Dubuque-Rockford-Chicago Amtrak and Commuter Rail Benefit-Cost Analysis

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EXECUTIVE SUMMARY

Benefit-cost analysis is conducted of proposed passenger rail: Amtrak intercity service from Dubuque, Iowa to Chicago, Illinois via Genoa; commuter service from Rockford to Chicago via Belvidere; and a combination of both through the latter route. A matrix summarizing the analysis is provided. Results are highly dependent upon ridership projections from other studies. Sole Amtrak service would likely need more than 700 daily passengers, which is substantially higher than expectations, to approach a benefit/cost ratio of more than 1. Commuter rail patronage would need to be near the projection of 5,221 daily weekday passengers to achieve a benefit/cost ratio of more than 1. Overall performance of both services together would be similar to the commuter rail option alone scenario. Performance is restricted by: the lack of nearby dominant population and employment high density clusters outside downtown Chicago, particularly west of Rockford, to support higher ridership; travel times marginally competitive with the automobile; and underpricing of road usage.

Status/ Baseline & Problem to be Addressed	Change to Baseline / Alternatives	Population Affected by Impacts	Economic Benefits	Economic Costs	Benefit-Cost Ratio (Discount Rate)
Lack of modal options and escalating con-gestion, travel delays on Chicago area roadways.	Reestablish intercity rail service along 180-mile corridor and/or new commuter rail service ½ the distance.	Road traffic, local residents, businesses.	Monetized Value: Reduced costs for travel, noise, emissions, resource consumption, health care/mortality, transport barrier effects, accidents (deaths/ injuries/ property damage). Increased value residual/property, transport diversity.	Monetized Value: Increased costs for capital, operating & maintenance, travel time.	<u>Intercity</u> 0.52 (3%) 0.48 (5%) 0.45 (7%) <u>Commuter</u> 1.21 (3%) 1.10 (5%) 1.01 (7%) <u>Combined</u> 1.19 (3%) 1.08 (5%) 0.99 (7%)

INTRODUCTION

For many years community officials, stakeholders and other advocates have been seeking to begin passenger train intercity and/or commuter service in northern Illinois from Chicago to Rockford and to as far west as Dubuque. The purpose is to address increasing roadway congestion in the Chicago area and to provide a viable alternative to the automobile and bus service. Prior to the advent of Amtrak in 1971, the Illinois Central Railroad operated intercity passenger service from Sioux City, Iowa to Chicago via Dubuque and Rockford. Two trains ran daily in each direction: The Hawkeye; and Land O'Corn, which only went as far west as Waterloo, Iowa. Scheduled travel time for the 182.1-mile trip between Dubuque and Chicago ranged from about 4 to 4½ hours *(1)*. Amtrak operated The Blackhawk between Dubuque and Chicago over the same route from 1974 to 1981 with similar scheduled travel times *(2)*. With one roundtrip train per day, annual Amtrak Blackhawk service ridership was 32,005 (88 daily) in 1976 and

43,975 (121 daily) in 1978 *(3)*. This paper summarizes methodologies used in a benefit-cost analysis (BCA) to determine if the benefits of the proposed Amtrak service and commuter rail service are worth the costs, as shown by the metrics of benefit-cost ratio and net present value (NPV).

BENEFITS AND COSTS DEVELOPMENT/ASSUMPTIONS

A benefit-cost ratio of more than one signifies that overall society, i.e. the United States, is better off due to a project as benefits outweigh costs. A ratio of less than one is an indicator that implementation of a project is questionable as costs to society on the whole outweigh benefits. The base case is the no-build alternative. The BCA analysis period extends from 2015 to 2046 including a 30-year operational/useful life period beginning in 2017. Reference studies include the following publicly available documents: *Chicago-Rockford-Dubuque Corridor Intercity Passenger Rail Service* (via Genoa), Service Development Plan, Illinois Department of Transportation, Bureau of Railroads, dated October 2, 2009 (IDOT Report) *(4)*; *Feasibility Report on Proposed Amtrak Service*, Chicago-Rockford-Galena-Dubuque, dated June 22, 2007 (Amtrak Report) *(5)*; and *Northern Illinois Commuter Transportation Transportation Initative (NICTI) Alternatives Analysis* (via Belvidere), Draft Second Level Screening Report, TranSystems, dated April 2008 (NICTI Report) *(6)*.

Note that the Amtrak Report analyzes capital costs under the four intercity rail service scenarios listed below. This BCA considers Route C through Genoa as more comprehensive data is available for it in the IDOT Report. The BCA also looks at a second scenario via Belvidere for the Chicago to Rockford commuter rail service as proposed in the NICTI Report. Finally, a combined scenario of intercity and commuter rail service is analyzed which would use Route A.

- Route A – Chicago to Elgin via the Metra Milwaukee District-West (MD-W); Union Pacific (UP) to Rockford; and Canadian National (CN) to Dubuque;
- Route B – Chicago to Elgin via MD-W; Iowa, Chicago and Eastern Railroad (ICE) to Davis Junction; Illinois RailNet Railroad (IRY) to Rockford; and CN to Dubuque;
- Route C – Chicago to Dubuque via Genoa on the CN;
- Route D – Chicago to Elgin via MD-W; ICE to Genoa; CN to Dubuque via Rockford.

Benefit and cost unit values are from a number of cited transportation economics guidance documents and empirical studies. The U.S. Department of Transportation (USDOT) TIGER Benefit-Cost Analysis Resource Guide (TIGER BCA Guide) provides support to applicants for the Transportation Investments Generating Economic Recovery funding. The Guide recommends using a discount rate of 7 percent, pursuant to the U.S. Office of Management and Budget A-4 and A-94 circulars, and an alternative analysis using 3 percent *(7)*. This BCA uses these discount rates in addition to a mid-range of 5 percent. All figures are in 2015 dollars using the U.S. Department of Labor, Bureau of Labor Statistics, Consumer Price Index (CPI) on-line calculator.

Capital Costs

Capital Costs includes right-of-way (ROW) acquisition, design, engineering and construction during the presumed years of 2015-2017. According to the IDOT Report, Table 3.2, on page 28, the total capital cost for intercity rail from Chicago to Dubuque is $136,815,000 (2010$) or $146,634,920 (2015$). This includes track work, stations, at-grade roadway crossings, layover facilities, vehicles, professional services, and contingencies. Rolling stock contingencies are 10 percent while construction and professional services contingencies are 30 percent. It is assumed that the funds will be spent over three years from 2015-2017 at an average of $48,878,307 per year.

According to the NICTI Report, Table 3.1, on page 2, the total estimated capital cost for commuter rail from Chicago to Rockford is $247,100,100 (2008$) or $268,222,000 (2015$). This includes track work, stations, at-grade roadway crossings, layover facilities, vehicles, professional services, and contingencies (30 percent). It is assumed that the funds will be spent over three years from 2015-2017 at an average of $89,407,000 per year.

Under the combined intercity and commuter rail alternative, Chicago to Dubuque via Rockford, average annual capital costs assumed for the 2015-2017 period include the above $89,407,000. The proportion of route miles west of Rockford is about 0.53. For simplicity, it is assumed that the proportion of annual average capital costs in the IDOT Report will be reduced accordingly to $25,905,503. It is realized there could be some variance from this based on detailed capital costs by track segment. The sum average capital costs for the 2015-2017 period under the combined intercity/commuter rail alternative is $115,312,836 per year.

Operating and Maintenance Costs

The IDOT Report, page 39, states that the intercity service operating and maintenance (O&M) annual budget is $4,850,000 (2009$) or $5,280,000 (2015$). This assumes one roundtrip per day between Chicago and Dubuque.

The NICTI Report states on page 2 that the estimated commuter service O&M annual budget is $10,200,000 (2008$) or $11,071,890 (2015$). This assumes three roundtrips per day between Chicago and Rockford. These costs include labor, overhead, fuel, ROW maintenance, and protective/feeder bus services.

Under the combined scenario, annual O&M costs for a 0.53 proportion of the intercity rail project are added to the O&M costs for the commuter rail project resulting in an annual total of $13,870,290.

Ridership and Vehicle Miles Traveled

The IDOT Report, page 31, estimated beginning Amtrak ridership in FY2013 of 82,700 (227 daily) passengers plus 3,400 (9.3 daily) additional riders on other routes due to positive impacts of the new service. Page 40 of the IDOT report estimates a vehicle miles traveled (VMT) reduction of 5,700,000 per year. The total number of new riders (86,100) is divided by an assumed average of 1.5 persons per automobile or 57,400 automobile trips taken off the road. Using the 5,700,000 VMT reduction divided by 57,400 = 99 VMT eliminated per auto/light truck trip. The IDOT Report ridership estimate could be considered high as this is an increase of about 100 percent over the aforementioned Blackhawk ridership statistics in the 1970s. Population in the general service area (Counties of Cook, Du Page, Kane, McHenry, Boone, Winnebago, Stephenson, Jo Daviess, and Dubuque) only increased from about 6.8 million in 1980 to 7.5 million in 2013 (about 10 percent) according to the Census Bureau. Nevertheless, the IDOT Report ridership/VMT estimates are used but with no assumed annual increases.

The NICTI Report, page 2, states that commuter service is expected to generate 5,221 daily transit trips according to travel demand modeling analysis. An assumption is made that riders would otherwise have driven with vehicle occupancy of about 1.5 persons per car. Consequently, it is estimated that 3,481 daily auto/light truck trips are either eliminated or reduced to driving to/from a commuter parking lot. Rockford to Elgin is about 50 miles while Elgin to Chicago is about 40 miles. An assumption is made that the average driver would have traveled 50 miles per trip by auto/light truck. Therefore, based on 260 annual weekdays, there is an estimated reduction in auto/light truck of 45,253,000 AVMT.

An assumption is made that daily bus VMT will increase by 200 VMT or 52,000 annual VMT (AVMT)(200 x 260 days) for connecting service. The 2013 AAA per mile operating costs of average sedans, SUVs, and minivans is $0.68 (same in 2015 $). The variable rate (non-fixed) of this cost assumed is $0.2608 (2015$)*(8)*. According to the National Transit Database (NTD), 2013 National Transit Profile Summary, average operating expenses for buses per vehicle revenue mile were $10.60 ($10.63 in 2015 $)*(9)*.

Empirical research has found that: "In cities with a rail system, a 10 percent increase in rail route miles reduces annual VMT by 0.2 percent *(10)*." According to *IDOT Illinois Travel Statistics for 2013*, the eight-county area of northeastern Illinois including IDOT District 1, Winnebago and Boone Counties, had annual AVMT in 2013 of 61,533,485,631 *(11)*. Metra and CTA have 1,155 and 224.1 route miles, respectively, totaling 1,371.1 miles. The addition of 50 track miles for the NICTI project adds 3.626 percent to the existing system. This equates to a 0.07252 percent (3.626/10 = x/0.2; x=0.07252 percent) reduction of 44,624,084 AVMT which is very close to the calculated reduction based on the estimated transit trips from the Project per the NICTI Report.

Further validation was done by examining Northern Indiana Commuter Transportation District (NICTD) South Shore ridership documented in the NTD and historical ridership by station available via the Regional Transportation Authority Mapping System (RTAMS). The South Shore Line can be considered comparable to the proposed NICTI project as the terminus of both, the South Bend and Rockford urbanized areas, have similar population numbers and are about the same distance from downtown Chicago. According to the NTD, NICTD had 3,606,926 riders in 2013 with average weekday ridership of 12,046. RTAMS data shows ridership on the South Shore during the weekday in 2006 at about 14,000 with the outer 50 miles at about 7.4 percent of this or 1,036. 2006 is the most recent publicly available data by station *(12)*. This daily ridership for the outer 50 miles of the South Shore Line is substantially lower than the aforementioned NICTI daily projection of 5,221 for commuter service between Chicago and Rockford. Note that the NICTD service currently has five roundtrips between Chicago and South Bend on weekdays while the proposed NICTI service between Chicago and Rockford would have three roundtrips.

Detailed travel demand modeling data is unavailable for this BCA. It is assumed that an increase in service frequency of 1 percent will increase ridership by 0.5 percent *(13)*. Therefore, supplementing the NICTI commuter service of 5,221 daily riders (3 roundtrips) with the Amtrak service (1 roundtrip) is a frequency increase of 33 percent and a projected 16.5 percent increase in ridership. This equates to an 861 additional daily weekday riders totaling 6,082 daily (30,410 weekly). Estimated average daily Amtrak ridership of 236 is assumed for weekend days based on the IDOT Report 86,100 annual ridership estimate. The estimated Amtrak ridership alone of 86,100 is 236 passengers daily (472 per weekend). Consequently, it is assumed under the combined intercity/commuter rail scenario that annual ridership will be 1,605,864 [(30,410 + 472) x 52 weeks]. An associated total reduction of 53,533,145 AVMT is assumed based on an additional reduction of 8,280,145 AVMT, or about 18.3 percent, over the base NICTI figure of 45,253,000 AVMT. This was calculated by maintaining the same ridership/ AVMT reduction proportion under the base commuter rail scenario.

Productivity

Train passengers that otherwise would have driven a car have the potential to increase productivity. An assumption is made that 20 percent of drivers from the annual automobile trips reduced would opt to work 2 hours and 1 hour on each intercity and commuter rail train trip, respectively. An average of 1 hour is assumed under the combined intercity/commuter rail scenario. According to the 2014 USDOT TIGER BCA Guide the value of time for business purposes is $25.23 (2013 $) or $25.31 (FY2015 $).

Noise

The Transportation Research Board (TRB) Transportation Benefit-Cost Analysis web site provides noise impact values per VMT for urban highways from several studies. Dollar values for noise impacts in these cited studies show the following ranges per VMT (converted to 2015 $): heavy trucks ($0.035-$0.26); and auto ($0.001 and $0.028). Mid-levels of $0.1475 for trucks (and buses) and $0.0145 for autos are used. The autos value is multiplied by the annual VMT savings while the bus value is multiplied by the VMT increases *(14)*. Additionally, the *Handbook on Estimation of External Cost in the Transport Sector* is used for the monetized values of passenger train noise. The average proportion noise values for cars (day, night, urban, suburban, and rural) in this study are compared to the same for passenger trains. The latter monetized value is about 65 times that of automobiles. Consequently, $0.0145 (value used for autos) multiplied by 65 is used to determine an estimated value of $0.9425 for passenger train noise per mile *(15)*.

Emissions

Apart from the TIGER BCA Guide, documents used for calculating monetized values of air emissions due to the project are as follows: IDOT Report; *Transportation Energy*

Databook, Edition 33 (TED) *(16)*; *Average Annual Emissions and Fuel Consumption for Gasoline-Fueled Passenger Cars and Light Trucks* (AAE)*(17)*; *Emission Factors for Locomotives* (EFL)*(18)*; *Average In-use Emissions for Urban Buses and School Buses* (AEB)*(19)*.

The IDOT Report, Figure 5.8, reports air emissions reductions estimates per year based on the expected VMT reductions. However, there is no information given on the methodology for the calculations. Consequently, the AAE document is used to estimate reductions for carbon dioxide (CO_2), volatile organic compounds (VOC), nitrogen oxides (NO_X), particulate matter (PM_{10}), and $PM_{2.5}$. The IDOT Report sulfur dioxide SO_2 value is used as the AAE document does not have a corresponding rate. All of these rates are used to make calculations based on the assumptions for VMT reductions. The TED document is used to calculate an estimate for gallons of diesel fuel used by intercity and commuter trains. The respective levels are 0.63 MPG and 0.25 MPG. The costs for bus fuel usage assume 3 MPG per the AEB document.

<u>Carbon Dioxide</u>
The AAE document value of 368.4 grams for CO_2 is multiplied by the estimated VMT reductions and then divided by 1,000,000 (grams to MT factor) to calculate the MT reduction for automobiles/light trucks annually under each scenario. The formula to estimate CO_2 changes for passenger train locomotives is from page 5 of the EFL document: CO_2 (g/gal) equals (fuel density of 3200) × (44 g CO_2 /12 g C) × (C content of fuel of 0.87). The result is then divided by 1,000,000 resulting in the MT value for the increase of CO_2 from locomotives under each scenario.

For diesel buses, the AEB document does not have a CO_2 value. The CO value of 3.376g per miles is estimated to be 1/39th the CO2 value based on the CO/ CO_2 ratio of 9.4g/368.4g for auto light trucks in the AAE document. This is then used to calculate an estimated CO_2 value of 132.3g per mile for urban buses. The result is then divided by 1,000,000 (grams to MT factor). Social cost of carbon (SCC) values are obtained from the TIGER BCA Guide. The data is then multiplied for each year by the social cost of carbon (SCC) values converted from 2013 $ to 2015$. Per the guidance, the CO_2 values are only discounted at the 3 percent discount rate but are also used in the 5 and 7 percent columns as either costs or benefits.

<u>Nitrogen Oxides</u>
The AAE NO_X value of 0.693 grams per VMT is used and multiplied by auto/light truck AVMT reduced and then divided by 1,000,000 (grams to MT factor) to calculate the reduction for automobiles/light trucks annually. For the new train service in each scenario, the total gallons of fuel is multiplied by the emissions factors in the EFL document, which are declining annually due to increasing emissions restrictions, and then converted from grams to MT. For connecting bus service, the grams per mile value for urban buses per the AEB document is 14.793. This is multiplied by the increase in bus miles and then converted to MT. The TIGER BCA Guide value for NO_X is $7,877 (2013 $) and $7,937 (2015 $).

Particulate Matter
The AAE respective values of 0.0044 and 0.0041 grams per VMT for PM_{10} and $PM_{2.5}$ are used and multiplied by VMT changes and then divided by 1,000,000 (grams to MT factor) to calculate the reduction for automobiles/light trucks annually. For the new train service, the total gallons of fuel is multiplied by the emissions factors in the EFL document for PM_{10} ($PM_{2.5}$ is 0.97 that of PM_{10}), which are declining annually due to increasing emissions restrictions, and then converted from grams to MT. The AEB respective values of 0.0297 and 0.0274 grams per VMT for PM_{10} and $PM_{2.5}$ are used for buses. The TIGER BCA Guide value for PM is $360,383 (2010 $) and $363,113 (2015 $).

Volatile Organic Compounds
The AAE VOC value of 1.034 grams per VMT is used and multiplied by auto/light truck AVMT reduced and then divided by 1,000,000 (grams to MT factor) to calculate the reduction for automobiles/light trucks annually. For the new train service, the total gallons of fuel is multiplied by the emissions factors in the EFL document (HC values x 1.053), which are declining annually due to increasing emissions restrictions, and then converted from grams to MT. For the connecting bus service, the grams per mile value for urban buses per the AEB document is 0.349. This is multiplied by the increase in bus miles and then converted to MT. The TIGER BCA Guide value for PM is $1,999 (2013 $) and $2,014 (2015 $).

Sulfur Dioxide
The IDOT Report, Figure 5.8, page 40 states that the Amtrak project will reduce auto/light truck SO_2 by 0.04 MT per year. For the other scenarios this data is used to calculate SO_2 reductions based on the amounts of lower VMT. For the new train service, the aforementioned MPG assumptions for intercity and commuter trains are used to calculate total gallons. This is then multiplied by the following formula in the EFL document SO_2 (g/gal) = (fuel density) × (conversion factor) × (64 g sO2/32 g S) × (S content of fuel) OR (3200) × (0.978) × (2.00) × (300×10^{-6}) and then converted from grams to MT. The TIGER BCA Guide value for SO2 is $46,561 (2013 $) and $46,711 (2015 $).

Resource Consumption
The Victoria Transport Policy Institute (VTPI) Transportation Cost and Benefit Analysis web site (VTPI BCA Resource) provides substantial details on numerous monetized costs. Resource consumption costs are external costs of transport fossil fuels production (primarily petroleum) which is the opposite of social benefits from resource conservation. These include military security costs for foreign oil, trade deficits from its importation, environmental damages from oil extraction, oil company tax subsidies, and human health risks from injuries and pollution during extraction. Depletion of non-renewable resources for future generations is an externality as well although it is not costed.

The VTPI, *Transportation Cost Analysis Spreadsheet* has default cost values per VMT as follows in 2007 $ for average travel: average car $0.039 ($0.044 in 2015 $); light truck/van $0.050 ($0.056 in 2015 $). $0.050 (2015 $) is used for combined cars/light truck/van *(20)*. Automotive fuel consumption savings assume an average of 23 MPG and are calculated from the VMT reductions in each scenario. The locomotive and bus fuel usage costs are based on the number of miles and aforementioned MPG assumptions.

Parking

The VTPI, *Transportation Cost Analysis Spreadsheet* has default parking cost values per VMT as follows in 2007 $ for average travel: car/pickup/van $0.064 ($0.072 2015 $) (internal); $0.060 ($0.068 2015 $)(external) for a total of $0.124 ($0.140 in 2015 $). Internal costs are paid directly by users for residential parking while external costs are for off-street parking paid by non-users through increased bundled goods costs and services that includes free/reduced cost parking. The scenarios do not affect residential parking. There could be some potential benefit in external cost reductions due to passengers arriving at their destination and not needing parking. However, this could be completely offset by station parking lots where passengers board trains. Therefore, no benefit or cost is assigned.

Health and Mortality

The VTPI *Transportation Cost Analysis Spreadsheet* has default health cost values per VMT as follows in 2007 $ for average reductions as follows: walking: $0.24 (internal) ($0.26 2015 $); $0.24 (external)($0.26 2015 $); bicycling $0.095 (internal)($0.107 2015 $); $0.095 (external)($0.107 2015 $). Internal cost reduction is reflected through extended lives and reduced mortality rates. External cost reduction is shown through reduced hospital and health care costs. Reference is made to *Costs and Estimates of Bicycling Investments in Portland, Oregon* by Thomas Gotschi, in the Journal of Physical Activity and Health, 2011. Three studies are cited in this paper for annual per capita health care costs per inactive person, with the average being $544 in 2008 $ ($591 in 2015 $). The paper also notes that there was an annual average increase of 4.2 percent in these costs above inflation from 1991-2008 *(21)*.

An assumption is made that the average health care costs (external) growth rate above inflation will continue at a conservative annual rate of 2.1 percent to a beginning value in 2017 of $0.2662 for walking and $0.1100 for bicycling. It is not assumed that any growth rate above inflation will continue after 2017. Internal costs are increased 1.18 percent annually to account for the rise in the value of a statistical life documented in the TIGER BCA Guide. Consequently, the year 2015 values are increased by this amount annually to a beginning value in 2017 of $0.2662 for walking and $0.110 for bicycling with the increases continuing at the same annual rates. The following assumptions are made: 5 percent of riders will walk an average of 1/4 mile to their boarding station; 5 percent will bicycle an average of one mile to their boarding station; and 50 percent will walk an additional 1/4 mile at their destination station to their final destination. These distances are then multiplied by the aforementioned monetary values both for health and mortality benefits.

Barrier Effects

These are delay costs to non-motorized travel caused by motorized travel. The VTPI, *Transportation Cost Analysis Spreadsheet* has default barrier effect cost values per VMT as follows in 2007 $ for average travel: car/pickup/van $0.014 ($0.016 in 2015 $) and diesel bus $0.023 ($0.026 in 2015 $). It is assumed that diesel buses and heavy trucks have the same values. Note that values for bus and heavy trucks are not applicable to this analysis. The VMT reduction is multiplied by the car/pickup/van value.

Transport Diversity

According to the VTPI *Transportation Cost Analysis Spreadsheet*, the value per VMT for transportation diversity is $0.007 in 2007 $ ($0.008 in 2015 $). This represents the benefits of improving transportation options brought about by the project scenarios resulting in reduced overall transportation costs for the public. Additionally, the value measures the extent disadvantaged populations (elderly, low income, minority) are able to travel due to increased accessibility brought about by improved mode choice.

Vehicle Hours Traveled

The TIGER BCA Guide lists hourly values of time for all purposes (personal and business) for both local and intercity automobile travel. It is assumed for this BCA that local and intercity automobile travel will be split evenly. The midpoint of the weighted averages for local and intercity travel is $15.94 (2013 $) and $16.06 (2015 $) per hour. Vehicles taken off the road likely provide some travel time savings for other drivers but it is assumed to be negligible. There could be benefits to truck and freight train travel time. However, they are not included as the results are also likely negligible.

According to the Amtrak Report, the option via Genoa (Route C) has the best intercity rail travel time performance. Estimated travel time for the full run from Dubuque to Chicago is 5 hours, 10 minutes. According to Google Maps, an automobile could make the trip in about 3 hours without traffic congestion and without stopping for breaks. It is assumed the train would travel during peak periods in the Chicago area. An automobile trip during this time could add about 45 minutes delay. Accounting for driving breaks and congestion delay, an assumption is made that the average delay for an automobile driver/passenger converting to riding Amtrak is about 1 hour per trip.

According to a NICTI proposed schedule, estimated travel time for downtown Rockford to Elgin, Big Timber is just over an hour. Transfer to Metra going to downtown Chicago adds about 1½ hours, for a total trip time of about 2½ hours. There would be added time for driving to the train station and any connecting bus travel, perhaps up to a total of a ½ hour. Times would be less for travelers using stations closer to Chicago than Rockford. According to Google Maps, an automobile could make the trip uncongested from Rockford to Big Timber in about 55 minutes and downtown Chicago in 1 hour 50 minutes. Peak period congestion could add another 45 minutes to downtown Chicago making the trip about 2½ hours. It is assumed the train would travel during peak periods in the Chicago area. Accounting for driving breaks and congestion delay, an assumption is made that the average delay for an automobile driver/passenger converting to riding the commuter train is about ½ hour per trip.

Property Impacts
The TIGER BCA Guide states the following: "1) The benefit of any property value increase can only be considered as a one-time stock benefit and cannot be treated as a stream of benefits accruing annually; 2) It cannot include any investment by developers; 3) Other benefits to land value already counted, such as travel time savings, must also be netted out."

According to the Rockford Township, Office of the Assessor web site, the total estimated value of property in its jurisdiction is $6.9 billion. This covers an area of about 111 square miles *(22)*. According to *Capturing the Value of Transit by Reconnecting America's Center for TOD*, studies have shown ranges of residential property increases near public transportation as follows: residential land, 2-45 percent; and office/retail, 1-167 percent within a 1/4-mile radius of TOD *(21)*. An assumption is made that the two stations in Rockford will impact property values within a one square mile area. The value of this property based on the assessor's office is calculated as follows: 1/111 X $6.9 billion = $62,162,162. An assumption is made that this value for property (two stations) will increase in value by 20 percent or $12,432,432 ($6,216,216 per station). This is a one-time benefit. A similar methodology was calculated for Freeport to estimate an increase in property value of $7,079,446. The Rockford and Freeport data along with population data for the other cities to receive stations was used to conduct a trend analysis to estimate property value increases around other stations.

Safety
According to the *2010 Illinois Crash Statistics* publication, totals for the state are as follows: 105.74 billion VMT; 289,260 crashes; and 927 fatalities *(23)*. The crash rate is 1 accident per 365,561 VMT. This rate is used with the estimated annual VMT savings in each project scenario to calculate the estimated annual reduction of accidents. The fatality/crash ratio is 0.0032047 based on the 2010 data. This is used to estimate fatalities based on the VMT savings for each project scenario.

The TIGER BCA Guide identifies the value of a statistical life as about $9.2M in 2013 $ or $9.23M in 2015$. The guide also states that the growth rate in this metric is about 1.18 percent above inflation. This amount is increased annually by 1.18 percent with the beginning value in 2015 of $9.33 million. The estimates for injury severity are based in part on the TIGER BCA Guide, Section 3. Accordingly, the data on number of accidents reduced is converted to the Abbreviated Injury Scale (AIS) to determine estimated level of injury by severity rates (none, minor, moderate, serious, severe, critical). The number of non-fatal accidents probability values in Table 4, column 8 on page 13 of the guidance are multiplied by the AIS unit value levels on page 3 of the guidance and then multiplied by the number of accidents. Comparable to the methodology for internal costs in the above Health and Mortality section, values of injuries are not adjusted further to account for any continuation of the historic rise in health care costs above inflation.

U.S. DOT *National Transportation Statistics Railroad Passenger Safety Data* provides passenger fatalities, injuries, and train miles. This data was analyzed for the most recent 10 years available: 2003 to 2012. Annual averages for this period are as follows:

97,700,000 passenger train miles; 7 fatalities; and 1,172 injuries *(25)*. The data is used to estimate fatalities and injuries in each project scenario based upon the number of train miles. Results provide an offset to the safety benefits from roadway VMT reductions.

Residual Value

The expected life of the project elements A-C were obtained from *Transport infrastructure evaluation using cost-benefit analysis: improvements at evaluating the asset through residual value a case study (26)*. Useful life for project element D is based on general internet searches, and E is from the Federal Transit Administration (FTA)*(27)*. Values are loosely based on the capital costs from the IDOT Report and the NICTI Report. Total estimated residual values are then calculated after 30 years of implementation in the year 2046.

A. Stations, 50 percent after 30 years (60 years life);
B. Permanent Way (tracks, ballast, subgrade, roadway crossings), 20 percent after 30 years (38 years life);
C. Protection Works (at-grade roadway crossing warning devices), 50 percent after 30 years (60 years useful life);
D. Locomotives, 0 percent after 30 years (30 years useful life);
E. Coach Cars, 0 percent after 30 years.

RESULTS

Table 1 summarizes benefits and costs for the Amtrak service based on the above assumptions and analysis. At all three discount rates the benefit/cost ratios are well below 1. Capital and O&M expenditures make up the vast majority of costs. However, increased travel time is also a substantive cost. Benefits in descending order are from property value increases, traffic accident injury reductions, lower vehicle operating expenses, increased worker productivity, and residual value of the infrastructure. Cost effectiveness analysis at the mid-range 5 percent discount level shows total capital and O&M expenditures of about: $80.11 per rail passenger ($206.7 million/2.58 million passengers); $1.21 per VMT reduced ($206.7 million/171.0 million VMT); and $521,970 per accident reduced ($206.7 million/396 accidents).

TABLE 1 Dubuque-Rockford-Chicago Amtrak Service (via Genoa) Benefit-Cost Analysis Summary (2015 $ in millions)

DISCOUNTED COSTS	**3%**	**5%**	**7%**
Capital Costs	($138.26)	($133.11)	($128.27)
Operating & Maintenance	($97.55)	($73.62)	($57.23)
Train Noise	($2.32)	($1.75)	($1.36)
NO_X Increase	($1.23)	($1.03)	($0.88)
PM Increase	($2.93)	($2.44)	($2.07)
SO_2 Increase	($0.31)	($0.23)	($0.18)
VHT Increase	($19.16)	($14.46)	($11.24)
TOTAL DISCOUNTED COSTS	**($260.91)**	**($225.80)**	**($200.39)**

TABLE 1 Dubuque-Rockford-Chicago Amtrak Service (via Genoa) Benefit-Cost Analysis Summary (2015 $ in millions)			
DISCOUNTED BENEFITS	**3%**	**5%**	**7%**
VMT Reduction - Auto	$27.46	$20.73	$16.11
Increased Worker Productivity	$10.74	$8.10	$6.30
Noise Decrease – Auto	$1.53	$1.15	$0.90
CO_2 Decrease	$0.83	$0.83	$0.83
VOC Decrease	$0.21	$0.16	$0.12
Resource Consumption Decrease	$0.78	$0.59	$0.46
Health Care Reduction	$0.02	$0.02	$0.01
Mortality Reduction	$0.02	$0.02	$0.01
Barrier Effect Reduction	$1.68	$1.27	$0.99
Transport Diversity Increase	$0.84	$0.64	$0.49
Land Value Increase	$42.36	$39.99	$37.79
Fatalities Reduced	$8.58	$6.37	$4.88
Injuries Reduction	$30.98	$23.38	$18.17
Property Damage Reduction	$0.83	$0.63	$0.49
Residual	$10.74	$5.81	$3.17
TOTAL DISCOUNTED BENEFITS	**$136.79**	**$108.84**	**$89.90**
NET PRESENT VALUE	**($124.13)**	**($116.96)**	**($110.49)**
BENEFIT/COST RATIO	**0.52**	**0.48**	**0.45**

(Numbers may not add exactly due to rounding.)

Table 2 summarizes benefits and costs for the NICTI commuter rail service based on the above assumptions and analysis. At all three discount rates the benefit/cost ratios are marginally above 1. The monetary values of the costs and benefits are significantly higher than for the Amtrak service due to the different proportions in extensive capital track improvements needed and the expectations for ridership. Again, capital and O&M expenditures make up the vast majority of costs while increased travel time is also a substantive cost. Benefits in descending order are from traffic accident injury reductions, increased worker productivity, traffic fatality reductions, lower vehicle operating expenses, lower resource consumption costs, increased property values, and residual value of the infrastructure. Cost effectiveness analysis at the mid-range 5 percent discount level shows capital and O&M expenditures of about: $9.77 per rail passenger ($397.9 million/40.72 million passengers); $0.29 per VMT reduced ($397.9 million/1,357.6 million VMT); and $108,686 per accident reduced ($397.9 million/3,661 accidents).

TABLE 2 Rockford-Belvidere-Chicago Commuter Rail Service Benefit-Cost Analysis Summary (2015 $ in millions)			
DISCOUNTED COSTS	**3%**	**5%**	**7%**
Capital Costs	($252.90)	($243.47)	($234.63)
Operating & Maintenance	($204.56)	($154.38)	($120.00)
Bus Costs	($10.21)	($7.71)	($5.99)
Bus Noise	($0.14)	($0.11)	($0.08)
Train Noise	($1.36)	($1.03)	($0.80)
PM Increase	($0.35)	($0.38)	($0.38)
VHT Increase	($201.39)	($151.98)	($118.14)
TOTAL DISCOUNTED COSTS	**($670.91)**	**($559.05)**	**($480.02)**
DISCOUNTED BENEFITS	**3%**	**5%**	**7%**
VMT Reduction – Auto	$218.05	$164.56	$127.91
Increased Worker Productivity	$84.63	$63.87	$49.65
Noise Decrease – Auto	$12.12	$9.15	$7.11
CO_2 Decrease	$17.86	$17.86	$17.86
NO_X Decrease	$3.42	$2.52	$1.92
VOC Decrease	$1.73	$1.31	$1.01
SO_2 Decrease	$0.07	$0.06	$0.04
Resource Consumption Decrease	$39.17	$29.56	$22.98
Health Care Reduction	$1.06	$0.80	$0.62
Mortality Reduction	$1.06	$0.80	$0.62
Barrier Effect Reduction	$13.40	$10.11	$7.86
Transport Diversity Increase	$6.70	$5.05	$3.92
Land Value Increase	$28.44	$26.85	$25.37
Fatalities Reduced	$80.14	$59.52	$45.59
Injuries Reduction	$286.79	$216.43	$168.24
Property Damage Reduction	$7.72	$5.83	$4.53
Residual	$20.05	$10.84	$5.92
TOTAL DISCOUNTED BENEFITS	**$822.39**	**$625.09**	**$491.15**
NET PRESENT VALUE	**$151.48**	**$66.03**	**$11.13**
BENEFIT/COST RATIO	**1.23**	**1.12**	**1.02**

(Numbers may not add exactly due to rounding.)

Table 3 summarizes benefits and costs for the combined Amtrak intercity and NICTI commuter rail service via Belvidere based on the above assumptions and analysis. A more detailed spreadsheet of this scenario is in Appendix 1. At all three discount rates the specific benefits and costs in addition to the overall benefit/cost ratios are very similar to the NICTI commuter rail service alone. Cost effectiveness analysis at the mid-range 5 percent discount level shows capital and O&M expenditures of about: $10.53 per rail passenger ($507.4 million/48.18 million passengers); $0.32 per VMT reduced ($507.4 million/1,606.0 million VMT); $118,885 per accident reduced ($507.4 million/4,268 accidents).

TABLE 3 Dubuque-Rockford-Belvidere-Chicago Combined Intercity and Commuter Rail Service Benefit-Cost Analysis Summary (2015 $ in millions)

DISCOUNTED COSTS	**3%**	**5%**	**7%**
Capital Costs	($326.17)	($314.02)	($302.62)
Operating & Maintenance	($256.26)	($193.39)	($150.33)
Bus Costs	($10.21)	($7.71)	($5.99)
Bus Noise	($0.14)	($0.11)	($0.08)
Train Noise	($3.67)	($2.77)	($2.16)
PM Increase	($3.31)	($2.94)	($2.56)
SO_2 Increase	($0.22)	($0.16)	($0.13)
VHT Increase	($219.18)	($165.41)	($128.58)
TOTAL DISCOUNTED COSTS	**($819.05)**	**($686.36)**	**($592.31)**
DISCOUNTED BENEFITS	**3%**	**5%**	**7%**
VMT Reduction – Auto	$257.94	$194.66	$151.32
Increased Worker Productivity	$100.12	$75.56	$58.73
Noise Decrease – Auto	$14.34	$10.82	$8.41
CO_2 Decrease	$19.76	$19.76	$19.76
NO_X Decrease	$2.46	$1.69	$1.19
VOC Decrease	$2.04	$1.53	$1.19
Resource Consumption Decrease	$42.34	$31.95	$24.84
Health Care Reduction	$1.25	$0.94	$0.73
Mortality Reduction	$1.25	$0.94	$0.73
Barrier Effect Reduction	$15.85	$11.96	$9.30
Transport Diversity Increase	$7.91	$5.97	$4.64
Land Value Increase	$45.51	$42.96	$40.59
Fatalities Reduced	$93.36	$69.33	$53.11
Injuries Reduction	$334.35	$252.33	$196.14
Property Damage Reduction	$9.00	$6.79	$5.28
Residual	$25.74	$13.92	$7.60
TOTAL DISCOUNTED BENEFITS	**$973.00**	**$740.96**	**$583.45**
NET PRESENT VALUE	**$153.95**	**$54.61**	**($8.86)**
BENEFIT/COST RATIO	**1.19**	**1.08**	**0.99**

(Numbers may not add exactly due to rounding.)

Table 4 presents expectations for benefit/cost ratios and NPV using sensitivity analysis due to unforeseen cost increases and differing ridership projections. A 15 percent increase in capital/O&M costs would reduce the benefit/cost ratios by relatively small amounts for all three scenarios. In terms of ridership, for intercity passenger rail service alone, Amtrak would need to increase daily patronage about 300 percent to an average of 700 to achieve a mid-range benefit/cost ratio of more than 1. The NICTI project alone is expected to achieve a benefit/cost ratio of more than 1 with the projected base 5,221daily ridership. However, NICTI's benefit/cost ratio drops to below 1 at the mid-range 5 percent discount rate if this has been overestimated by about 15 percent. It drops further to about 0.84 if ridership is overestimated by 33 percent. It could be much worse if ridership is closer to that of the outer 50 miles of NICTD's South Shore Line to South Bend.

The IDOT Report identifies the intention to upgrade the CN track for up to 80 MPH service in a second phase that would add an unknown amount of costs. The IDOT Report states this work would include raising super elevation on curves where the track geometrics indicate that increased speeds are possible. The report identifies a goal in this second phase of raising the travel time average from 35 MPH to 50 MPH which would be comparable to other Amtrak routes in the Midwest and competitive with automobile travel. This assumption is used along with an increased travel time average for NICTI from 46 MPH to 50 MPH in sensitivity analysis. Consequently, with this scenario the travel time loss assumptions are reduced to zero for Amtrak and incrementally for NICTI. Assumptions are made that capital costs would increase by $50 million for Amtrak alone and $5.1 million for NICTI alone.

The VTPI report, *Transit Price Elasticities and Cross-Elasticities*, cites literature regarding service elasticities. The report is focused on public transportation as opposed to intercity train travel. However, there are elements of commuter travel from Chicago to Rockford. Based on the literature cited in that report, particularly in the Service Elasticities section on pages 10-11, an assumption is made that the speed elasticity of demand is 0.3 (i.e. 1 percent speed increase = 0.3 percent ridership increase)*(13)*. Therefore, the 42 percent train speed increase would improve Amtrak ridership 13 percent. An increase in NICTI average train speed from 46 MPH to 50 MPH or 8.7 percent would increase ridership 2.6 percent.

The IDOT Report states that further upgrades to signals would not be necessary. Timing adjustments would need to be made to street crossing signals. According to the *Feasibility Report Austin-San Antonio Commuter Rail Study*, track maintenance costs per train travel mile are $5.00 in 1998 $ or $7.00 in 2015 $ *(28)*. Therefore, one roundtrip Amtrak train per day, 365 days per year, imposes track maintenance costs of $931,042 annually. According to *High-Speed Rail Technology Review*, track maintenance costs double when upgrading from Class 3 to Class 4 track. This is due in part to increased track inspections and higher quality specifications per 49 CFR Part 213 *(29)*. Consequently, annual maintenance costs are increased by $931,042 for intercity service. An assumption is made that NICTI alone track maintenance costs would increase about $96,429 ($931,042 x 0.5 x 8.7/42). Table 4 shows the changes to benefit/cost ratio do not change substantively for intercity service with the increased speed scenario but the improvement for commuter service is much better.

Research shows that optimal pricing for all roads could reduce overall VMT by 30 percent *(30)*. An assumption is made that pricing via tax increases alone will reduce VMT 30 percent and will not incur any implementation charges. The amount of the pricing increase for all roads does not add any additional costs as society is already incurring the capital and O&M costs. They are just being transferred to the direct users from portions that are normally paid for via general revenues. Consequently, it is assumed that the new combined Amtrak/NICTI service will also increase ridership 30 percent. This would require purchase of three additional rail cars for the commuter service at an assumed $3.2 million each and increase in O&M costs of 10 percent. The expected improvement to the benefit/cost ratios and NPV is also shown in Table 4.

TABLE 4 Dubuque-Rockford-Chicago Intercity and Commuter Rail Sensitivity Analysis (2015 $ in millions)

	3%		5%		7%	
Scenario	**B/C Ratio**	**NPV**	**B/C Ratio**	**NPV**	**B/C Ratio**	**NPV**
Base Annual Ridership Projections -Amtrak: 86,100; NICTI: 1.36M; Combined: $1.61M						
Amtrak only	*0.52*	*($124.13)*	*0.48*	*($116.96)*	*0.45*	*($110.49)*
NICTI only	*1.23*	*$151.50*	*1.12*	*$66.05*	*1.02*	*$11.14*
Combined	*1.19*	*$153.95*	*1.08*	*$54.61*	*0.99*	*($8.86)*
+15% Base Capital/O&M Cost Increase						
Amtrak only	*0.46*	*$159.50*	*0.42*	*$147.97*	*0.39*	*$138.32*
NICTI only	*1.11*	*$82.89*	*1.01*	*$6.37*	*0.92*	*($42.05)*
Combined	*1.07*	*$66.58*	*0.97*	*($21.50)*	*0.88*	*($76.81)*
-33% Annual Ridership Projections - Amtrak: 57,400; NICTI: 904,930; Combined: 1.07M						
Amtrak only	0.41	($150.68)	0.38	($137.16)	0.36	($126.34)
NICTI only	0.93	($43.26)	0.84	($82.15)	0.76	($105.23)
Combined	0.89	($82.81)	0.80	($125.50)	0.73	($150.25)
+50% Annual Ridership Projections - Amtrak: 129,150; NICTI: 2.04M; Combined: 2.41M						
Amtrak only	0.69	($84.30)	0.63	($86.68)	0.58	($86.73)
NICTI only	1.58	($443.60)	1.45	($288.31)	1.34	($185.66)
Combined	1.55	($509.02)	1.42	($324.72)	1.51	($203.17)
+300% Annual Ridership Projections - Amtrak: 258,300; NICTI: 4.07M; Combined: 4.82M						
Amtrak only	1.12	$35.17	1.02	$4.18	0.93	($15.45)
NICTI only	2.23	$1,319.87	2.11	$955.07	1.99	$709.20
Combined	2.26	$1,574.22	2.12	$1,135.07	1.99	$839.29
Amtrak Only Speed Increase 35 to 50 MPH Avg.; Followed by: Road Pricing; Triple Freq.; Increase to 39% Base NICTI Ridership						
+ Speed	0.54	($135.68)	0.49	($138.37)	0.44	($135.46)
+ Pricing	0.67	($101.12)	0.60	($109.09)	0.54	($112.53)
+3X Freq.	0.49	($293.02)	0.45	($263.07)	0.42	($240.08)
++Induced	1.10	$57.66	1.01	$3.21	0.92	($31.53)
NICTI Only Speed Increase 46 to 50 MPH Average; Followed by Road Pricing						
+ Speed	1.29	$190.62	1.17	$94.13	1.07	$31.74
+ Pricing	1.54	$380.35	1.41	$238.44	1.29	$144.99
NICTI -70% Annual Ridership Projections; Followed by Speed Increase to 50 MPH Average; Followed by Road Pricing						
-70% Riders	0.52	($257.42)	0.46	($245.11)	0.41	($233.18)
+ Speed	0.58	($200.03)	0.51	($203.29)	0.45	($201.97)
+ Pricing	0.69	($157.44)	0.61	($172.93)	0.54	($179.91)

Finally, sensitivity analysis was performed further with the Amtrak only option by adding two roundtrips per day and assuming implementation of the aforementioned train speed increase and roadway pricing. Based on the Amtrak and IDOT Reports, capital costs are increased by $48,655,000 (2015 $) to account for additional rolling stock. M&O costs are tripled. Ridership is expected to increase significantly but not enough to effectively increase the benefit/cost ratio. However, if the Amtrak ridership does increase 2.5 times over this expectation, or to about 39 percent of the total estimated base NICTI ridership, then intercity rail can achieve a benefit/cost ratio of about 1 at the mid-range 5 percent discount rate.

CONCLUSIONS

In the best case scenario, commuter rail service from Chicago to Rockford through Belvidere, either separately or together with duplicative Amtrak intercity service to Dubuque, may be a viable build option. However, the benefit/cost ratio is not substantively more than 1. Further, this finding is highly dependent on the realization of projected passenger ridership levels from the referenced studies, particularly for usage of commuter trains. None of the project scenarios are viable in terms of benefit/cost ratio if ridership levels are overestimated to any great extent. Amtrak service alone does not fare well due to the lack of ridership and population centers west of Rockford.

A number of actions are recommended to help ensure maximum viability of any build option. First, track improvements should be at a level to ensure travel times by each of the rail modes are fully competitive with the automobile. Second, statewide pricing of roads should be revamped to reflect actual usage by all drivers to cover the full amount of social costs or externalities. The expected automobile/light truck travel demand reductions of up to 30 percent from this pricing could add substantial increases to passenger train ridership. Finally, county and municipal land use plans and associated zoning codes should be revised to reflect transit supportive, clustered development that increases population and employment densities around rail stations.

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