on an integrated basis and the financial performance of both the MWRRS Cleveland line and Ohio Hub Detroit line have been substantially improved.
- Finally, the allocations approach was incapable of dealing with the issue of connecting revenue impacts. For example, adding a Fort Wayne to Columbus link would substantially increase the revenue and ridership of the MWRRS Chicago to Fort Wayne link, without needing to add much more investment on that link. An approach was needed that would be able to identify these connecting revenue benefits and incorporate them into the Ohio Hub Cost Benefit calculations.

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

To develop an integrated planning approach, the three eastern MWRRS routes were incorporated into the Ohio Hub ridership and financial forecasting models. This level of integration is consistent with the previous 2004 Ohio Hub report, which assumed both MWRRS ridership interconnectivity as well as substantial cost-sharing with the MWRRS system. The key difference is that in the new analysis, revenue, ridership and financial statistics were collected and reported for the MWRRS eastern routes as well as for the Ohio Hub segments. Although these MWRRS routes were integrated into the Ohio Hub models, financial reporting was still kept separate so that route and subnetwork-level statistics could still be identified.

For implementation planning an integrated model permits any combination of MWRRS and Ohio Hub lines to be assembled in any order desired. However, a hypothetical three-layered network structure was envisioned that clustered corridors into logical subnetworks, as follows:

- MWRRS corridors first (to establish prerequisite MWRRS connectivity)
- The four Ohio Hub "core" routes then added on top of the MWRRS, corresponding to the "Preferred Option 1" identified in the earlier 2004 study, and finally
- The three "incremental" corridors in the last stage.

Exhibits 7-1 through 7-3 show these three network layers, which are intended to correspond to the historical development of the Ohio Hub system planning process. The numbers next to each line show the train frequency that was assumed over each segment in the jointly-optimized train operating plan. Additional frequencies were needed in the larger networks to accommodate increased ridership demand. These layered networks were developed to allow a preliminary assessment of connecting revenues and the financial viability of the Ohio Hub system, and served as input to development of the final implementation plan. The "Indianapolis Shortcut" shown in Exhibit 7-3 was assessed separately by a Columbus-Indianapolis parametric analysis. The Shortcut did not receive am engineering assessment in this study. The analysis of the Indianapolis Shortcut is provided in Appendix.

The 2025 revenue and financial forecasts for the three layered 110-mph networks are given in Exhibit 7-4 through 7-6. A 79-mph forecast for layers 2 and 3 is given in Exhibit 7-7. Total revenues include passenger fares, on board food sales, express parcel and feeder bus.

It can be seen that the 110-mph forecasts for Layer 1 are very close to the MWRRS evaluation that was published in 2004. By comparison to Exhibit 10-4 from the MWRRS plan, it can be seen that Michigan revenues are practically the same; Cincinnati line revenues are $8 million lower than they were in the MWRRS plan; but Cleveland line revenues are $2 million higher. The passenger miles and ridership results are also very close. Accordingly, the new Ohio Hub model is calibrated slightly conservatively relative to the original MWRRS forecast. The three-route Layer 1 MWRRS subnetwork would be operationally self-sufficient attaining a positive operating ratio of 1.35.

Exhibit 7-1: Layer 1- MWRRS Eastern Routes

Exhibit 7-2: Layer 2- MWRRS Eastern Routes + Ohio Core

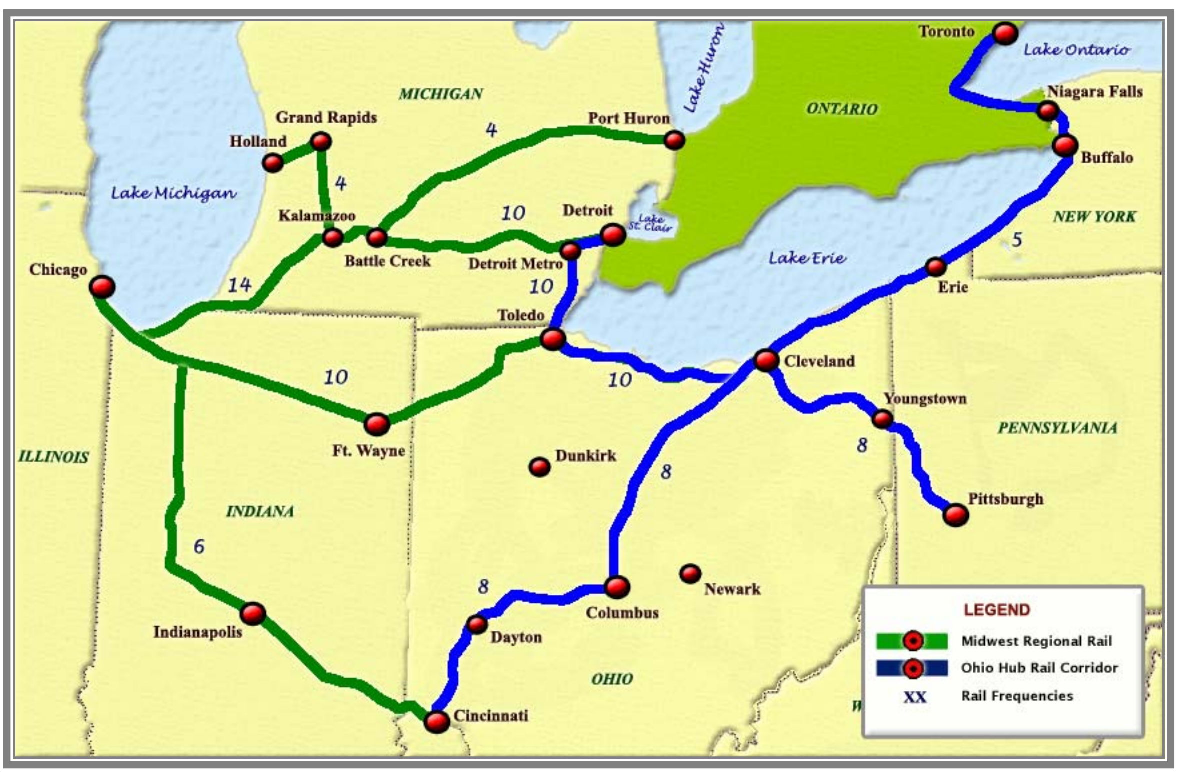
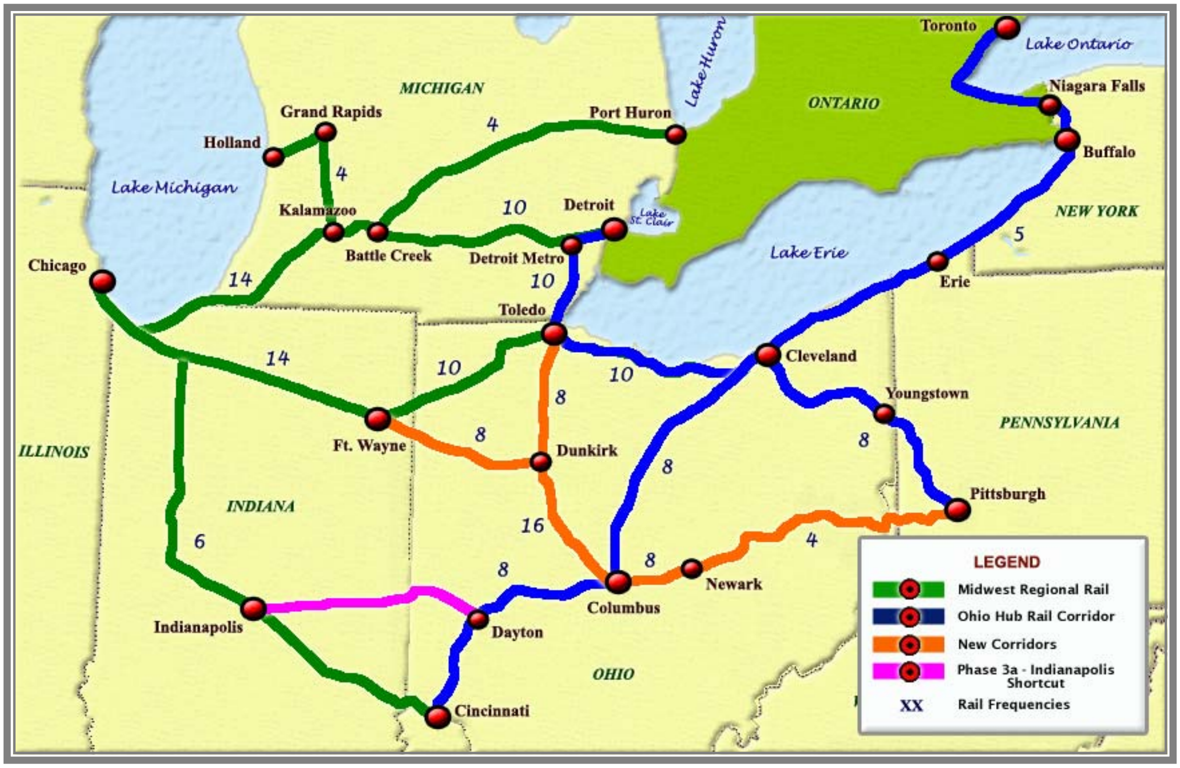


Exhibit 7-3: Layer 3- MWRRS Eastern Routes + Ohio Core + Incremental Corridors



As compared to the original MWRRS forecasts, the differences in Cincinnati and Cleveland line revenues in Layer 1 are mostly attributed to fact that the Ohio Hub employs a different feeder bus network. Ohio Hub feeder buses tend to favor the Cleveland line, whereas the MWRRS bus network had been adjusted to favor the Cincinnati line instead. In any case, since direct rail service from Cincinnati to the east is added as soon as the 3-C corridor opens, there is no need to develop an extensive Cincinnati feeder bus network in the Ohio Hub model.

Another difference as compared to the previous MWRRS result is that reporting of Chicago to Cleveland line is broken into two parts: Chicago-Toledo and Toledo-Cleveland.[52] In Layers 2 and 3, the Toledo to Cleveland riders and revenue are all reported as part of Ohio Hub Detroit corridor rather than as a part of the MWRRS. Even so, adding 110-mph Ohio Hub core routes in Layer 2 strongly boosts the revenues of the MWRRS Cleveland line. In Layer 2, all revenues from Cleveland to Toledo accrue to the Cleveland-Detroit line; but it can be seen that the revenues of the MWRRS Cleveland line still increase from $75 million to up $87 million, in spite of the cutting-back of the MWRRS corridor to Toledo. The 2025 operating ratio of the eastern MWRRS lines improves from 1.35 to 1.48 while the four Ohio Hub corridors are forecast to generate a very strong 1.76 operating ratio, mostly because of the high average revenue yield assumption that was earlier established for the core Ohio Hub routes.

[52] By comparison to Table 4-35 in the June 2004 MWRRS Project Notebook, it can be seen that the Layer 1 results reflect a total of 282.1 million passenger-miles versus 252.1 million passenger-miles that was published in the MWRRS report. This reflects a slight strengthening of the Toledo to Cleveland forecast that occurred in the new Ohio Hub model, but the overall ridership forecast for the MWRRS Cleveland corridor is not that much greater than it was before. The reason the ridership increased from 1.12 million to 2.03 million riders is because the double-counting of riders through Toledo, which occurs now as a result of breaking the Chicago-Cleveland line into two segments for financial reporting purposes. The actual forecast ridership has not increased by that much.

Exhibit 7-4: Forecast 2025 Financial Results for Layer 1 Routes*

Corridor	Revenue	Cost	Rev/TM	Cost/TM	Surplus	Op Ratio	Riders	Psgr Miles	Load Fctr	Trip Len	Yield
Chicago-Michigan	$136	$99	$47.57	$34.84	$36	1.37	3.69	608.7	0.71	165	$0.22
Chicago-FTW-Toledo-Clev	$75	$59	$42.22	$33.51	$15	1.26	2.03	282.1	0.53	139	$0.26
Chicago-Cincinnati	$58	$41	$50.00	$35.06	$17	1.43	0.93	200.4	0.58	217	$0.29
Total MWRRS Eastern	**$268**	**$199**	**$46.42**	**$34.48**	**$69**	**1.35**	**6.64**	***1091.3***	**0.63**	**164**	**$0.25**

Exhibit 7-5: Forecast 2025 Financial Results for Layer 1 + 2 Routes

Corridor	Revenue	Cost	Rev/TM	Cost/TM	Surplus	Op Ratio	Riders	Psgr Miles	Load Fctr	Trip Len	Yield
Chicago-Michigan	$136	$96	$47.64	$33.58	$40	1.42	3.83	610.8	0.71	159	$0.22
Chicago-FTW-Toledo	$87	$54	$56.48	$35.05	$33	1.61	1.99	327.1	0.71	164	$0.27
Chicago-Cincinnati	$55	$39	$47.69	$33.29	$17	1.43	0.93	200.4	0.58	217	$0.28
Total MWRRS Eastern	**$278**	**$188**	**$50.10**	**$33.93**	**$90**	**1.48**	**6.75**	**1138.4**	**0.68**	**169**	**$0.24**
Cleveland-Cincinnati	$100	$50	$77.72	$39.11	$50	1.99	1.98	264.3	0.68	133	$0.38
Cleveland-Detroit	$55	$36	$50.42	$32.73	$19	1.54	2.11	213.8	0.65	101	$0.26
Cleveland-Niagara Falls	$43	$24	$66.43	$37.06	$19	1.79	0.88	112.1	0.58	127	$0.38
Cleveland-Pittsburgh	$34	$22	$48.64	$31.29	$12	1.55	0.93	104.6	0.50	112	$0.32
Subtotal OHIO Base	***$232***	***$132***	***$62.30***	***$35.42***	***$100***	***1.76***	***5.91***	***694.7***	***0.62***	***118***	***$0.33***
TOTAL OHIO HUB	**$232**	**$132**	**$62.30**	**$35.42**	**$100**	**1.76**	**5.91**	**694.7**	**0.62**	**118**	**$0.33**

Exhibit 7-6: Forecast 2025 Financial Results for 110-mph Layer 1 + 2 + 3 Routes

Corridor	Revenue	Cost	Rev/TM	Cost/TM	Surplus	Op Ratio	Riders	Psgr Miles	Load Fctr	Trip Len	Yield
Chicago-Michigan	$136	$97	$47.73	$34.12	$39	1.40	3.87	614.2	0.72	159	$0.22
Chicago-FTW-Toledo	$99	$64	$53.72	$34.81	$35	1.54	2.39	371.9	0.67	155	$0.27
Chicago-Cincinnati	$60	$40	$51.44	$34.42	$20	1.49	1.39	204.7	0.59	147	$0.29
Total MWRRS Eastern	**$295**	**$202**	**$50.36**	**$34.40**	**$94**	**1.46**	**7.66**	**1190.9**	**0.68**	**155**	**$0.25**
Cleveland-Cincinnati	$100	$55	$78.01	$42.88	$45	1.82	2.56	267.3	0.69	104	$0.38
Cleveland-Detroit	$51	$36	$46.44	$32.82	$15	1.41	2.23	200.0	0.61	90	$0.25
Cleveland-Niagara Falls	$45	$25	$69.49	$38.32	$20	1.81	0.91	116.5	0.60	128	$0.39
Cleveland-Pittsburgh	$30	$22	$43.17	$31.24	$8	1.38	0.86	92.9	0.44	108	$0.32
Subtotal OHIO Base	***$226***	***$138***	***$60.74***	***$36.96***	***$89***	***1.64***	***6.56***	***676.7***	***0.61***	***103***	***$0.33***
Pittsburgh-Columbus	$25	$20	$41.22	$32.98	$5	1.25	0.92	90.9	0.51	99	$0.27
Columbus-Ft Wayne	$36	$26	$45.40	$33.04	$10	1.37	1.12	142.20	0.59	127	$0.25
Columbus-Toledo	$24	$18	$42.85	$31.83	$6	1.35	0.75	94.80	0.56	127	$0.25
Subtotal OHIO Incremental	***$85***	***$64***	***$43.39***	***$32.67***	***$21***	***1.33***	***2.78***	***327.85***	***0.56***	***118***	***$0.26***
TOTAL OHIO HUB	**$311**	**$202**	**$54.76**	**$35.48**	**$110**	**1.54**	**9.34**	**1004.58**	**0.59**	**108**	**$0.31**

Exhibit 7-7: Forecast 2025 Financial Results for 110-mph Layer 1 plus 79-mph Layer 2 + 3 Routes

Corridor	Revenue	Cost	Rev/TM	Cost/TM	Surplus	Op Ratio	Riders	Psgr Miles	Load Fctr*	Trip Len	Yield
Chicago-Michigan	$136	$100	$47.73	$35.19	$36	1.36	3.87	606.4	0.71	157	$0.22
Chicago-FTW-Toledo	$87	$64	$47.28	$34.68	$23	1.36	2.11	325.0	0.59	154	$0.27
Chicago-Cincinnati	$59	$41	$50.41	$35.37	$17	1.43	1.36	200.6	0.58	147	$0.29
Total MWRRS Eastern	***$282***	***$205***	***$48.12***	***$35.06***	***$76***	***1.37***	***7.34***	***1132.1***	***0.64***	***154***	***$0.25***
Cleveland-Cincinnati	$40	$42	$30.99	$32.43	($2)	0.96	1.60	167.5	0.65	105	$0.24
Cleveland-Detroit	$28	$31	$26.07	$28.42	($3)	0.92	1.52	136.9	0.63	90	$0.21
Cleveland-Niagara Falls	$18	$19	$27.22	$29.47	($1)	0.92	0.59	75.7	0.59	128	$0.23
Cleveland-Pittsburgh	$17	$20	$24.25	$28.64	($3)	0.85	0.60	64.3	0.46	108	$0.26
Subtotal OHIO Base	***$103***	***$112***	***$27.63***	***$30.03***	***($9)***	***0.92***	***4.30***	***444.5***	***0.60***	***103***	***$0.23***
Pittsburgh-Columbus	$14	$17	$23.13	$28.99	($3)	0.80	0.62	62.1	0.52	101	$0.22
Columbus-Ft Wayne	$20	$24	$25.47	$29.72	($3)	0.86	0.79	93.54	0.59	118	$0.22
Columbus-Toledo	$14	$16	$24.04	$27.74	($2)	0.87	0.53	62.36	0.55	118	$0.22
Subtotal OHIO Incremental	***$48***	***$57***	***$24.35***	***$28.93***	***($9)***	***0.84***	***1.94***	***218.01***	***0.56***	***113***	***$0.22***
TOTAL OHIO HUB	**$151**	**$168**	**$26.50**	**$29.65**	**($18)**	**0.89**	**6.24**	**662.46**	**0.39**	**106**	**$0.23**

*** Revenue, Cost and Surplus in ($2002 millions); Riders and Passenger-Miles in Millions**

The main effect of Ohio Hub connectivity is to boost the MWRRS Cleveland corridor; the revenue effects on the Cincinnati corridor and Michigan Corridors are minor because of redistributional effects. For example, some Indianapolis and Michigan ridership shifts towards the east when Ohio Hub is added; this results in more uniform train load factors, but not much of a direct increase to the revenues of these routes. MWRRS Cincinnati to Cleveland riders shift to the direct 3-C corridor; but that loss to the MWRRS system is more than offset by added connecting riders from Indianapolis through to Dayton, Columbus and even Cleveland who take advantage of the 3-C connection available at Cincinnati. Ohio Hub connectivity certainly will not hurt the revenues of the MWRRS Cincinnati and Michigan routes, but the main effect of the Ohio Hub is to boost the ridership and revenues of the MWRRS Cleveland line.

With the addition of Layer 3 again the revenues are boosted; the three incremental corridors directly earn $85 million in 2025, of which $6 million is traffic diverted from the Ohio Hub core routes (such as Pittsburgh-Cleveland-Columbus) to more direct routings (such as the Panhandle), but another $17 million in connecting revenues are added to the MWRRS, primarily on the Cleveland line from Fort Wayne into Chicago.

As can be seen in Exhibits 7-4 through 7-6 as more corridors are added to the network, the interconnecting traffic base and revenues grow. Given a viable start-up network developed in Layer 1 that consists of the three eastern MWRRS routes, train-mile costs remain relatively stable as train-miles grow. On the one hand, average overhead costs tend to decline as fixed costs can be spread over a larger base. Offsetting this however, is the natural tendency towards higher passenger-mile and ridership-related costs, such as credit card commissions and call center expenses, as ridership and train load factors improve and larger trains can be deployed. All corridors, including the proposed new incremental corridors, are forecast to perform well and to return comfortably positive operating ratios. On an operating basis, the original four Ohio Hub core corridors tend to perform slightly better than the incremental corridors, but the core corridors also tend to have a much higher capital cost.

The 79-mph Ohio Hub forecasts shown in Exhibit 7-7 produce an operating ratio of 0.89 for the Ohio Hub system, requiring a subsidy of $18 million in 2025, as compared to the $110 million operating surplus that would be generated by a 110-mph system in the same year.

The original 2004 study implied that a 79-mph system with 110-mph connectivity might cover its operating costs out of farebox revenues. This was consistent with the modeling that had been done earlier for the MWRRS Michigan branch lines – as relatively short extensions of a new high-speed, high capacity corridor to Chicago. However, this 2007 update has adopted more conservative modal bias factor reflecting the fact that a 79-mph Ohio Hub would have entire corridors, rather than just short sections of line operating at the slower speed. For the 2007 update, it was considered more prudent to revise downward the original 79-mph forecasts, than to continue to make the assumption that the entire system would be viewed by the public as a 110-mph service, even if significant portions of it actually operate at a much slower speed.

In the new 79-mph forecasts as shown in Exhibit 7-7, the system comes close to breakeven only because of the strong positive effect of MWRRS connectivity with no fewer than three connecting 110-mph corridors. Without such connectivity, operating ratios in the 0.6 - 0.7 range would be expected for a 79-mph system. For this reason, the 79-mph option was excluded from further consideration in the development of the implementation plan in Chapter 9.

7.3 Economic Benefits Methodology

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

The methodology used to estimate economic benefits and costs is based on the approach the Federal Railroad Administration (FRA) used in its analysis of the feasibility of implementing high-speed passenger rail service in selected travel corridors throughout the country. The key elements of the economic benefits analysis conducted for this study are listed in Exhibit 7-8 and further discussed below.

Exhibit 7-8: Key Elements of the Economic Benefits Analysis

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

Two measures of economic benefit were used to evaluate the alternative options – net present value (NPV) and cost/benefit ratio, which are defined as follows:

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

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

Where present values are calculated using the standard financial discounting formula, that was presented at the beginning of this chapter.

7.3.1 User Benefits

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

- User Benefits: The reduction in travel times and costs (consumer surplus and system revenues) that users of the Ohio Hub receive
- Benefits to Users of Other Modes: The reduction in travel times and costs that users of other modes receive as a result of lower congestion levels
- Resource Benefits: Savings in airline fares and reductions (savings) in emissions as a result of travelers being diverted from air, bus and auto to the Ohio Hub

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

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

Consumer surpluses exist because there are always consumers who are willing to pay a higher price than that actually charged for the commodity or service, (i.e., these consumers receive more benefit than is reflected by the system revenues alone). Revenues are included in the measure of consumer surplus as a proxy measure for the consumer surplus foregone because the price of rail service is not zero. This is an equity decision made by the FRA to compensate for the fact that highway users pay zero for use of the road system (the only exception being the use of toll roads). The benefits apply to existing rail travelers as well as new travelers who are induced (those who previously did not make a trip) or diverted (those who previously used a different mode) to the new passenger rail system.

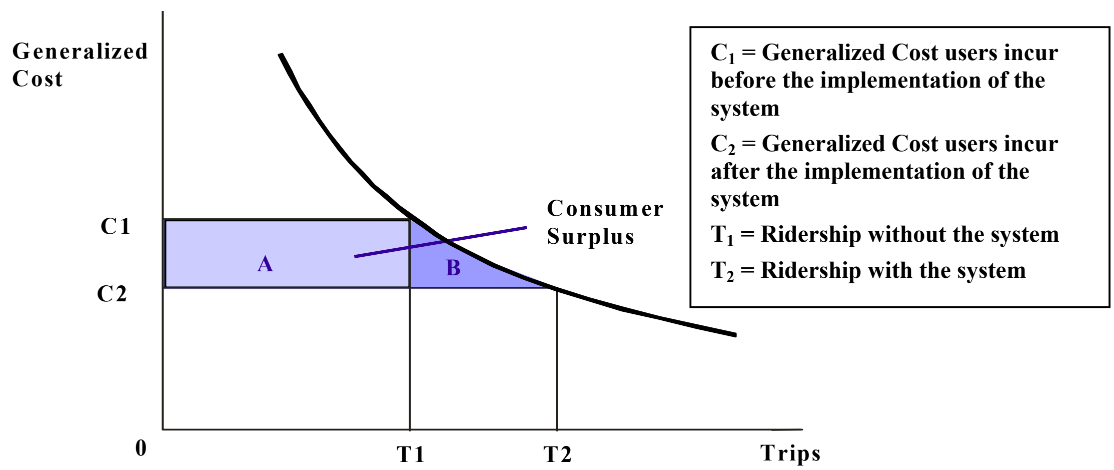
The *COMPASS*™ demand model estimates consumer surplus by calculating the increase in regional mobility, traffic diverted to rail and the reduction in travel cost measured in terms of generalized cost for existing rail users. The term *generalized cost* refers to the combination of time and fares paid by users to make a trip. A reduction in generalized cost generates an increase in the passenger rail user benefits. A transportation improvement that leads to improved mobility reduces the generalized cost of travel, which in turn leads to an increase in consumer surplus.

The passenger rail fares used in this analysis are the average optimal fares derived from the Revenue-maximization Analysis that was performed for each Ohio Hub corridor. User benefits incorporate both the measured consumer surplus and the system revenues, since the revenues are user benefits transferred from the rail user to the rail operator.

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

To calculate consumer surplus, the number of trips and generalized cost of travel without the Ohio Hub System were compared to the number of trips and generalized cost of travel with the system. In Exhibit 7-9, the shaded area under a typical demand curve represents improvements in the generalized cost of travel for induced and/or diverted users (the consumer surplus). The shaded area is defined by the points $(0, C_1)$, $(0, C_2)$, (T_1, C_1), and (T_2, C_2). The equation assumes that Area B is a triangle and the arc of the demand curve is a straight line. Equation 1, which follows the exhibit, measures consumer surplus.

Exhibit 7-9: Consumer Surplus Graphically Displayed



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

Where:

CS = Consumer Surplus

Rectangle A = $(C_1 - C_2)\,T_1$

Triangle B = $(C_1 - C_2)(T_2 - T_1)(0.5)$

The formula for consumer surplus is as follows:

$$\text{Consumer Surplus} = (C_1 - C_2)*T_1 + ((C_1 - C_2)*(T_2 - T_1))/2$$

Where:

C_1 = Generalized Cost users incur before the implementation of the system

C_2 = Generalized Cost users incur after the implementation of the system

T_1 = Number of trips before operation of the system

T_2 = Number of trips during operation of the system

TEMS' *COMPASS™* demand forecasting model estimates consumer surplus by calculating the increase in regional mobility (i.e., induced travel) and traffic diverted to the system (Area B in Exhibit 7-9), and the reduction in travel costs, measured in terms of generalized cost, for existing system users (Area A). The reduction in generalized cost generates the increase in users' benefits. Consumer surplus consists of the additional benefits derived from savings in time, fares and other utility improvements.

Passenger Revenues

Passenger revenues provide another measure of system benefit. The fare rate that passengers pay shows the direct value of the benefit they receive. Passenger revenues are calculated by multiplying the fares charged by the number of riders. Revenues are incorporated in the FRA methodology as a benefit because they are a component of consumer surplus that has been internalized by the railroad operator. Revenue benefits apply to existing rail travelers as well as new travelers who are induced or diverted to the new passenger rail system.

Benefits to Users of Other Modes

In addition to rail-user benefits, travelers using other modes will also benefit from the Ohio Hub System because it will contribute to highway congestion relief and reduce travel times for users of other modes. These benefits were measured by identifying the estimated number of air and auto passenger trips diverted to rail and multiplying each by the benefit levels used in the FRA *Commercial Feasibility Study.*

Resource Benefits

The implementation of a transportation project also has an impact on the resources all travelers use. The consequent reduction in airport congestion attributable to the Ohio Hub System will result in resource savings to airline operators and reduced emissions of air pollutants for all non-rail modes.

7.3.2 Costs

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

Capital Investment Needs

The capital investment needs for each option were calculated using input from the Engineering Assessment outlined in Chapter 2. The capital investment estimates include both infrastructure and rail equipment needs.

Operating and Maintenance Expenses

The operating and maintenance expenses for each alternative were calculated using the output of the operating cost analysis set forth in Chapter 6. A capital track maintenance component was separately calculated for the High-Speed Scenario. Since the need for infrastructure replacement does not occur for some years into the future, this cost has minimal impact on the cost/benefit ratio calculation, but has been included for completeness.

7.4 Economic Benefits Results

The 2007 Incremental Corridors update resulted in the construction of a new financial model that incorporated the three eastern MWRRS routes, in order to be able to jointly reoptimize certain MWRRS operations – particularly, those of the Chicago-Fort Wayne-Toledo-Cleveland line, which is significantly impacted by the Ohio Hub proposals. In particular, there was a desire to be able to assess the impacts of connecting revenue and ridership on the MWRRS as well as on the Ohio Hub system.

This section presents the results of a *parametric analysis*, performed *prior* to the development of a detailed implementation plan, to assess the economic benefits of sets of line investments at a *subnetwork* level. This parametric analysis does not reflect an exact calculation of cost benefit ratios but results from a projection of the 2025 operating cash flows reported in Exhibits 7-4 through 7-6 along with the capital costs of each line segment.

An eastern subnetwork of MWRRS, consisting of the three routes that together share the South-of-the-Lake improvement (Layer 1), comprised the starting point for this analysis.[53] *The MWRRS capital and operating costs and revenues were included as Layer 1* of the Three-Layer analysis and showed that this subnetwork of the MWRRS would be viable on a stand-alone basis. After this, the Ohio Hub revenues, operating costs and capital costs were added in Layers 2 and 3 and showed very strong cost benefit ratios, taking into account not only the direct revenue and ridership of the added Ohio Hub routes, but also the connecting revenue and ridership impacts on the MWRRS routes. As mentioned earlier, connecting benefits can be very significant, since they add considerably to both revenue and consumer surplus without adding much in capital cost to the line segments that had been developed earlier.

[53] Capital costs for the MWRRS routes were taken from the MWRRS report, and the operating costs and revenues were taken from the updated 2007 Ohio Hub model. Layer 1 MWRRS costs do include the cost of Cleveland to Toledo in the 3-Layer analysis, although elsewhere in the report, particularly in the *formal recalcuation*, the costs of Cleveland to Toledo are treated as an Ohio Hub capital cost.

A second cost-benefit calculation will appear in Chapter 8, based on the exact specified implementation plan for specific Ohio Hub and MWRRS corridors. This *formal recalculation* differs from the one presented here, since no MWRRS capital, operating costs or revenues were included in the formal recalculation. *Accordingly, the formal recalculation of Ohio Hub cost benefit in Chapter 8 does not capture the full social benefit of MWRRS connecting revenues.* That is why the Cost Benefit results in Chapter 8 are somewhat more conservative than the results that are presented below. Exhibit 7-10 presents Cost Benefit ratios that were developed by the Three Layer analysis.[54]

Exhibit 7-10: Ohio Hub 110-mph system, Benefits and Costs - Three-Layer Parametric Analysis (Lifecycle Present Values in Millions of 2002$, 30 years at 3.9%)

Overall Cost Benefits			
	Layer 1 - MWRRS Base	**Layer 2- OHIO Base**	**Layer 3- OHIO Increm**
Revenue	$3,506	$6,647	$7,862
Consumer Surplus	$4,133	$6,181	$7,705
Other Mode + Resource	$3,920	$6,583	$7,988
Total Benefit	**$11,559**	**$19,412**	**$23,554**
Capital Cost	$2,138	$4,340	$5,284
Operating Cost	$2,699	$4,329	$5,292
Track Capital Maintenance	$135	$216	$265
Total Cost	**$4,972**	**$8,886**	**$10,840**
Cost/Benefit Ratio	**2.32**	**2.18**	**2.17**

Incremental Cost Benefits		
	Layer 2- OHIO Base	**Layer 3- OHIO Increm**
Revenue	$3,141	$1,214
Consumer Surplus	$2,048	$1,523
Other Mode + Resource	$2,663	$1,405
Total Benefit	**$7,852**	**$4,142**
Capital Cost	$2,202	$943
Operating Cost	$1,631	$963
Track Capital Maintenance	$82	$48
Total Cost	**$3,914**	**$1,954**
Cost/Benefit Ratio	**2.01**	**2.12**

[54] The Capital Costs shown in Layer 1 are an NPV based on a multi-year spend plan, not the direct capital cost from Chapter 2. Layer 1 includes the three MWRRS corridors as described in Chapter 2. The NPV shown for Layer 2 does not include the cost of Cleveland-Toledo, since in the three-layer analysis the cost of this line segment is treated as part of Layer 1. However, the actual Implementation plan developed in Chapter 8 implements the Detroit-Cleveland corridor earlier than the MWRRS Cleveland line, so the cost of the Cleveland-Toledo segment accrues to the Ohio Hub in the Formal Recalcuation.

In Exhibit 7-10, it can be seen that the MWRRS eastern subnetwork, even including the high cost of the South-of-the-Lake improvement, generates a very high cost benefit ratio. As already shown by the MWRRS economic impact study, the implementation of these MWRRS corridors would yield considerable economic benefits to the States of Michigan, Indiana and Ohio.

When Ohio Hub lines are added to this system in Layers 2 and 3, *additional ridership, revenue, consumer surplus and environmental benefits are added to the previously-existing corridors* without requiring a proportional capital investment. This results in a multiplier effect as more corridors are added to the system, resulting in the very strong incremental cost /benefit ratios that are reported for both the Ohio Base and Incremental Corridors network expansions if the connecting revenue effect is included in the calculation.

7.5 Conclusions

On the basis of the *Commercial Feasibility* criteria that have been established by the FRA, all the proposed Ohio Hub subnetworks are viable. Financially, the three eastern MWRRS routes, along with the 3-C and Chicago-Columbus corridors are the strongest performers; after this, more Ohio Hub routes can be added and network interconnectivity results in a multiplier effect on revenue, ridership, consumer surplus and external mode benefits. The connecting ridership effect helps maintain high operating and cost benefits ratios as the network is expanded.

In terms of the options that were evaluated in the earlier 2004 plan, it was shown that Option 1 using Detroit Metro Airport and Youngstown was the route combination that produced the best financial result. For this reason only Option 1 was carried forward into the 2007 incremental corridors plan. In terms of technology, 110-mph options are far superior to any of the 79-mph options both in operating performance and cost-benefit results. While the original 2004 analysis suggested that some 79-mph routes may be viable as feeders to an 110-mph MWRRS system, in fact the Ohio routes are all economically strong enough to justify upgrading to 110-mph except where physical constraints such as curvature or urban speed restrictions prevent this. 110-mph service would boost ridership on average by about 50%, double revenues and could enable the Ohio Hub to be viable as a stand-alone system. A 110-mph upgrade more than doubles consumer surplus and environmental benefits without proportionately raising capital or operating cost, and therefore 110-mph produces much higher cost benefit ratios than a 79-mph option.

This study has found that a 110-mph Ohio Hub system could meet the FRA *Commercial Feasibility* criteria and could even be developed separately from the MWRRS system, although clearly the results would be better if the two systems were developed together. For this reason 110-mph Option 1 (Detroit Metro Airport plus Youngstown) was taken forward for development of a detailed implementation plan for the Ohio incremental corridors system. A possible detailed implementation plan for building the Ohio Hub corridors will be discussed in the next chapter.