ES.5 Appendix B

Benefit-Cost Analysis of the Chicago-Iowa City High Speed Intercity Passenger Rail Program

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IOWA DEPARTMENT OF TRANSPORTATION

CHICAGO-IOWA CITY

HIGH-SPEED INTERCITY PASSENGER RAIL (HSIPR) PROGRAM

BENEFIT-COST ANALYSIS OF THE CHICAGO-IOWA CITY HIGH-SPEED INTERCITY PASSENGER RAIL PROGRAM

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1 Project Overview

The States of Iowa and Illinois propose to implement a new passenger-rail service between Chicago, Illinois, and Iowa City, Iowa, consisting of two daily round trips. Service is expected to commence in 2015 carrying an estimated 246,800 riders during its first full year of operation. The Iowa Department of Transportation (Iowa DOT) and Illinois Department of Transportation (Illinois DOT) are applying for the Federal Railroad Administration's High-Speed Intercity Passenger Rail (HSIPR) program funding through the Service Development Program application process.

2 Cost Benefit Analysis (CBA) Framework

The Cost Benefit Analysis (CBA) framework is a comparison of values – the cost to build and operate the passenger rail service measured as the forgone value of the investment in the project (which could alternatively be directed elsewhere) and the benefits of the project, assessed as the improvement in social welfare due to the project. To be deemed economically feasible, projects must pass one or more value benchmarks: the total benefits must exceed the total costs of the project on a present value basis, and/or the rate of return on the funds invested should exceed the cost of raising capital, often defined as the long-term treasury rate or the social discount rate.

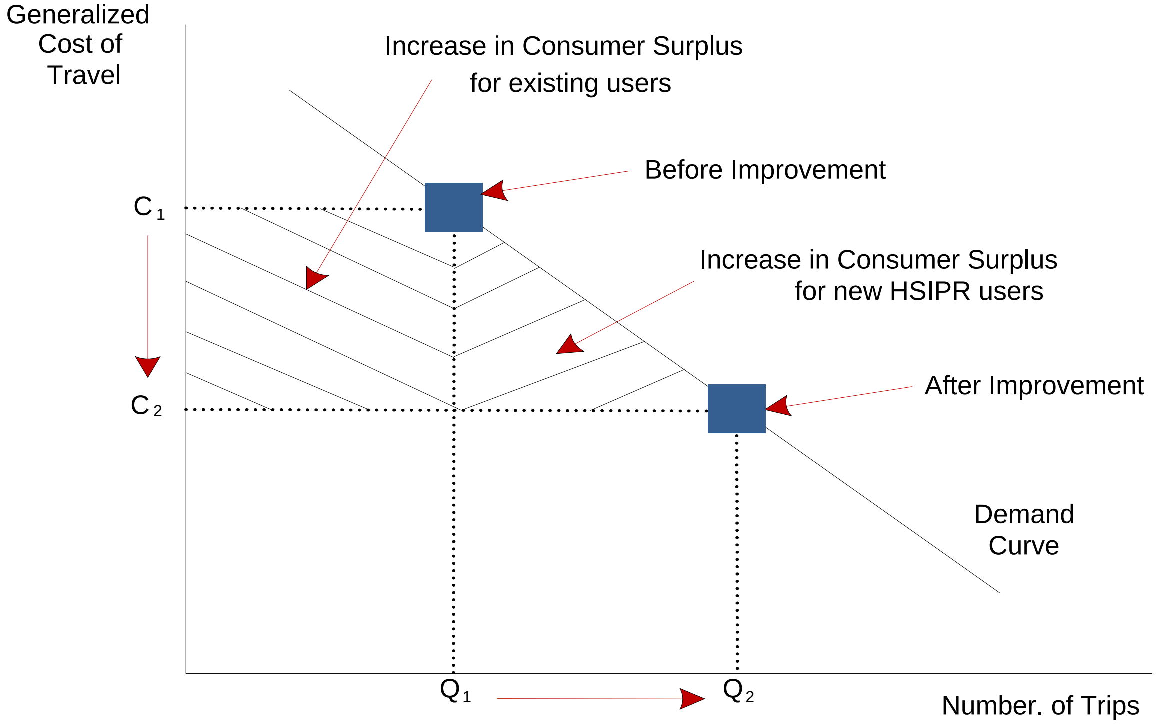
Benefits are estimated for current and future users on an incremental basis, as the change in welfare that consumers and, more generally, society derive from the access to the new passenger rail service in comparison to an estimated "no build" situation. As with most transportation projects, the benefits derived from implementation are actually a reduction in the costs associated with transportation activities. However, the reduction of costs due to the rail service affects users differently depending on their preferences and the way the project changes their specific transportation options and costs. These cost reductions may come in the form of time saved by users, travel cost savings, reduced costs of unreliability, reduction of pollution and accidents, or more generally, a combination of these effects.

In general, benefits primarily represent the creation of economic value from changes in the quantity of final uses and the quality (time spent, reliability, among other factors) of the services provided to affected travelers.

3 Methodology

In general, the economic benefits of transportation investments can be illustrated with a simple graph relating the generalized cost of travel to the demand for travel. The demand for travel is measured as the total number of trips per time period, while the generalized cost of travel includes the value of travel time under different service levels, the costs of unreliability, and any out-of-pocket expenses such as fares for transit (for car users the generalized costs include fuel, oil and depreciation costs). This relationship, the travel demand curve, is illustrated in Figure 1, below.

Figure 1: The Demand for Travel and Consumer Surplus from Lowered Costs



The travel demand curve, in the diagram above where the number of trips is represented on the horizontal axis and the generalized cost of travel on the vertical axis, is downward sloping: as the generalized cost of travel decreases, the number of trips increases. Investment in new rail systems, or new routes, can be evaluated by estimating the change in the generalized price of travel brought about by the investment, and the associated change in trip making.

Riders on the implemented passenger-rail service may experience travel-time savings compared to their previous travel mode; or they can be motivated by changes in the comfort and reliability of the system; or by reductions in their trip expenses. In addition, the availability of transportation at a more affordable price will encourage users to travel more, increasing the total number of trips.

Highway users will also benefit from the improved passenger rail system, as trip diversion from auto to rail frees up capacity on the highways. Benefits to highway users will include benefits to both existing and new highway users, as the reduction in highway congestion (due to trip diversion) reduces the generalized cost of highway travel (travel time, fuel and oil consumption, accident costs, etc.)

The benefits of the passenger rail service could therefore be evaluated by considering the travel cost savings accruing to travelers switching from other modes. This is accomplished using the consumer surplus methodology, which compares transportation costs per trip between the base case and the implementation case (see Figure 1).[1] The social cost of a trip on a congested road includes travel time, vehicle operating cost, safety cost, and emission costs.

The availability of passenger rail service can result in social cost savings as well, benefits in addition to direct travel trip savings. These can include vehicle operating cost savings, emission cost savings, and accident cost savings. In compliance with the HSIPR application guidelines, the following sections discuss each category of benefits within the context of the evaluation criteria set forth by the HSIPR program.

4 Principles

The following principles guide the estimation of benefits and costs for this study:

- Only incremental benefits and costs are measured
    - Incremental in this situation means that only net additions in costs to the current situation will be considered. Any investments or operating costs required for the operation of the existing rail system are not considered costs associated with this project.
    - The incremental benefits of the project include the transportation cost savings for the users of the service as a result of the implementation of the transportation improvements.
    - The incremental costs of implementation of the project include initial and recurring costs. Initial costs refer to the capital costs incurred for design and construction of a list of enhancements designed to create the capability for the new service, such as an increase in the maximum permissible speed of the existing tracks, construction required capacity for the new trains, or required safety systems. Recurring costs include incremental operating costs, and additional administration and marketing expenses. Only additions in cost to the current operations and planned investments are considered as costs of the project.
- Benefits and costs are valued at their opportunity costs. The benefits stemming from the implementation of the transportation improvement are those above and beyond the benefits that could be obtained from the best existing transportation alternative. For instance, the transportation costs savings for users are measured relative to the next best existing option, which may be the highway or the existing bus service, depending on the type of user. The benefit is the net cost saving in transportation costs relative to the best alternative.

[1] The consumer surplus in this case is estimated by valuing the cost saved for each trip – the difference between the new price and the old price.

The costs of the project will only include those incremental costs that represent an opportunity costs to the funding entities. Expenditures are considered foregone opportunities to invest in the next-best alternative.

5 Guidance

U.S. Department of Transportation's (USDOT) Federal Railroad Administration (FRA) guidance (CFR Vol. 74 No. 119 Docket No. FRA-2009-0045) indicates that applications will be reviewed and assessed against three main categories, 1) public return on investment, 2) project success factors and 3) other attributes.

Metrics for the measurement of the first category, public return on investment, include service reliability, schedule and capacity, and transportation in passenger miles, including diversion from other modes as well as induced ridership. Within this category, benefits are divided into three main evaluation criteria: transportation benefits, economic recovery benefits and other public benefits.

The transportation benefits criterion relates to improved intercity passenger rail service, as well as transportation network integration, including intermodal connections and transportation safety benefits. Meanwhile, economic recovery relates to preserving and creating jobs, particularly in economically distressed areas. The final criterion, other public benefits focuses on measuring environmental quality, energy efficiency and livable communities. Table 1 below summarizes benefits metrics.

The guidance indicates that analysis in support of HSIPR program funding should include careful and systematic economic analysis that quantifies and demonstrates the monetary value of user benefits and, if available, public benefits. FRA will consider benefits and costs using standard data provided by applicants and seek to evaluate applications in a manner consistent with Executive Order 12893, Principles for Federal Infrastructure Investments, 59 FR 4233, to base infrastructure investments on systematic analysis of expected benefits and costs, including both quantitative and qualitative measures.

In order to accomplish that, monetizing factors of project performance (e.g. accident costs per vehicle mile traveled, or VMT) are included in the analysis. However, in the absence of quantitative measures, other categories and measures of benefits are used, including qualitative assessments of potential benefits. Furthermore, in compliance with the Office of Management and Budget (OMB) circulars, A-4 and A -94, sensitivity analyses for discount rates and other assumptions are conducted to provide for a complete perspective on the range of potential value for the project.

The approaches utilized in conducting the analysis are also consistent with the Benefit-Cost Analysis guidelines provided by the U.S. Department of Transportation for TIGER and TIGER II discretionary grants.

Table 1: Potential Benefits by Evaluation Criteria

Criteria	Criteria Description	Benefit Category
Transportation Benefits	Improved intercity passenger rail service, transportation network integration (including intermodal connections, transportation safety benefits)	User Cost Savings (existing and diverted riders) – Vehicle Operating Costs, Travel Time
		User Cost Savings to Remaining Roadway Users – Vehicle Operating Costs, Travel Time
		Induced Ridership
		Improved Safety
		Pavement Maintenance Savings
Other Public Benefits	Environmental quality, energy efficiency; and livable communities	Reductions in Environmental Emissions and gallons of gasoline used

All benefits and costs are estimated in 2011 dollars. The benefits are valued using a number of assumptions that are required to produce monetized values for all these non-pecuniary benefits. The different components of time, for instance, are monetized using a "value of time" assumed to be equivalent to the user's willingness to pay for time savings in transit. Premiums on the value of time are also considered in association with reliability, comfort and other characteristics associated with the quality of the trip. Other estimates used in the monetization of benefits include the cost of operating a vehicle, including maintenance, repair, and depreciation, and the cost per ton of pollution, among other elements. Assumptions and inputs are discussed in greater detail below.

6 General Assumptions

The methodology makes several important assumptions and seeks to avoid overestimation of benefits and underestimation of costs. Specifically:

- The methodology assumes that the number of users of the rail service will increase as a result of its implementation. In other words, the implementation of the project will result in induced demand, producing more riders in the system than the existing alternatives.

- Congestion relief benefits derived by current and future users of other transportation alternatives are accounted for in the analysis.

- Average improvements in welfare are estimated for those riders who are expected to switch from other modes of transportation. Welfare improvements are approximated by the change in the average generalized transportation cost for those who switch.

- Input prices are inflated to 2011 dollars.

7 Input Categories

Input values used in this analysis are taken from the U.S. Department of Transportation (USDOT) guidance on the preparation of Cost Benefit Analyses, including the recently published guidelines for the HSIPR program and TIGER and TIGER II Grant applications. Where USDOT has not provided valuation guidance or a reference to guidance, standard industry practice has been applied.

Estimates used in the monetization of benefits include the cost of operating a vehicle, including maintenance, repair, and depreciation.

Table 2 below lists input variables used in this analysis, adjusted for 2011 dollars.

As part of calculating diversion benefits, the number of vehicles that would be taken off the road due to the improved rail service is calculated. The expected increase in ridership is used in conjunction with the average vehicle occupancy (1.78 persons/vehicle) to estimate the reduction in the number of vehicles.

Benefits resulting from the reduction in the number of vehicles are based on values for congestion cost, pavement maintenance, noise pollution as well as accident costs, all in dollars per vehicle miles. Internal costs include those for fuel, both for vehicles as well as train miles, in addition to estimates for fare per passenger mile as well vehicle operating cost per car mile.

Meanwhile, emission costs are expressed as dollars per ton and are based on the benefits associated with recently-adopted regulations that limit emissions of air pollutants from passenger cars.

Table 2: Input Variables used in the Cost Benefit Analysis

Parameter	Units	Values
General Assumptions		
Discount Rates	%	7% and 3%
Period of Study (life-cycle)	Years	2011 - 2045
Vehicle occupancy - normal (HSIPR)	Persons / Vehicle	1.78
External Costs - Vehicles		

Parameter	Units	Values
Congestion cost per vehicle mile	$ / Vehicle mile	0.060
Pavement maintenance cost per vehicle mile	$ / Vehicle mile	0.003
Noise pollution cost per vehicle mile	$ / Vehicle mile	0.001
Accident cost per vehicle mile	$ / Vehicle mile	0.030
Internal costs - Bus, Train, Air, Vehicle		
Fare per HSIPR passenger mile	$ / passenger mile	0.17
Vehicle operating cost per car mile	$ / Vehicle mile	0.37
Air Fare	$/one way	462.6
Bus Fare	$/one way	48.9
Average Daily Airport Parking	$/day	16.5
Value of time[2]		
Value of travel time (per hour) - Air	$ / Hour	45.9
Value of travel time (per hour) - Auto	$ / Hour	23.8
Value of travel time (per hour) - Bus	$ / Hour	13.0
Value of travel time (per hour) - HSIPR	$ / Hour	22.3
Emissions Costs per Ton		
NO_X	$ / ton	4,166
PM	$ / ton	174,976
VOC	$ / ton	1,771
CO_2	$/ton	34

8 Results

The benefits of the rail service are evaluated in this analysis based on the HSIPR funding evaluation criteria published in CFR Vol. 74 No. 119 Docket No. FRA-2009-0045. Additional

[2] Transportation Economics & Management Systems, Inc. 2004. Midwest Regional Rail Initiative Project Notebook. Note: HDR used the Illinois value of time (Exhibit 4-5; Page 4-9) and adjusted it from 2002 to 2009 dollars using the real increase in wages (Increase in Wages: BLS Series Id. CIS1020000000000I (C); Increase in Consumer Prices: BLS Series Id. CUSR0000SA0).

guidance is provided in section D of the Federal Rail Administration's (FRA) application forms for Tracks 1 and 2.

8.1 Operational and Ridership Benefits Metrics

It was estimated that opening year ridership would be 246,800. The first year of operation is 2015 and the annual growth rate in ridership is assumed to be 2.00%.

Table 3 below shows the estimated average annual level of ridership for the passenger rail service from Chicago to Iowa City over the 31 year analysis period. In addition, the table shows how many rail passengers are diverted from other modes (auto, air and bus) or represent newly induced trips.

Table 3: Incremental Ridership by Source

	Value
Average Annual Level of Passenger Train Ridership	330,233
Average Annual Trips Diverted from Auto	205,436
Average Annual Trips Diverted from Air Travel	73,746
Average Annual Trips Diverted from Bus	28,094
Average Annual Induced Trips	22,957

As a result of the above-mentioned diversion of trips from auto to passenger rail, Table 4 below shows the total amount of auto trips diverted throughout the study period and estimated average annual reduction in vehicle miles traveled (VMT). Induced trips are not included in these calculations, since induced users previously made no trips at all.

Table 4: VMT and Auto Reduction

	Value
Total Auto Trips Reduced	3,541,703
Average Annual vehicle miles traveled (VMT) Reduced	25,611,484

A result of the diversion from auto usage to the passenger rail service, Table 5 below show the total VMT avoided over thirty-one years in addition to the pavement maintenance cost savings.

Table 5: VMT Reduction and Pavement Maintenance Savings

	Value
Total VMT Avoided	896,401,930
Pavement Maintenance Savings ($M)	$0.8

Note: Monetary values were discounted using a 7 percent rate.

In terms of Vehicle Operating Cost (VOC) savings, Table 6 below illustrates the net VOC savings, in addition to the induced demand benefits for new passenger-rail users. Induced demand benefits accrue to users who were not making the trip between Chicago and Iowa City using the available modes of transportation prior to the project, and are now using the rail service for the trip.

Table 6: VOC Net Savings to New Users and Induced Demand Benefits

	Value
Net VOC Savings ($M)	$99.6
Induced Demand Benefits ($M)	$0.0

Note: Monetary values were discounted using a 7 percent rate.

Benefits to remaining highway users include average annual VMT reduction, which results in a reduced cost of congestion and reduced accident costs (from fewer accidents). Table 7 below shows these benefits.

Table 7: Benefits to Remaining Highway Users and Safety Benefits

	Value
Average Annual VMT Reduced	25,611,484
Reduced Cost of Congestion ($M)	$16.3
Reduced Accident Costs ($M)	$7.4

Note: Monetary values were discounted using a 7 percent rate.

8.2 Environmental Benefits

Environmental benefits are calculated by: (1) estimating the reduction in vehicle and plane emission from trips being diverted to rail; and, (2) estimating the increase in emission from introducing new passenger rail service. Table 8 indicates the total life-cycle emission reduction for the project.

Table 7: Environmental Reduction

	Value
Reduced Gallons of Fuel	10,791,109
Reduced NO_x Emissions (tons)	-3,638
Reduced PM Emissions (tons)	-188.0
Reduced VOC Emissions (tons)	292
Reduced CO_2 Emissions (tons)	89,943

Meanwhile, Table 8 below shows the net emission savings over the 30 year analysis period.

Table 8: Emission Cost Savings

	Value
Environmental Benefits ($M)	($12.6)
NO_x Cost Savings ($M)	($4.3)
PM Cost Savings ($M)	($9.4)
VOC Cost Savings ($M)	$0.2
CO_2 Cost Savings ($M)	$1.0
Noise Emission Savings ($M)	$0.3

Note: Monetary values were discounted using a 7 percent rate.

8.3 Findings and Overall Results

The table below summarizes the CBA findings. Annual costs and benefits are computed over a long-run planning horizon and summarized over the life-cycle of the project. The project is assumed to have a useful life of at 31 years, and that time horizon is used in the analysis. Construction is expected to be completed by 2015, but operating costs continue through the whole horizon of the project. Benefits also accrue during the full operation of the project.

At a 7% discount rate, a $386.2 million investment (capital and O&M) results in fully $656.7 million of benefits. This yields a benefit to cost ratio of approximately 1.70. At a 3% discount rate, a $536.6 million investment (capital and O&M) results in fully $1,269.3 million of benefits. This yields a benefit to cost ratio of approximately 2.37.

Table 9: Overall Results of the Cost

	7% Discount Rate	3% Discount Rate
Benefit Cost Analysis Results		
Total Discounted Benefits ($M)	$656.7	$1,269.3
Total Discounted Costs ($M)	$386.2	$536.6
Benefit - Cost Ratio	1.70	2.37
Net Present Value ($M)	$263.2	$718.9
Internal Rate of Return	14.28%	14.28%

Table 10: Detailed Results of the Cost Benefit Analysis

	7% Discount Rate	3% Discount Rate
Transportation Benefits		
Benefits to High Speed Rail Users		
Total Ridership	10,153,789	10,153,789
Average Annual Ridership	330,233	330,233
Average Annual Reduction in VMT	25,611,484	25,611,484
Transportation Cost Savings to New Users ($M)	$569.7	$1,107.1
Induced Demand Benefits ($M)	$0.0	$0.0
Revenues ($M)	$74.9	$140.4
Benefits to Remaining Highway Users		
Congestion Cost Savings ($M)	$16.3	$30.6
Accident Cost Savings ($M)	$7.4	$13.8
Pavement Maintenance Savings ($M)	$0.8	$1.5
Environmental Benefits		
Environmental Benefits ($M)	($12.6)	($4.6)
NO_x ($M)	($4.3)	($8.4)
PM ($M)	($9.4)	($18.3)
VOC ($M)	$0.2	$0.3
CO_2 ($M)	$1.0	$1.8
Noise Pollution Savings ($M)	$0.3	$0.5

9 Sensitivity Analysis

Sensitivity analysis has been conducted on the ridership forecasts to determine what level of ridership would result in a break even Net Present Value for the project or an Internal Rate of Return equal to 7 percent. The analysis shows that as long as average annual ridership is at least 200,493 (which is about 40% less than our forecast), the project will have a positive outcome using a discount rate of 7 percent.

Table 12: Ridership Values Required to Break-Even

	7% Discount Rate	3% Discount Rate
Value Required for NPV to equal zero		
Average Annual Ridership	200,493	144,476