Benefit-Cost Analysis Guidance for Rail Projects

Federal Railroad Administration

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Acronym List

AASHTO	American Association of Highway Transportation Officials
AIS	Abbreviated Injury Scale
BCA	Benefit-Cost Analysis
BEA	Bureau of Economic Analysis
BTS	Bureau of Transportation Statistics
CH_4	Methane
CO_2	Carbon Dioxide
CPI	Consumer Price Index
CS	Consumer Surplus
dBA	Decibels
DOT	United States Department of Transportation
ECP	Electronically Controlled Pneumatic
EPA	Environmental Protection Agency
FAST	Fixing America's Surface Transportation Act
FASTLANE	Fostering Advancements in Shipping and Transportation for the Long-term Achievement of National Efficiencies
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
G&A	General and Administrative
GDP	Gross Domestic Product
GHG	Greenhouse Gas
ITIC	Intermodal Transportation Cost Model
N_2O	Nitrous Oxide
NOFO	Notice of Funding Opportunity
NO_x	Nitrous
NPV	Net Present Value
O&M	Operating and Maintenance
OBS	On-board Services
OIG	Office of the Inspector General
OMB	Office of Management and Budget
PDO	Property Damage Only
PM	Particulate Matter
PTC	Positive Train Control
ROW	Right-of-Way
SCC	Social Cost of Carbon
SO_2	Sulfur Dioxide
SOGR	State of Good Repair
YOE	Year-of-Expenditure Dollars
STB	Surface Transportation Board
TIGER	Transportation Investment Generating Economic Recovery
U.S.	United States of America
VOC	Volatile Organic Compounds
VSL	Value of a Statistical Life
VTTS	Value of Travel Time Savings

1. Overview and Background

This guidance document is intended to provide a consistent approach for completing a benefit-cost analysis (BCA) for passenger and freight rail project proposals. The systematic process of identifying, quantifying, and comparing expected benefits and costs helps decision-makers organize information about, and evaluate trade-offs among, alternative transportation investments.

A BCA compares the anticipated benefits that accrue from a project to the anticipated costs of the project over a specified period of time. A BCA looks at project benefits that accrue to both direct users (e.g., rail passengers or freight rail shippers) and non-users (e.g., society at large), as well as the costs required to achieve a project's expected outcomes. Benefits could include such factors as improved safety, air quality, mobility, or transportation system connectivity, while costs should include the capital, operating, and maintenance expenses necessary to deliver the project benefits.

In addition to serving as a valuable tool for defining and narrowing investment alternatives, BCAs are also increasingly a prerequisite to receive financial assistance under Federal investment programs, including those administered by the Federal Railroad Administration (FRA). The two competitive railroad infrastructure improvement grant programs authorized in the Fixing America's Surface Transportation (FAST) Act, Public Law 114-94 (December 4, 2015), specifically require the Secretary of Transportation to take into account cost-benefit analysis as a project selection criterion (Section 11301, Consolidated Rail Infrastructure and Safety Improvements; and Section 11302, Federal-State Partnership for State of Good Repair).[1] In addition, two grant programs administered by the Office of the Secretary of Transportation that contain rail project eligibilities – the Transportation Investment Generating Economic Recovery (TIGER) program and the Fostering Advancements in Shipping and Transportation for the Long-term Achievement of National Efficiencies (FASTLANE) program – either require or request (depending on the size and other characteristics of the project) a BCA as part of the grant application process.

While BCA is just one of many tools that can be used in making decisions about infrastructure investments, FRA believes BCAs provide a useful benchmark from which to evaluate and compare potential transportation investments. As Federal funding for passenger and freight rail investments becomes available, FRA will expect project sponsors to provide BCAs that are consistent with the methodology outlined in this guidance as part of their justification for seeking Federal support. Additionally, FRA encourages project sponsors to incorporate this BCA methodology into any relevant planning activities, regardless of whether the sponsor is seeking Federal funding.

[1] "Benefit-cost analysis" and "cost-benefit analysis" are interchangeable names for the same process of comparing a project's benefits to its costs. FRA and other operating administrations of the U.S. Department of Transportation use "benefit-cost analysis" to ensure consistent terminology and because one widely used method for ranking projects, is the benefit-cost ratio.

This guidance:

- Describes a methodological framework that is acceptable to FRA for purposes of preparing BCAs for passenger and freight rail projects;
- Identifies common data sources, values, and additional reference materials for various BCA inputs and assumptions; and
- Provides the necessary equations and illustrative calculations to assist project sponsors in preparing many of the quantitative elements of a BCA.

BCAs can vary greatly in complexity and workload from one project to the next. The minimum requirements for a BCA will be dependent upon multiple factors, including the type of project proposed, the development stage of the project, and the cost of the project. FRA will provide additional guidance to project sponsors on minimum BCA requirements specific to individual financial assistance programs in a program's Notice of Funding Opportunity (NOFO) announcement.

This guidance describes a number of areas that may be useful to consider in BCA, but for which the United States Department of Transportation (U.S. DOT) has not yet developed formal guidance on recommended methodologies or parameter values. Future updates of this guidance will include improved coverage of these areas as research on these topics is incorporated into standard BCA practices.

2. Statutory and Regulatory References

Section 11313(b) of the FAST Act requires the Secretary of Transportation to "enhance the usefulness of assessments of benefits and costs for intercity passenger rail and freight rail projects," including providing guidance, training, and consistent requirements to potential applicants and project sponsors. FRA drafted this guidance to be consistent with the BCA guidance established by the U.S. DOT, which applies to a wide range of surface transportation projects (e.g., highways, transit, rail, ports) under the TIGER and FASTLANE grant programs.[2] This FRA BCA guidance provides greater granularity and specificity to benefit and cost issues associated with passenger and freight rail projects.

The FRA will consider benefits and costs using standard data and qualitative information provided by applicants and project sponsors, and will evaluate applications and proposals in a manner consistent with Executive Order 12893 (Principles for Federal Infrastructure Investments, 59 FR 4233), the Office of Management and Budget (OMB) Circular A-94 (Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs), and OMB Circular A-4 (Regulatory Analysis). FRA encourages project sponsors to familiarize themselves with these documents while preparing a BCA.

[2] For information on the Department's BCA guidance (applicable to both the TIGER and FASTLANE programs), please see: https://www.transportation.gov/office-policy/transportation-policy/benefit-cost-analysis-bca-resource-guide.

3. General Principles

To determine if project benefits justify the project costs, a project sponsor should conduct an appropriately thorough BCA. A BCA estimates the net benefits (benefits minus costs) over a specified time period. The benefit-cost ratio (benefits divided by the costs) is also an important metric; projects that yield positive net benefits have a ratio greater than one. However, as OMB Circular A-4 mentions, the benefit-cost ratio can sometimes produce misleading results, and is only one of many useful tools that a project sponsor can use to help choose among competing uses of resources. Where a project sponsor's investment budget is limited (and all other project evaluation factors are otherwise equal), a project sponsor should normally accord preference for funding to those projects with the highest benefit-cost ratios (provided the ratio for those projects exceeds one), since doing so will maximize the benefits a project sponsor can obtain from its limited resources.

To develop a BCA, project sponsors must quantify and monetize all potential costs and benefits of a project. Some benefits (or costs) may be difficult to capture or may be highly uncertain. If a project sponsor cannot monetize certain benefits or costs, it should attempt to quantify them using the physical units in which they naturally occur. When a project sponsor is unable to either quantify or monetize the benefits, the sponsor should describe the benefits qualitatively.

In this guidance document, FRA provides recommended nationwide average values to monetize common benefits from transportation projects. FRA recognizes that in many cases, project sponsors may have additional local data that is appropriate for use in evaluating a given project. FRA supports analyses that blend these localized data with national estimates or industry standards to complete a more robust analysis where those local values are reasonable and well-documented. FRA also describes standard methodologies developed by U.S. DOT that project sponsors may use to complete a BCA.

The following section outlines general principles of BCA that project sponsors should incorporate.

3.1. Discounting

BCAs use discounting to express benefits and costs that occur at different points in time in comparable terms. Discounting adjusts for the time value of money, and allows for benefits and costs to be valued in equivalent units—called present values—that are independent of when they occur. The time value of money expresses the principle that costs and benefits that occur sooner in time are more highly valued than those that occur in the more distant future. FRA recommends that project sponsors follow OMB Circular A-94, which recommends as its base case discounting future benefits and costs using a real discount rate (i.e., the discount rate net of the inflation rate) of 7 percent per year (see Section 3.5 below). To illustrate the sensitivity of its results to discounting, the BCA should also provide an alternative analysis using a real discount rate of 3 percent. The following formula should be used to discount future benefits and costs:

$$PV = \frac{FV}{(1+i)^t}$$

Where PV = Present discounted value of a future payment from year *t*

FV = Future value of payment in real dollars (i.e., dollars that have the same purchasing power as in the base year of the analysis, see the next section for further discussion on this topic) in year *t*

i = Real discount rate applied

t = Years in the future for payment (where base year of analysis is t = 0)

For example, the present value in 2014 of $5,200 real dollars (i.e., dollars with the same purchasing power as in the 2014 base year) to be received in 2020 would be $4,355 if the real discount rate (i.e., the time value of money) is three percent per annum:

$$PV = \frac{\$5{,}200.00}{(1+0.03)^6}$$
$$= \$4{,}354.92$$

If the discount rate is estimated correctly, a person given the option of either receiving $5,200 in 2020 or $4,355 in 2014 would be indifferent as to which he or she might select. If the real discount rate were actually 7 percent, the present value of the $5,200 sum would be only $3,465. It should be clear from the formula above that as the discount rate increases, the present values of future benefits or costs will decline significantly. Further reading and examples on discounting may be found in OMB Circulator A-94 and OMB Circular A-4.

3.2. Converting Nominal Dollars into Real (Constant) Dollars

The discussion above and throughout this document focuses on real dollars, also known as constant dollars. As noted, a real dollar has the same purchasing power from one year to the next. In a world without inflation, which erodes the purchasing power of dollars from year to year, all current and future dollars would be real dollars. However, due to the effects of inflation, $1,000 dollars in 2018 will be expected to buy fewer goods of the same average quality than would $1,000 dollars in 2014. Dollars that have not been adjusted to reflect the effects of inflation are called nominal dollars. Although BCA can be done in either real dollar or nominal dollars, FRA recommends using real dollars and real discount rates because future inflation rates are difficult to predict.[3]

[3] A nominal BCA will be more labor intensive because the project sponsor will need to predict inflation rates for all years of the analysis period, and ensure that consistent assumptions about inflation are applied to all categories of costs and benefits. Nominal BCA also run the risk of introducing more uncertainty in the analysis due to these predicted inflation rates. FRA will accept nominal BCA if a project sponsor prefers this methodology, however, it is not generally recommended due to its complexity.

Sometimes data obtained for use in BCAs is expressed in nominal dollars from several different years. These dollar amounts can readily be converted into real dollars of a common base year, so that they will measure equivalent purchasing power. OMB Circular A-94 and OMB Circular A-4 recommend using the Gross Domestic Product (GDP) Deflator as a general method of converting nominal dollars into real dollars. The GDP inputs can be found from the U.S. Bureau of Economic Analysis (BEA). The following shows the formula using estimates from the BEA:[4]

$$(Year\ Z\ \$) = (Year\ Y\ \$)x\ \left(\frac{Year\ Z\ GDP}{Year\ Y\ GDP}\right)$$

Example: What is the real value in 2014 of $1,000,000 earned in 2000, measured using the Implicit GDP Deflator?

$$\begin{aligned}(2014\ Real\ Value\ of\ \$1{,}000{,}000\ in\ 2000) &= \$1{,}000{,}000\ x\ \left(\frac{112.7}{81.9}\right) \\ &= \$1{,}376{,}068\end{aligned}$$

The GDP Deflator captures the changes in the value of a dollar over time by considering changes in the prices of all goods and services in the U.S. economy.[5] While in most cases this adjustment is sufficient for a BCA, in some circumstances, other deflators may be more appropriate. Other commonly used deflators include the Bureau of Labor Statistics' Consumer Price Index, which measures changes in prices paid for goods and services purchased by urban households. The project sponsor should document which deflator they use.

3.3. Analysis Period

The selection of an appropriate analysis period is a fundamental consideration in any BCA. Many transportation projects involve large initial capital expenditures, while their resulting benefits continue over many years. To capture this dynamic, the selected analysis period should encompass the full construction period—including all phases of a multi-phase project or program—and a subsequent operational period during which the on-going service benefits and any recurring costs are realized. Normally, this operational period corresponds to the expected service lifetime of the infrastructure or other assets comprising a project. The FRA recommends that the analysis period of a BCA consist of the full construction period of the project, plus at least 20 years after the completion of construction during which the full operational benefits and costs of the project can be reflected in the BCA. This approach is consistent with the BCA guidance issued by the U.S. DOT's TIGER Program, and with the FRA's requirement that its Federal funding recipients ensure that project outcomes achieved with Federal funds are maintained for a minimum of 20 years from the date a project is put in service.

[4] Bureau of Economic Analysis, *National Income and Product Accounts* Table 1.1.9 "Implicit Price Deflators for Gross Domestic Product," (March 2016), (http://www.bea.gov/iTable/iTable.cfm?ReqID=9&step=1).

[5] Note that both the GDP Deflator and the Bureau of Labor Statistics' Consumer Price Index also adjust for changes in the quality of goods and services over time.

Project sponsors may encounter situations where a longer or shorter analysis period is appropriate. For example, if the project's useful life is less than 20 years, a shorter timeframe may be reasonable to demonstrate that benefits are delivered within the useful life period. Conversely, 20 years of operations may be insufficient to provide a full assessment of the benefits of long-term rail assets, such as major structures or tunnels, which are often designed for a useful life of 50 or more years. Another case where a longer analysis period may be appropriate is for large-scale capital programs with multiple construction phases, several distinct project elements with independent utility, and phased implementation of new rail operations. Longer analysis periods may help to capture the full impact of these programs.

However, there is a limit to the utility of modeling project benefits over very long time scales. General uncertainty about the future, as well as specific uncertainty about how travel markets and patterns may shift or evolve, means that predictions over an exceedingly long term begin to lose reliability and perhaps even meaning. Additionally, in a BCA, each subsequent year is discounted more heavily than the previous year, and thus each subsequent year is less and less likely to impact the overall findings of the analysis. For these reasons, FRA recommends that project sponsors generally avoid analysis periods extending beyond 40 years of full operations. Instead of extending the analysis period indefinitely, project sponsors should establish their reasonable horizon year and then consider an assessment of the value of the remaining asset life in situations where project assets have useful lifetimes that continue beyond the end of the analysis period (as described below in Section 6.3).

Project sponsors should clearly state the calendar or fiscal year to which the initial year of the analysis period corresponds. Often this initial year is also the initial year used for the baseline or base case (as described below in Section 3.5). The end, or horizon, year of the analysis period should also be clearly identified. Project sponsors can also establish a project year timeline, which is often helpful to explain the timing of key project milestones or service implementations. In addition, specifying a year-by-year project timeline will enable the BCA to recognize changes in benefits or recurring project costs during the project's lifetime.

For example, a BCA may have a 30-year analysis period, spanning the calendar years of 2010 to 2040. Thus, the initial year, and initial project year, is 2010, and the horizon year is 2040. Key project year milestones could include a five-year construction period, with full operations beginning at project year six and continuing through the horizon year.

3.4. Benefit-Cost Analysis vs. Economic Impact Analysis

A common mistake when developing a BCA occurs when project sponsors conflate economic *impacts* with economic *benefits*. A BCA measures the value of a project's benefits and costs to society, while an economic impact analysis measures the impact of increased economic activity within a region. Common metrics for measuring economic impacts include retail spending, business activity, tax revenues, jobs, and property values. Economic impact analyses often take a strictly positive view, (i.e., increased jobs, spending) and do not examine how the resources used for a project might have benefitted alternative societal uses of the resources (i.e., they do not assess the net effect to society).

For example, an economic impact analysis views the initial investment in infrastructure as a stimulus to the local economy, rather than as a cost to the local government. In addition, economic impact analyses typically use a regional perspective, while BCA uses an economy-wide or "societal" perspective. Positive impacts in one region may be accompanied by offsetting losses in a neighboring region, reflecting a transfer of spending or jobs that may be a net neutral summation. Similarly, increases in jobs in one industry could reflect a decrease in jobs in a different industry. By contrast, BCAs estimate first order net benefits that result from transportation projects by accounting for losses, costs, cost savings, benefits, and transfers of transportation time savings, investment costs, improved safety, reduced infrastructure maintenance costs, etc. BCA does not quantify second and third order impacts such as jobs or sales that may be generated in part by the first order net benefits. Moreover, second and third order economic impacts typically do not add to the value of first order net benefits measured by BCA, but instead represent impacts into which these first order net benefits are translated as they are transmitted through a complex economy.[6]

Understanding and addressing economic impacts is important to understand how a project may affect a particular economy or region, but this analysis should be done as an independent follow-on exercise after assessing the benefits and costs of a project through a BCA. BCA is the main tool to determine whether a project generates sufficient value to society, measured as positive net benefits, and used to justify spending on a particular program or project. A project with a negative net benefit could generate positive regional economic benefits simply by increasing spending or employment within a specific geographic area while from a national standpoint its overall economic impacts would likely be negative.

3.5. Baseline and Alternatives

Each analysis needs to include a well-defined baseline against which to measure the benefits and costs of a proposed project. A baseline is sometimes referred to as the "do-nothing base case" or "no-build alternative," although it is perhaps more accurately characterized as a "maintain current conditions" scenario. A baseline defines the world without the proposed project. As the status quo, the baseline should consider factors—including future changes—that will affect the project outcome but are not brought on by the project itself and would occur even in its absence.

For example, the baseline needs to reflect the projected economic growth, increased traffic volumes, growing population, and projected passenger traffic and freight shipping flows that would occur regardless of whether the proposed project is implemented.

Many times a BCA will only consider the no action alternative (the baseline) and the proposed project. To complete a thorough BCA, a project sponsor should present and consider several reasonable alternatives to the project that is ultimately proposed. Good candidate alternatives would be projects that target the same goal as the proposed project but achieve the outcome in a different way.

For example, if the proposed project replaces a rail bridge, one reasonable alternative could be restoration of the existing bridge. OMB Circular A-4 recommends that alternatives include a more

[6] Transfers should be identified in a BCA but do not impact the total net benefits.

extreme case and a less extreme case than the proposed project. The FRA generally expects that the BCA should feature the option that offers the highest present value of net benefits as the selected or proposed project. Additional resources on baselines can be found in "Benefit-Cost Analysis Analyses Guidance for TIGER Grant Applications,"[7] OMB Circular A-4, and OMB Circular A-94.

3.6. Transparency and Reproducibility

BCAs should be transparent and reproducible by a qualified analyst with access to only those resources that were available to the project sponsor conducting the BCA. All assumptions, inputs, and outputs need to be clearly outlined, explained to the reader, and documented. As OMB Circular A-4 emphasizes, an analysis should be transparent so that a qualified third party can understand all of its assumptions, reproduce the analysis with the same results, and would be likely to reach the same conclusions. The analysis should also identify any assumptions that heavily influence the results and could change the outcomes if varied. Project sponsors should provide a reference for all data sources and models. Additional information on submission guidelines is found in Section 4 below.

3.7. Uncertainty and Sensitivity Analysis

Most BCAs will include some level of uncertainty attributable to the use of preliminary cost estimates, difficulty of modeling future traffic levels, or use of other imperfect data and incompletely understood parameters. When describing the assumptions employed, BCAs should identify those that are subject to especially large uncertainty and emphasize which of these has the greatest potential influence on the outcome of the BCA.

If key data elements are uncertain, the BCA should include a sensitivity analysis illustrating how its results would change if it employed alternative values for those elements. A simple sensitivity analysis will take one variable and assume multiple valuations of that variable. For example, if the benefits of a particular project rely on an uncertain crash risk reduction, a sensitivity analysis should be done to estimate the benefits under different assumptions of crash risk reduction. The project sponsor should show how the benefits (and corresponding net results) change under assumptions of greater and lesser risk reduction. If several variables are uncertain, a project sponsor may include a broader range of sensitivity analyses or a Monte Carlo simulation, which estimates the net benefits by varying several key inputs at the same time. A Monte Carlo simulation assumes a probability distribution for each uncertain key variable, and then samples repeatedly from each distribution, often repeating this sampling process several thousand times in order to construct a range of potential net benefits.

[7] Available online at: https://www.transportation.gov/policy-initiatives/tiger/tiger-bca-guidance.

4. Submission Guidelines

Project sponsors should submit a complete BCA package and refer to any applicable NOFO for specific guidelines on financial assistance applications. Absent additional guidelines, FRA suggests the following requirements for submitting the BCA. Instructions provided in the NOFO supersede the recommendations provided below.

Each application should include a project narrative, a BCA narrative and summary, and an accompanying spreadsheet of BCA calculations. The project narrative should focus on the scope and characteristics of the project itself (i.e. not the BCA) and include:

Project Narrative

1. Project Description
2. Project Location
3. Project Parties and Specific Responsibilities
4. Total Project Cost, Grant Funds, Other Sources of Funding, and Uses of Project Funds
5. Project Readiness, Technical Feasibility, and Required Permits
6. Project Schedule

The project narrative should also be accompanied by a BCA narrative and summary, which at a minimum should include:

BCA Narrative

1. Executive Summary
    a. Project Description
    b. Major Assumptions
    c. Summarized Benefits
    d. Summarized Costs
    e. Net Benefits
    f. Qualitative Analysis
2. Project Benefits
    a. Monetized Benefits
    b. Qualitative Benefits
    c. Uncertainty Analysis
3. Project Costs
    a. Monetized Costs
    b. Cost Uncertainties
4. Net Benefits

For the BCA narrative, each section should detail all the assumptions, calculations, and results of the BCA. The narrative should provide enough information so that a qualified third party can reproduce the results. The project sponsor should include all data sources in addition to information on how each source feeds into the analysis.

For example, if a project sponsor uses a monetary value for emissions provided by the U.S. Environmental Protection Agency (EPA), and needs to inflate that figure to the current year dollars for the analysis, the narrative should include the information about how the project sponsor calculated the current year dollars (e.g., which inflator it used). The narrative should provide detail on the estimates that include some level of uncertainty, as well as a discussion of how incorporating that uncertainty would impact the results of the BCA. Finally, project sponsors should submit an unlocked Excel workbook for review that includes the underlying calculations used in the BCA. Calculations should not be hard-coded.

The executive summary should provide a high level summary of the key components of the BCA, including the benefits, costs, major assumptions, net benefits, and benefit cost ratio with accompanying discussion. The summary should also include a summary table with the monetized values for each component of the BCA, as shown in Table 1. Project sponsors should include only the benefits and costs that are relevant to the project or program for which they are specifically seeking funds, and should not attribute benefits to the project that are associated with other projects not included in the funding request. The table below includes the most common benefits and costs as discussed in this guidance, but is not an exhaustive list for the types of benefits and costs that could be included in the analysis.

Table 1. Example Net Present Value Of Costs, Benefits and Net Benefits/Ratio (2014 $ Millions)

Benefits	
Travel Time Savings	$1.2
Reliability	Qualitative
Safety	$10.3
Environmental Benefits	$1.3
State of Good Repair	N/A
Total Benefits	**$18.6**
Costs	
Capital Expenditures	$10.1
O&M Costs	$2.0
Renewal/Replacement Costs	NA
Value of Remaining Assets	-$1.2
Total Costs	**$10.9**
Net Benefits/Ratio	
Net Benefits	**$7.7**
Benefit Cost Ratio	**1.7**

5. Benefits

Benefits are the economic value of positive outcomes that are reasonably expected to result from the implementation of a project, which can be experienced by users of the transportation system or the public at-large. Benefits accrue to the users of the transportation system as a result of changes to the characteristics of the trips they make (e.g., trip time reductions). Examples of benefits that accrue to society at large include emissions reductions or transportation safety improvements.[8] In a BCA, benefits are monetized throughout the analysis period and constitute the numerator of the benefit-cost ratio, or the "plus side" of the net benefits calculation.

All of the benefits reasonably expected to result from the implementation of the project or program should be monetized (if possible) and included in a BCA. This section of the guidance document describes acceptable approaches for assessing the most commonly included benefit categories, but it is not necessarily an exhaustive list of all of the relevant benefits for a particular project.

Benefits should be recorded on an annual basis throughout the entire analysis period. In general, benefits only begin to accrue once a project enters regular service.[9] For projects that use a phased implementation, the types and amount of benefits may also phase-in over a period of time as additional portions of the project are completed. Phasing and implementation assumptions made by the project sponsor should be thoroughly described in supporting documentation for the BCA.

Whether by statute or a matter of DOT policy, individual financial assistance programs and funding opportunities may contain eligibility or other requirements regarding the presence or share of project benefits, costs, and Federal funding requests that may be attributed to the public versus private sectors. Please refer to the specific NOFO for program requirements. Within a BCA, it is recommended that project sponsors identify the distribution of benefits and costs among public and/or private entities, considering the sectors that bear the cost of the project in contrast to who realizes the benefits.

Modal Diversion

Improvements to both passenger and freight rail service may increase the utilization of rail travel, both by attracting new passenger trips or freight shipments and by diverting passengers or shipments from competing modes (including highways and aviation). While passengers and shippers who change modes will experience most of the benefits from intermodal shifts prompted by improved rail service, these shifts can also create benefits for users of the modes from which they are drawn.

Freight rail projects that promote shifts from truck to rail may remove some heavily-loaded freight trucks from major highway routes and bridges, while improvements to passenger rail service may reduce the number of automobiles using highways during peak travel periods. Since damages to

[8] Note that some transportation improvements may result in a mix of positive and negative outcomes (e.g., an increase in travel speeds that may be accompanied by an increase in emissions). In such cases, those negative outcomes would be characterized as "disbenefits" and subtracted from the overall total of estimated benefits.

[9] Some infrastructure projects may result in temporary service delays or interruptions during construction. Such impacts could be quantified as disbenefits that accrue during that time period.

pavement and bridge structures caused by heavy trucks and delays caused by heavy traffic are real economic costs, rail improvement projects that draw new passengers or shipments from cars or trucks can provide additional benefits to highway users and public agencies responsible for highway maintenance by reducing these costs.

These benefits, however, will arise only to the extent that such projects successfully divert freight shipments or passenger travel from highways. Moreover, their value is limited to any resulting reduction in the difference between these pavement damage or delay costs and the benefits that truck operators and automobile travelers derive from the highway travel that generates these costs.[10] This difference is often challenging to estimate empirically, and the amount by which it declines in response to reduced travel by heavy trucks or less severe traffic congestion can be particularly difficult to estimate.

Many factors influence trucks' impacts on public agencies' costs for pavement and bridge maintenance, such as their loaded weight, number and spacing of axles, pavement thickness and type, bridge type and span length, volume of truck traffic, and volume of passenger traffic. As a consequence, estimating savings in pavement and bridge maintenance costs that result from projects to improve rail service is likely to be difficult and require detailed, locally specific input data.

Similarly, estimating reductions in delay costs caused by diversion of passenger and freight traffic from highway vehicles to improved railroad services is empirically challenging, usually requiring elaborate models and detailed, geographically specific inputs. Thus, only projects where shifts of passengers or freight shipments from highway vehicles to improved rail service travel can be convincingly demonstrated to be significant, estimated reliably, and documented clearly should consider including reductions in pavement and bridge damage or delay costs among their estimated benefits.

Shifts to rail use from other modes may also provide environmental and safety benefits. Safety benefits would accrue when the rail trip reduces the risk of crashes, injuries, or fatalities when compared to the same trip taken by the original mode of travel. Similarly, environmental benefits would accrue when the comparable rail trip produces fewer emissions of greenhouse gases or other localized air pollutants than the previous method of travel. Both of these benefit categories are discussed in more detail in sections 5.2 and 5.3 below, respectively.

5.1. Benefits to Users of the Transportation System

Often the most substantial and important benefits of a passenger or freight rail project are those that accrue directly to the existing or new users of the rail service. For rail trips, users experience both time costs (e.g., journey duration) and money costs (e.g., fares or fees). Users are often willing to substitute one type of cost for the other: paying a higher fare in exchange for a shorter trip time, for example. Changes in other trip amenities, such as improved ride quality or comfort, or on-board services such as

[10] In economic parlance, the benefits from reducing pavement damage costs and congestion delays are limited to the value of the reduction in "welfare costs" or "dead-weight losses" they caused. The value of such welfare losses is measured by the excess of pavement damage or delay costs over the value that truck and automobile users who are responsible for those costs receive from the highway use that generates them.

wireless internet or food and beverage service, may also impact users' perceived cost of travel, making rail a more attractive mode of transportation.

When passengers and shippers make use of the transportation system, they are indicating that the perceived benefits of the trip are at least as great as their perceived costs of making the trip. Before proceeding to a discussion of benefits to users of rail services, however, it is important to clarify the economic treatment of fares and fees.

Treatment of Fares and Freight Fees in BCA

Virtually all users of railroad transportation pay for the use of this service through fares (for passengers) and fees (for shippers). In many instances, it seems natural to include changes in those charges as costs of a project, and the increased revenues they represent for operators of rail service as a benefit. In fact they represent exactly offsetting impacts of a transfer of resources from users to operators, and thus do not affect overall economic welfare. As a consequence, viewing fares and fees from the exclusive perspective of either users or operators of rail service and identifying changes in their total value as benefits or costs of improving that service in a BCA is usually incorrect.

Fares, fees, tolls, taxes, and other user charges for transportation projects constitute important potential revenue sources to public and private entities for financing transportation projects. However, these revenue sources are not "benefits" of a project as measured by BCA. Rather, these charges represent a mechanism by which some of the benefits to users of rail projects (e.g., the value they assign to improvements in the efficiency, safety, and convenience of rail travel) can be transferred in whole or in part (in the form of cash payments by the users) to the public or private entity that operates the improved rail service or facility. Similarly, the rail operator could transfer savings it receives from a project (e.g., lower operating and maintenance costs) to users by reducing passenger fares or fees it charges to shippers. Because changes in fares and fees are transfers of the value of real benefits (e.g., travel time savings) and costs (e.g., construction costs) from users to operators of improved rail services, adding changes in fare and fee revenues to the value of changes in travel time, reliability, safety, vehicle operating cost, etc., caused by the project would represent a double counting of benefits or costs.

Nevertheless, when changes in fares or fees are proposed for a project, the BCA process must account for the effect of such charges on the use of the improved facility or service. In particular, the payment of an increased fare transfers the value of some of the time saving or other user benefits caused by a project from the traveler to the facility operator, thereby reducing the net value of benefits realized by the traveler. Consequently, such a fare increase would cause some travelers to use the improved facility less often than if the fare were not increased, reducing future trips on the facility compared to the level that would result from the service improvement alone. This impact must be considered when conducting ridership or freight volume projections for a project.

Revenues from fares, fees, tolls and taxes must also be considered when evaluating a project's financial feasibility (which is different than the economic efficiency measured by BCA). Financial analysis measures whether the improvement can be funded through a combination of revenues, grants, interest rate subsidies, and tax credits to pay for its development and operation. This financial evaluation is important to determine whether the improvement can be funded, but does not demonstrate or disprove its economic merit. Similarly, it will help reveal if the project can be built and operated by a private sector vendor, or through a public-private partnership, without additional public subsidy.

Overview of Rail Service Improvements

The amount and type of user benefits in a BCA depends on the estimated market response to the set of service improvements implemented by a project. A wide variety of service improvements might impact demand. For example, rail service improvements could include, but are not limited to:

- Reduced trip times
- Improved reliability
- Increased frequency
- Improved stations, facilities or equipment
- Enhanced passenger amenities (e.g., ride comfort, accessibility for all passengers, food/beverage offerings, internet or entertainment options)

Other external factors, such as marketing campaigns, changes in consumer/shipper preferences, reductions in the utility of other travel options, or fluctuations in energy prices, may also impact demand for rail services. Of course, many of these potential service improvements are closely linked to one another—new rolling stock may provide faster trips while simultaneously improving ride comfort and adding universal accessibility.

In practice, this variety of factors can make estimating the demand response for passenger and freight rail services complex and challenging. Project sponsors of passenger train services may be able to estimate ridership increases (i.e., increased demand) based on past experience with changes to fares, trip times, or other factors. Sponsors may also be able to use or develop market data, such as traveler surveys. Freight operators have access to extensive market data showing changes in demand associated with higher or lower freight rates and delivery times, as well as experiences with comparable track or facility improvements (e.g., adding a second track on a corridor) that enable them to reliably estimate changes in shipping times and costs. Freight railroads can also be a source of information on potential train service improvements and reduced costs associated with projects on track that carry both freight and passengers.

For some projects that involve rail interactions with highway vehicles and pedestrians, such as highway-rail grade separation projects, use of travel demand models or traffic simulation models may be required to capture the full benefits of a project. Such benefits will include benefits to rail users as well as automobile and truck traffic which will no longer have to wait at crossings, or will benefit from reduced road congestion due to removal of automobile trips. These projects often also provide safety and emissions benefits, which are described elsewhere in this guidance.

In all cases, the project sponsor should carefully document the method used to estimate changes in demand and associated benefits to users. Additional guidance about important types of service benefits— travel time savings and reliability— is discussed in the next two sections.

Value of Time Savings

Estimation of time savings from a railroad improvement will depend on engineering calculations and a thorough understanding of how the improvement will affect traffic flows. Such improvements may reduce the time that rail freight and passengers spend in transit (including wait times). These in turn may also impact the travel times of automobile passengers and truck freight, which may be able to flow more efficiently due to grade separations or reduction of vehicular congestion due to the diversion of some passenger or freight movements to rail. Similarly, reliability and other benefits from rail improvements can be translated into hours of time saved, as discussed below.

The FRA follows the U.S. DOT's published guidance on the appropriate value of travel time savings (VTTS) for use in evaluating the benefits of transportation infrastructure investment. The Department's Office of Policy in the Office of the Secretary of Transportation updates this guidance on an annual basis. Project sponsors preparing a BCA should read this guidance document for an important discussion about the appropriate application and potential limitations on value of travel time savings research. [11]

The current recommended values, presented in dollars per person-hour, are reproduced as Table 2 in this document.[12] In addition, the U.S. DOT VTTS guidance provides plausible ranges for these values. Project sponsors should use the values from Table 2 as the default or standard, and may use the ranges for sensitivity testing or scenario analysis. Project sponsors should reference the most recent U.S. DOT-guidance for the most recent estimates for travel time.

Selecting the appropriate value(s) requires the project sponsor to specify the trip category (local or intercity travel) and the trip purpose (personal or business). Local travel generally applies to shorter trips contained within a single metropolitan area, such as those on commuter rail, that are usually less than 50 miles in length. Intercity travel includes trips longer than 50 miles, such as those on intercity passenger rail service. If the shares of personal and business travel are not known in a specific market, project sponsors may use the "all purposes" values as their VTTS category.

Travel mode also affects the selection of the appropriate VTTS. U.S. DOT guidance recommends treating all conventional surface modes (e.g., auto, bus, fixed-guideway rail, conventional intercity passenger rail, commuter rail) with the uniform values given below. These modes are viewed as relatively close substitutes in location, purpose and trip distance, and thus travelers using these modes are likely to have similar distributions of incomes and preferences. However, air and high-speed rail travel are not likely to act as close substitutes to the conventional surface modes.[13] U.S. DOT guidance indicates that users of air and high-speed rail are charged higher fares for travel and express a correspondingly higher

[11] U.S. Department of Transportation Department of Policy, *Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis* https://www.transportation.gov/resources/revised-departmental-guidance-valuation-travel-time-economic-analysis.

[12] Table 2 is included in the November 2016 update to the Department wide benefit-cost analysis resource guide, available at: https://www.transportation.gov/office-policy/transportation-policy/benefit-cost-analysis-bca-resource-guide.

[13] High-speed rail travel is defined as rail travel with operating speeds of 125 mph or greater and conventional intercity rail is defined as rail travel with operating speeds below 125 mph.

preference for travel time savings. Thus, the value for travel time savings in these modes reflect the higher incomes and value placed on travel time savings by these users.

Table 2. Recommended Hourly Values of Travel Time Savings (2015 U.S. $ per person-hour)

Category	Surface Modes (except High-Speed Rail)	Air and High-Speed Rail Travel
Local Travel		
Personal	\$13.60	N/A
Business	\$25.40	N/A
All Purposes	\$14.10	N/A
Intercity Travel		
Personal	\$19.00	\$36.10
Business	\$25.40	\$63.20
All Purposes	\$20.40	\$47.10

Value of Time Savings Example Calculation

An intercity rail corridor is being improved to allow for a time savings of 12 minutes between a particular origin and destination pair. Current intercity rail demand between the two cities is 100,000 trips per year for all trip purposes, and the project sponsor estimates that demand will increase to a total of 110,000 trips per year after the project is implemented.

Existing passengers experience the full 12 minutes (0.2 hours) of travel time savings, as follows:

$$\begin{aligned} VTTS(existing) &= Value\ of\ time\ x\ Change\ in\ trip\ time\ x\ Affected\ trips \\ &= \frac{\$20.40}{hr} x\ \ 0.2\ hr\ x\ 100{,}000\ trips/year \\ &= \$408{,}000/year \end{aligned}$$

Project sponsors should repeat this calculation for each of the relevant trip markets along the corridor. The sum of the trip time savings across all origin and destination pairs provides the total trip savings to existing passengers.

In some cases, trip time savings (and/or reductions in fares) would be expected to attract new passengers or shippers using rail services. New passengers (or shippers) will generally not experience a comparable value of trip time savings on a per passenger basis, since they only start using the rail service once the shorter trip time is available. Thus, some portion of the trip time savings was necessary to attract that passenger to the rail mode from another mode, or to encourage the passenger to make a new trip they previously would not have made. A straightforward assumption is that new passengers were attracted equally by each additional increment of trip time savings, with the first additional passenger realizing almost the full value of benefits as pre-existing passengers, and the last new passengers switching to rail realizing only a small share of the overall benefits of the pre-existing passengers. That is, an equal number of new passengers were attracted by the first minute of savings as by the twelfth, with each new increment experiencing a diminishing share of net benefits. In this case, new passengers will on average value the time savings resulting from the service improvement at one-half of its value to existing passengers.

$$
\begin{aligned}
VTTS(new) &= Value\ of\ time\ x\ \frac{1}{2}\ x\ Change\ in\ trip\ time\ x\ Affected\ trips \\
&= \frac{\$20.40}{hr} x\ \frac{1}{2}\ x\ 0.2\ hr\ x\ 10{,}000\ trips/year \\
&= \$20{,}400/year
\end{aligned}
$$

Project sponsors should also repeat this calculation for each of the relevant trip markets along the corridor. The sum of the trip time savings across all origin and destination pairs provides the total trip savings to new passengers. Total VTTS is then the sum of the $VTTS_{(existing)}$ and $VTTS_{(new)}$, or $428,400 annually in the simplified example above.

Value of Reliability

Reliability refers to the predictability and dependability of train service. Highly reliable service may offer rail operators non-schedule benefits such as more efficient fleet use, thereby reducing the need for equipment. For passenger rail, reliable service is often viewed as a necessary condition for rail to be widely used by travelers. Passengers may choose a slower, but more reliable, trip over a trip that may be faster—but also frequently delayed. Improving the reliability of one type of rail service in a corridor may also produce benefits for other rail operators that share the corridor. Improvements to reliability are equally important in freight rail, as the predictability of shipment arrival times is vital to modern supply chain logistics. As part of public and stakeholder outreach conducted by the FRA during its passenger rail planning efforts, the FRA has found that participants uniformly value reliability of service as either the most important, or one of the most important, aspects of the quality of service of proposed passenger rail projects.

Although improving service reliability clearly increases the attractiveness of rail services, estimating its discrete quantitative value in a BCA can be challenging. Users may have significantly different preferences for different trips and for different origin and destination pairs. How people value reliability may relate more to how highly they value uncertainty in arrival times or the risk of being late than to how they value trip time reductions. Thus, assessing the value of improving reliability is more complex than valuing trip time savings and a perfect assessment in a BCA is unlikely.

Improving reliability will also provide other cost savings to passenger and freight rail operators. Passenger operators may see increased fleet and labor utilization due to a reduction in unscheduled delays and the emergency repairs that cause such delays. Right-of-way owners may also see reduced costs for on-going track maintenance as a consequence of the improved condition of the railroad and the retirement of obsolete parts.

Reliability is also an important element of freight rail service, because it affects the inventory costs shippers bear for maintaining the continuity of stocks to supply for manufacturing processes. More reliable delivery schedules also reduce inventory costs for retailers who must hold stock to meet fluctuations in customer demand. Maintaining stock for production or for customer demand can also force rail users to add to physical capacity to accommodate larger inventories, including investment in warehouses. Projects that increase the reliability of freight rail shipments could lower costs throughout the supply chain, thereby increasing the efficiency of freight movements.

However, improving the reliability of shipment delivery times is what provides value to shippers, and achieving this depends on wide-scale implementation of more reliable running times; it matters little to a shipper that a shipment traveled with great reliability over only a portion of its overall route.

If project sponsors have sufficient data about these cost reductions for either passenger or freight systems, the reductions can be included as a benefit in the BCA. However, it must be acknowledged that accurate data of this type are difficult to assemble, and will vary greatly based on the cargo being moved (e.g., coal versus intermodal shipments). If a project sponsor does not have sufficient data, FRA recommends that reliability benefits be described qualitatively in the BCA until such time as future guidance is issued.

5.2. Safety Benefits

Safety benefits for rail projects occur when a project reduces the likelihood of a derailment or any other type of railroad crash. Benefits can also occur if a project minimizes the severity of any railroad crash, because reducing crash risk or severity will result in fewer injuries and fatalities, as well as less property damage. To claim safety benefits for a project, project sponsors need to clearly demonstrate how a proposed project targets and improves safety. The project sponsor should include a discussion about various crash causation factors addressed by the project, and establish a clear link to how the proposed project mitigates these risk factors. Some examples of rail projects that are likely to generate safety benefits include: improvements to grade crossings (highway-rail, pedestrian-rail, rail-rail and rail-water grade crossings); shifts from alternative modes that involve higher safety risks to their users; and improvements in rail infrastructure or technology that reduce crash risk.

Monetized Values

To estimate the safety benefits from a project that generates a reduction in crash risk or severity, the project sponsor needs to determine the type of crash the project is likely to effect, and the effectiveness of the project by reducing the frequency or severity of such crashes.[14] Severity of prevented crashes is measured through the number of injuries and fatalities, and the extent of property damage. The U.S. DOT provides guidance on the monetized values for the value of reducing accidental fatalities in transportation incidents (the "value of a statistical life", or VSL), injuries, and property damage.[15] These values are summarized below, with corresponding references for additional information. The U.S. DOT recommends converting injuries to the Abbreviated Injury Scale (AIS) in order to monetize the value of reducing them.

[14] Rail crash for these purposes include, but are not limited to, derailments, head-on collisions, raking collisions, and at-grade crossing collisions.

[15] U.S. Department of Transportation Department of Policy, *Guidance on Treatment of the Economic Value of a Statistical Life*, https://www.transportation.gov/office-policy/transportation-policy/2016-vsl-guidance .

Table 3. Recommended Safety Related Monetized Value

<table>
<tr><th>Cost/Benefit Category</th><th>Monetized Value(s)</th><th>Reference and Notes</th></tr>
<tr><td>Value of a Statistical Life (VSL)</td><td>$9,600,000 per fatality ($2015)</td><td>Table 1. Recommended Monetized Values. TIGER Discretionary Grants Benefit-Cost Analysis (BCA) Resource Guide. Available at: https://www.transportation.gov/office-policy/transportation-policy/2016-vsl-guidance</td></tr>
<tr><td>Value of Injuries</td><td><table>
<tr><th>Severity</th><th>Fraction of VSL</th><th>Unit Value ($2015)</th></tr>
<tr><td>Minor</td><td>0.003</td><td>$28,800</td></tr>
<tr><td>Moderate</td><td>0.047</td><td>$451,200</td></tr>
<tr><td>Serious</td><td>0.105</td><td>$1,008,000</td></tr>
<tr><td>Severe</td><td>0.266</td><td>$2,553,600</td></tr>
<tr><td>Critical</td><td>0.593</td><td>$5,692,800</td></tr>
<tr><td>Not survivable</td><td>1.000</td><td>$9,600,000</td></tr>
</table></td><td>Table 1. Recommended Monetized Values. TIGER Discretionary Grants Benefit-Cost Analysis (BCA) Resource Guide. Available at: https://www.transportation.gov/office-policy/transportation-policy/2016-vsl-guidance

Note: Accident data (particularly those provided through law enforcement records) are typically reported as a single number (e.g. “X number of crashes in Year Y”) and/or on the KABCO scale of crash severity. Applicants should convert these values to the AIS scale before applying the recommended monetized values. Guidance is provided in Part II Section 3(“Converting available Accident Data into AIS Data”) of the Department wide BCA resource guide.</td></tr>
<tr><td>Auto Property Damage Only (PDO) Crashes</td><td>$4,198 per vehicle ($2015)</td><td>The Economic and Societal Impact of Motor Vehicle Crashes, 2010 (revised May 2015).

Note: Basis is PDO value of $3,862 ($2010) per vehicle involved in a PDO crash is an updated value currently used by NHTSA and based on the methodology and original 2000 dollar value referenced in The Economic and Societal Impact of Motor Vehicle Crashes, 2010 (revised May 2015), Page 12, Table 1-2, Summary of Unit Costs, 2000”. Also, while the cost of PDO crashes is presented here in 2010 dollars, applicants should convert this value (along with other monetized values presented in this section) to dollars applicable to whatever base year you are using, using the methodology provided earlier in this guidance.</td></tr>
</table>

The FRA's Office of Railroad Safety regularly publishes safety data, including accidents, incidents, and highway-rail grade crossing information on their website.[16] This website allows users to run dynamic queries and to download a variety of safety database files, publications and forms. Safety data can be classified by State, railroad, or type of incident in order to help the sponsor characterize the frequency and types of crashes that a proposed the project is likely to affect.

Example Railroad Safety Projects

Safety benefits can result when a project improves a grade crossing; for example, by removing the grade crossing altogether or increasing the signage, warnings, or other protection measures at the crossing. A project that removes the grade crossing will increase safety at the intersection by eliminating the likelihood of an auto and train crash at that intersection. Similarly, a project that installs flashing lights and gates at a previously unprotected crossing will enhance safety by reducing the likelihood of an auto and train crash at the intersection. Depending on the type of updates, grade crossing projects may also eliminate or reduce pedestrian access to the site, removing or lowering the likelihood of a pedestrian being hit by a train. For example, better signage or increased fencing might deter or prevent pedestrian access. FRA developed an interactive online tool, GradeDec, which assists project sponsors with estimating crash risks at grade crossings.[17] GradeDec estimates the relative risk at multiple crossings such that project sponsors can identify and prioritize higher risk crossings in their regions for potential investment, and can also be used to estimate the effectiveness of different improvements in reducing safety risks.

Technological advancements can also enhance the safety of rail corridors. Some current examples include positive train control (PTC), electronically controlled pneumatic (ECP) brakes, and enhanced tank car standards. For each type of technology enhancement, the project sponsor must develop a direct link between the technology improvement and any resulting safety improvement. The project sponsor should depict how the technology enhances safety, outline the types of crashes the technology aims to prevent, estimate its actual effectiveness in reducing their frequency or severity, and monetize any resulting benefits using the procedures outlined previously.

Example Safety Calculation

To demonstrate how to calculate safety benefits, consider a hypothetical grade crossing project that would grade separate the crossing. For this example, the project would eliminate 100 percent of the risk associated with rail-auto crashes (as well as provide other ancillary benefits with regard to surface congestion). To determine the safety benefit, the project sponsor should estimate a baseline crash risk (the existing conditions risk) to measure the risk reduction of the project.

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[16] Railroad safety statistics can be found at: http://safetydata.fra.dot.gov/OfficeofSafety/default.aspx.

[17] GradeDec can be found at: https://gradedec.fra.dot.gov/. FRA may also provide additional support to project sponsors who wish to use the program.

Depending on the project site and the frequency of crashes, this can be done in several ways. One strategy is to determine the historical crash rate and assume that it would remain constant in the absence of the proposed project; however, this strategy may not be realistic if the historical crash rate has been changing, and is not effective for high consequence/low probability events or in regions with very few events. The project sponsor may also need to adjust the calculation to take into account changes in the frequency of rail service and expected growth in automobile traffic, among other factors.

For example, if there are 10 crashes per year but the train flow is expected to increase by 10 percent over the next 5 years or automobile traffic is projected to increase, the baseline crash risk may also increase over the next 5 years. The most reliable approach to estimating the baseline risk and its reduction as a consequence of improving a crossing will depend on the location of the project, the objective of the project, and the data available. The project sponsor should document all assumptions on baseline crash risk and risk reduction, and how factors (e.g., population growth, expected changes in service, freight growth) impact the risk under the baseline and with the improvements resulting from a proposed project.

There are three main components to estimating the safety benefits: baseline risk; the reduction in risk expected to result from a project that improves a grade crossing; and the expected consequences posed by those risks. For this example, the FRA will assume that without the project (the baseline risk), the site would experience three collisions between trains and automobiles annually, resulting in an average consequence of one fatality and one minor injury per incident.[18] These fatalities and injuries represent the expected consequences of the baseline collision risk. Because the project removes the grade crossing and thereby eliminates all risk of auto-rail collisions, it also eliminates the expected consequences of that risk. Thus its expected safety benefits include eliminating three fatalities and three minor injuries annually.

The following calculation illustrates the estimated annual safety benefits from removing the grade crossing:

$$\begin{aligned} Safety\ Beneifts &= Baseline\ Risk\ x\ Risk\ Reduction\ x\ Expected\ Consequences \\ &= 3\ crashes/year\ x\ 100\%\ risk\ reduction\ x\ [1\ x\ \$9{,}600{,}000 + 1\ x\ \$28{,}800] \\ &= \$28{,}886{,}400/year \end{aligned}$$

When estimating the benefits, it is important to ensure that units align. For example, if risk reduction is defined on an annual basis, baseline risk should also be expressed on an annual basis. If expected consequences are expressed on an annual rather than a per crash basis, the number of crashes should be omitted from the equation.

5.3. Environmental Benefits

Transportation activities account for roughly one-third of all greenhouse gas emissions produced in the United States annually, and other emissions from transportation vehicles also contribute significantly to

[18] For simplicity, FRA assumes population growth, rail traffic, and highway traffic will remain constant.

localized air pollution.[19] The economic damages caused by changes in the global climate and exposure to air pollution represent externalities because travelers and operators whose decisions generate these emissions do not bear their resulting costs. By lowering these costs, transportation projects that reduce emissions produce environmental benefits. These benefits may result from a variety of actions, including reducing idling or traffic congestion and shifting passengers or shipments to less-polluting modes. In these circumstances, the BCA should quantify and estimate the value of such environmental benefits from a proposed project.[20]

Overview

Both passenger and freight rail projects offer the potential to reduce transportation's impact on the environment by lowering emissions of greenhouse gases and other air pollutants that result from production and combustion of transportation fuels. While comparisons are imperfect, passenger rail (both high-speed rail and conventional passenger rail) generally emit fewer pollutants than air or automobile travel when measured on a per passenger-mile basis, while moving a ton-mile of freight by rail generates lower emissions of greenhouse gases (GHG) than when it is carried by heavy-duty trucks or marine vessels.[21]

Project sponsors claiming these types of benefits should clearly demonstrate and quantify how the project would reduce emissions. Once project sponsors have adequately quantified levels of emission reductions, which can vary based on specific characteristics of a project, including technology, operations, and the equipment used, they should then estimate the dollar value of the resulting health and other benefits.

Valuing Reduced Emissions of CO2, NOx, SO2, PM and VOCs

The economic benefits from reducing emissions of greenhouse gases and local air pollutants are important to quantify. By far the most common greenhouse gas emitted as a result of transportation-related activity is carbon dioxide (CO_2), while the most common local air pollutants generated by transportation are sulfur dioxide (SO_2), nitrous oxides (NO_X) fine particulate matter (PM), and volatile organic compounds (VOC).[22]

The economic values for reducing emissions of various pollutants are based on guidance from the U.S. EPA. The tables below provide recommended values that may serve as a starting point to inform a BCA.

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[19] U.S. Department of Transportation, *Transportation's Role in Climate Change: Transportation and Greenhouse Gas Emissions*, (as of March 2016), (http://climate.dot.gov/about/transportations-role/overview.html).

[20] U.S. Environmental Protection Agency, *Guidelines for Preparing Economic Analyses*, (December 2010) (https://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0568-50.pdf/$file/EE-0568-50.pdf).

[21] The main greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases. For more information on greenhouse gases, refer to: https://www3.epa.gov/climatechange/ghgemissions/gases.html.

[22] Some of these are chemical precursors to local (or "criteria") pollutants that are synthesized during chemical reactions that occur in the earth's lower atmosphere, rather than pollutants themselves.

Table 4 provides data on the dollar value of avoided emissions on short-ton and metric-ton bases, while Table 5 provides greater detail concerning the social cost of carbon on an annual basis through 2050.[23]

If project sponsors wish to include monetized values for additional categories of environmental benefits (or disbenefits) in their BCA, then they should also provide documentation of sources and details of those calculations. Similarly, project sponsors using different values from the categories presented below should provide sources, calculations, and rationale for divergence from recommended values.

Table 4. Value of Avoided Emissions (2015 $)[24]

Emissions Type	$ / short ton	$ / metric ton
Carbon dioxide (CO_2)	(varies by year)*	(varies by year)*
Sulfur dioxide (SOx)	$42,947	$47,341
Nitrogen oxides (NO_x)	$7,266	$8,010
Volatile Organic Compounds (VOCs)	$1,844	$2,032
Particulate matter (PM2.5)	$332,405	$366,414

*Social Cost of Carbon (SCC) (3%) values below

[23] The recommended values for reducing CO_2 emissions reported in Table 5 represent the values of future economic damages that can be avoided by reducing emissions in each future year by one metric ton. They were constructed by discounting the damages caused by its contribution to changes in the global climate from that year through the distant future, using a 3% discount rate. After using these per-ton values to estimate the total value of reducing CO_2 emissions in any future year, the result must be further discounted to its present value as of the analysis year used in the BCA, again using the 3% discount rate (regardless of the rate at which other benefits and costs are discounted in the BCA).

[24] Corporate Average Fuel Economy for MY2017- MY2025 Passenger Cars and Light Trucks (August 2012), page 922, Table VIII-16, "Economic Values Used for Benefits Computations (2010 dollars)" http://www.nhtsa.gov/staticfiles/rulemaking/p df/cafe/FRIA_2017-2025.pdf. The FASTLANE Benefit Cost Resource Guide (https://www.transportation.gov/fastlanegrants/bca-resource-guide) converts these values into 2015 dollars.

Table 5. Social Cost of Carbon (SCC) per metric ton of CO_2[25]

Year	3% SCC (2015 $)
2015	$41
2016	$43
2017	$44
2018	$45
2019	$46
2020	$47
2021	$47
2022	$48
2023	$50
2024	$51
2025	$52
2026	$53
2027	$54
2028	$55
2029	$55
2030	$56
2031	$58
2032	$59

Year	3% SCC (2015 $)
2033	$60
2034	$61
2035	$62
2036	$63
2037	$64
2038	$65
2039	$67
2040	$68
2041	$69
2042	$69
2043	$70
2044	$71
2045	$72
2046	$73
2047	$74
2048	$76
2049	$77
2050	$78

For additional guidance on 3 percent social cost of carbon (SCC) values, refer to the Benefit-Cost Analysis Resource Guide (November 2016), Part II, Section 1 ("Clarification on the Social Cost of Carbon (SCC) Guidance and the Annual SCC Values.")[26]

Environmental Benefits Example Calculation

The U.S. DOT recommends slightly different procedures for estimating the values of benefits from reducing emissions of CO_2 and criteria air pollutants than for other benefit categories. As indicated previously the total value of reducing CO_2 emissions in any future year (the product of the per-ton value for that year and the number of tons of emissions by which a proposed project would reduce emissions during that year) should be discounted to its present value as of the analysis year used in the BCA using a 3 percent discount rate, regardless of the rate used to discount other benefits. For criteria air pollutants, the recommended unit values of reducing emissions remain constant over time, and should be discounted to their present values using the same rate as applied to other costs and benefits. Thus U.S. DOT recommends that project sponsors estimate a project's future benefits from reducing CO_2

[25] U.S. Department of Transportation, *Benefit-Cost Analysis (BCA) Resource Guide (November 2016)*, (https://www.transportation.gov/office-policy/transportation-policy/benefit-cost-analysis-bca-resource-guide; https://www.whitehouse.gov/sites/default/files/omb/assets/inforeg/technical-update-social-cost-of-carbon-for-regulator-impact-analysis.pdf).

[26] https://www.transportation.gov/office-policy/transportation-policy/benefit-cost-analysis-bca-resource-guide

emissions separately from other benefit calculations, discount the resulting estimates at 3 percent, and add these estimates to the project's other benefits after discounting those other benefits to their present values at 3 or 7 percent as appropriate.[27]

An example calculation of from reducing CO_2 emissions using the values reported in Table 5 is shown below in Table 6. In this example, CO_2 emissions increase in the initial years of the analysis when the project is under construction, but decline in later years after it is completed. The total value of changes in CO_2 emissions during each year of the analysis should be discounted to its present value using a 3 percent rate. The resulting series of annual values should then be summed and added to the present values of other benefits from the project, which should be discounted at both 3 and 7 percent rates.

Table 6. Example Calculation using the Social Cost of Carbon (SCC)

	Calendar Year	Tons CO_2 Reduced	3% Social Cost of Carbon	Undiscounted CO_2 Benefits @3% Ave SCC [CxD]	Present Value of CO_2 Benefits @ 3% [E/(1.03^A)]
A	B	C	D	E	F
0	2016	-25	$43	($1,075)	($1,075)
1	2017	-25	$44	($1,100)	($1,068)
2	2018	-25	$45	($1,125)	($1,060)
3	2019	100	$46	$4,600	$4,210
4	2020	100	$47	$4,700	$4,176
5	2021	100	$47	$4,700	$4,054
6	2022	100	$48	$4,800	$4,020
7	2023	100	$50	$5,000	$4,065
8	2024	100	$51	$5,100	$4,026

Benefits from reducing emissions of criteria pollutants should be estimated using the standard benefit calculation; that is, by multiplying the quantity of reduced emissions of each pollutant in various future years by the dollar value of avoiding each ton of emissions of that pollutant. For the example calculation, assume that the project will lower PM2.5 by 10 short tons annually; using the value from Table 6 above, this reduction would result in $3.3 million in benefits annually over its lifetime. Other emissions should be calculated similarly with their respective monetized value.

$$\begin{aligned} PM\ Reduction\ Benefit &= Quanity\ Reduced\ x\ Monetized\ Value \\ &= 10\ short\ tons\ x\ \$332{,}405/short\ ton \\ &= \$3{,}324{,}050/year \end{aligned}$$

[27] Id.

The economic value of reduced emissions during each year of the project's lifetime would then be discounted to its present value for use in the overall BCA evaluation.

5.4. Other Benefits

Agglomeration Economies and Productivity

New or improved rail services that enhance the connections between communities, people, and businesses can reshape the economic geography of a region. The economic theory of *agglomeration* suggests that firms and households enjoy positive benefit spillovers from the spatial concentration of economic activity. These benefits may stem from more effective exchange of information and ideas, access to larger and more specialized labor pools, availability of a wider array of firms and services, or more efficient use of common resources and facilities, such as transport and communications networks or hospitals and schools. Indeed, cities and urban areas developed historically at least in part as a result of people and businesses experiencing positive outcomes from clustering economic activities into what became urban areas.

The FRA recognizes the potential for agglomeration benefits resulting from rail projects that impact the size of the labor market and/or future concentration of economic activity at a location. However, the FRA believes the scale, type, and overall potential for such benefits is highly context- and project-specific, and U.S. DOT has not yet developed guidance on how such impacts might be quantified. Thus, at this time, the FRA is not recommending that project sponsors attempt to quantify such potential benefits in a BCA. Instead, the FRA recommends that project sponsors describe any agglomeration-related benefits in qualitative terms, fully describing their assumptions and discussing the potential limitations regarding potential scale and type of benefits noted above.

State of Good Repair

Ensuring that the U.S. proactively maintains its critical transportation infrastructure in a state of good repair (SOGR) is a key strategic goal of the U.S. Department of Transportation.[28] This goal is coupled with strategic objectives to maintain or improve operating conditions and sustain assets across the transportation system. The FAST Act defined "state-of-good-repair" as "a condition in which physical assets, both individually and as a system, are (A) performing at a level at least equal to that called for in their as-built or as-modified design specification during any period when the life cycle cost of maintaining the assets is lower than the cost of replacing them; and (B) sustained through regular maintenance and replacement programs." The FRA is able to ensure safe operations and influence the infrastructure condition of U.S. railroad assets through on-going inspections and enforcement of safety regulations. Although they remain safe, many railroad assets owned by Amtrak or commuter rail transit agencies face state-of-good-repair challenges due to aging structures and outdated components that hurt reliability and increase maintenance costs.[29]

[28] U.S. Department of Transportation, *Transportation for New Generation: Strategic Plan, FY14-FY18*, (February 2015), (https://www.transportation.gov/sites/dot.gov/files/docs/2014-2018-strategic-plan_0.pdf).
[29] Id.

The benefits of projects that replace, repair, or improve railroad assets to bring them to a state of good repair will typically be captured by the benefit and cost factors discussed elsewhere in this guidance, such as reduced long-term maintenance and repair costs of the assets, enhanced safety, and improved service reliability and quality. In some cases, a project sponsor may wish to highlight these impacts in their BCA as being related to SOGR. For example, while this guidance focuses on the treatment of operating and maintenance on the cost side of the benefit-cost ledger (see section 6 below), an alternative accounting could consider a construction project's impact on reducing ongoing operations and maintenance costs, *relative to the baseline*, as a SOGR benefit of the project.[30] However such impacts are accounted for, what is most important from a BCA perspective is that those costs (or cost savings) are only included once in the analysis.

Resilience

The ability of railroad infrastructure to withstand adverse weather and climate impacts, earthquakes, and threats and vulnerabilities is of great importance to the economic security of the United States. Investments that reduce the risk of loss of service due to these events will become increasingly important, particularly in coastal areas subject to sea level rise or more frequent flooding. Benefits for increasing resilience may be difficult to calculate due to the unpredictable occurrence of disruptive events. Project sponsors can draw on previous experiences with facility outages to calculate the value of reduced infrastructure and service outages, such as costs incurred by commuters and operators when bridges are closed, and include those potential impacts in their estimates of the user benefits associated with the project.

Noise Pollution

Noise pollution is defined as the form and level of environmental sound that is generally considered likely to annoy, distract or even harm people and animals. Noise can affect human health and well-being, reduce productivity and damage the natural environment.[31] Where relevant, project sponsors should consider whether a proposed project will significantly lower levels of noise generated by current transportation activity, as well as the extent to which faster or more frequent rail service will increase noise levels. A project sponsor would have to determine the change in noise level (often measured in decibels or dBA), and whether the change is expected to occur during the daytime or nighttime, as nighttime includes sleep disturbance, which typically has a higher assigned value. Projects that reduce the need to sound train whistles, for instance, can have significant noise benefits.[32]

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[30] Note that when operating and maintenance costs are accounted for in this manner, the cost side of the BCA would simply reflect the costs of implementing the infrastructure improvement.

[31] For example, a study published by the government of the United Kingdom found the annual social cost of urban road noise in England to be of a similar magnitude to road accidents and significantly greater than the impact on climate change. U.K. Department of Environment, Food and Rural Affairs, *Noise Pollution: Economic Analysis*, (April 2013; Updated December 2014), (https://www.gov.uk/guidance/noise-pollution-economic-analysis).

Currently, the U.S. DOT has not developed reliable means to estimate the public value of noise reductions for U.S. projects, and thus recommends that they be dealt with qualitatively in BCA until more definitive guidance on this issue is developed.

Livability

Broadly defined, livability focuses on tying the quality and location of transportation facilities to broader opportunities, such as access to good jobs, affordable housing, quality schools, and safer streets and roads. Incorporating livability approaches into transportation, land use, and housing policies can help improve public health and safety, lower infrastructure costs, reduce combined household transportation and housing costs, reduce vehicle miles traveled, and improve air and water quality, among many other benefits.

As a key initiative supported by U.S. DOT, project sponsors should qualitatively describe any key livability benefits and quantify those benefits where appropriate. Additional guidance on Livability is available on the U.S. DOT website.[33]

Ladders of Opportunity

In recent years, leadership at the U.S. DOT and within the Executive Branch of the Federal government has heightened the focus on transformative projects that create Ladders of Opportunity for local communities. Ladders of Opportunity projects may:

- Increase connectivity to employment, education, services and other opportunities
- Support workforce development and
- Contribute to community revitalization, particularly for disadvantaged groups such as:
    - Low income groups
    - Persons with visible and hidden disabilities
    - Elderly individuals and
    - Minority persons

When addressing Ladders of Opportunity in their BCA, project sponsors should be careful to qualitatively describe any key benefits, and attempt to quantify those benefits where appropriate.[34] Additional guidance on Ladders of Opportunity is available on the U.S. DOT website.[35]

[33] Livability information can be found at: https://www.transportation.gov/livability.

[34] For example, a highway-rail grade separation improvement could increase connectivity by reducing recurring travel delays at grade crossings experienced by members of the local community; such reductions could be valued and quantified.

[35] Ladders of Opportunity information can be found at: https://www.transportation.gov/sites/dot.gov/files/docs/Building_Ladders_Of_Opportunity_To_The_Middle_Class.pdf.

6. Costs

Project costs are the sum of the economic resources required to bring about a project's expected outcomes. Costs represent the inputs of capital, labor, and materials needed for the construction, operation, and maintenance of proposed projects. In a BCA, these costs are usually measured by their market values. The values of resources that would be used in each year of the project's lifetime—initially to construct any capital facilities and acquire equipment, and subsequently to operate and maintain the improved service—are quantified and discounted back to their present value as of the project's base year. This allows all of a project's costs to be expressed as a single sum, which can be deducted from the present value of its benefits to express the present value of the project's net benefits (often referred to as its net present value, or NPV), or used as the denominator of its benefit-cost ratio. Because of the "leverage" that costs exercise on these critical measures of a project's economic performance, BCA outcomes are often quite sensitive to a project's estimated costs. For this reason, it is important for project sponsors to describe any uncertainties in the cost data. If cost data are highly uncertain, project sponsors should perform a sensitivity analysis with the data to determine how this uncertainty could impact the BCA outcomes (see Section 3.7).[36]

Cost data used in the BCA should reflect the full cost of the project(s) necessary to achieve the benefits described in the BCA. Project sponsors should include all costs regardless of who bears the burden of specific cost categories, as well as identify the distribution between public expenditures and privately-borne costs. Cost data should include all funded and unfunded portions of the project when considering all funding sources, even if Federal funding is a relatively small portion of the total project cost.[37] Cost estimates used in a BCA should reflect a lifecycle cost approach, which considers both the initial cost to acquire or construct an asset as well as its on-going operating and maintenance costs, thus enabling analysts to develop a full picture of the total cost of each project asset over its entire useful life.

For example, a lifecycle cost estimate for new rolling stock would include the initial capital expense to procure the equipment, the cost to operate the equipment (including labor and fuel or electric power), and the cost of a routine maintenance program (e.g., preventive maintenance and repairs). Estimates also often include a cost for the replacement or major rehabilitation of each asset if the project is expected to have a long useful life. The operating and maintenance components constitute the "lifecycle" portion of the costs, as they are incurred during the years in which the equipment is anticipated to be in service. Project sponsors must make reasonable assumptions about the expected future costs of consumables (e.g., fuel) and on-going maintenance for equipment, and explain these assumptions when estimating these costs.

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[36] Examples of when costs might be highly uncertain include, but are not limited to: costs estimated at a corridor-wide level, where specific localized data is not incorporated; costs that are highly susceptible to timing fluctuations; or lack of specific data such as geologic or soil data when estimating the cost of tunnel construction.

[37] An exception would be if the BCA is specifically tailored to the costs and benefits of the federally funded portion of a project. This could occur if the federally funded portion provides independent utility that can be sufficiently analyzed for its stand-alone benefits and costs.

Most projects will incur costs in multiple years across the analysis period of the BCA. Costs should be recorded in the year in which they are expected to be incurred, regardless of when payment is actually made for those expenses (such as repayments of any principal and interest associated with financing the project). Project sponsors should take care to ensure that any future year costs are appropriately discounted to the baseline analysis year to allow for comparisons with other BCA elements. Similarly, if the project uses cost estimates developed in earlier years (e.g., a 2013 estimate for expenditures starting in 2016), the 2013 estimate should be adjusted to dollars of the base or analysis year established for the project before being used in the BCA.

Project sponsors may also need to reconcile cost estimates prepared in constant dollars versus costs in nominal or year-of-expenditure (YOE) dollars. YOE dollars are especially useful in developing a project financial plan, for which the sponsor needs to ensure that sufficient funds will be available to cover any project costs at the time they are incurred. Sponsors may need to help legislators and other stakeholders understand that the project will be paid for in nominal dollars, even though the BCA is conducted in real dollars. Project sponsors should clearly identify whether their cost data are in constant dollars or YOE dollars, and also explain any adjustments that are needed to standardize all cost data to the constant year dollars of the BCA.

6.1. Capital Expenditures

The capital cost of a project is the sum of the monetary resources needed to build the project or program and/or acquire the project's assets. Capital costs generally include the cost of all material and labor used in the project's construction. In addition to direct construction costs, capital costs may include costs for project planning and design, environmental reviews, land or real estate acquisition, or transaction costs for securing financing. For large programs that involve multiple discrete projects that are related to one another and are each integral to accomplishing overall program objectives, project sponsors should estimate and report the costs of the various component projects of the program and then sum those projects into a total cost.[38] Capital costs can generally be summarized into one of the following Standard Cost Categories.[39] Depending on the project, it may include costs across all of these categories, or only a few.

FRA Standard Cost Categories[40]:

- Guideway and track elements
- Stations, stops, terminals, and intermodal facilities
- Support facilities: yards, shops and administrative buildings
- Site preparation work, including to address special conditions

[38] It is generally incorrect to lump unrelated projects into a single BCA. Where projects are unrelated to each other and do not impact each other's individual benefit streams, they should be analyzed using separate BCAs.
[39] Project sponsors should also refer to FRA's *Capital Cost Estimating for FRA Grantees* (Not yet published) for additional guidance on capital cost estimation.
[40] FRA's standard cost categories also include Finance Charges; however, such costs would not be appropriate to include in a BCA.

- Systems
- Right-of-way, existing improvements
- Vehicles
- Professional services
- Unallocated contingency

Capital costs are time-series data and should be presented for the entire analysis period of the BCA. Some projects may expend all capital costs in their first few years, while for other projects capital costs may recur throughout most or all of the analysis period. Some projects may have uncertainty about when particular parts of a project would be constructed, and thus when portions of the capital costs would be expended. This could occur in the early stages of project planning (e.g., region-wide or corridor-wide planning efforts) or due to future funding uncertainty, or other factors. In these cases, project sponsors should use their best reasonable estimate for when capital costs would be incurred, and thoroughly describe the assumptions used in assigning these costs. Project sponsors may also consider applying uncertainty or sensitivity analysis to the timing of capital expenditures, to better understand how they affect the overall outcome of the BCA.

6.2. Operating and Maintenance Costs

Operating and maintenance (O&M) costs cover a wide array of costs required on a continuing basis to support core railroad functions. The ongoing O&M costs of the project throughout the entire analysis period should be included in the BCA, and should be directly related to the proposed service plan(s) for the project. Common O&M cost categories include:

- **Train staff and crews**: engineers, conductors, on-board services (OBS), and commissary support
- **Energy**: diesel fuel or electricity needs for train propulsion
- **Stations**: ticket sales, customer information and train dispatching services; utility and maintenance costs for the station building and related facilities (e.g., platforms, parking, landscaping)
- **Rolling stock**: lease payments on equipment[41]
- **Equipment maintenance**: routine planned maintenance of the rolling stock fleet; maintenance or repairs from vandalism and crashes; equipment cleaning
- **Railroad operations and maintenance**: train dispatching and right-of-way (ROW) inspection costs; routine maintenance and repair of track and related infrastructure to ensure safe operation and maintain capacity and track class standards
- **General and Administrative (G&A)**: management, marketing, sales and reservations, legal and finance functions, and all other general office expenses

Project sponsors should describe how they estimated O&M costs for each of these categories, if applicable. Note that the relevant O&M costs are only those required to provide the service levels used

[41] Capital purchases of rolling stock would be included with the project's capital costs; only include any lease payments as an operating cost.

in the BCA benefits calculations. For example, the BCA for a project that expands service frequency on an existing line from three passenger trains per day to five passenger trains per day may look only at the benefits of the additional two new daily trips. In that case, the O&M analysis would assess only the costs of providing those two additional daily departures, and not the cost of all five daily trips. Additional guidance on how to prepare an O&M cost estimate for intercity rail projects is available from the U.S. DOT Office of the Inspector General (OIG) in its report entitled *HSIPR Best Practices: Operating Costs Estimation.*[42]

In addition to ongoing routine maintenance, many assets used in railroad projects may require more extensive rehabilitation and renewal treatments at certain points in their service lives. For example, an asset with a 20-year service life may typically undergo a major mid-life overhaul at year 10, with lesser rehabilitation activities occurring at years 5 and 15. The cost of such activities, sometimes referred to as capital maintenance, should also be accounted for among the operating and maintenance costs of the project.

Operating and Maintenance Costs Example Calculation

To estimate the O&M costs, the project sponsor should include any labor, maintenance, and energy costs, among other items needed to operate and maintain the system. Only O&M costs above and beyond those necessary to sustain the baseline service level should be included. The Surface Transportation Board (STB) provides annual reports that estimate rail wages and track, equipment and other maintenance costs.[43]

For example, to estimate additional labor costs, the Bureau of Labor Statistics Occupational Handbook provides regional wage rates. The 2014 median pay for Railroad workers was $53,670 per year. These calculations can be on an hourly rate or an annual rate. The example below assumes that the project required two additional employees annually. Wage rates do not include fringe benefits offered from the employer (i.e., health care). These benefits may vary based on the type of work (public vs private) and should be added to the wage rate. This example assumes a 1.75 fringe benefit rate, which indicates that employer costs for fringe benefits are 75% of direct wage payments.

$$\begin{aligned} Labor\ Costs &= Number\ of\ Employees\ x\ Wage\ Rate\ x\ Fringe\ Benefit \\ &= 2\ employees\ x\ \$53{,}670\ x\ 1.75 \\ &= \$187{,}845/year \end{aligned}$$

[42] U.S. Department of Transportation, Office of the Inspector General (OIG), *HSIPR Best Practices: Operating Costs Estimation*, (June 2011), (https://www.oig.dot.gov/sites/default/files/files/OIG-HSR-Best-Practice-Operating-Cost-Report.pdf).

[43] Surface Transportation Board, *Industry Data > Economic Data: Financial & Statistical Reports*, (visited April 2016), (https://www.stb.dot.gov/stb/industry/econ_reports.html).

6.3. Asset Replacement Costs and Remaining Asset Life

As noted above, the BCA analysis period should be tied to the expected useful life of the infrastructure constructed or improved by the project. However, many railroad assets are designed for very long-term use, such as major structures (e.g., tunnels or bridges), and thus have an expected life that would exceed any reasonable analysis period for BCA. At the same time, a rail project may also include capital asset components with an expected useful life that is shorter than those of the overall project itself. These differences must be carefully considered when accounting for them in BCA.

For assets with useful service lives shorter than the analysis period, the project sponsor should assume that the asset will be replaced or repurchased, and the full cost of that asset will recur at that time. These costs represent the additional future capital costs that the operator or infrastructure owner would be obligated to spend in order to continue to provide the service improvements and benefits described in the benefits section of the BCA.

Some projects assets may also have remaining service life at the end of the analysis period. This could include both assets with expected service lives longer than the analysis period, and shorter-lived assets that might have been assumed to be replaced within the analysis period.[44] One approach to accounting for such situations in BCA is to net out the discounted remaining value of those assets at the end of the analysis period from the overall cost of the project. This is sometimes also referred to as the *residual value* of the project.

A simple approach to estimating the residual value of an asset is to assume that its value depreciates in a linear manner over its service life.[45] An asset with an expected useful life of 70 years would thus retain half of its value after 35 years in service, while an asset with a 50-year life would retain 30 percent of its value at that point in time.[46] Those residual values would then be discounted to their present value using the discount rate applied elsewhere in the analysis. Also, as noted above, long-lived assets may also require extensive rehabilitation at certain points in their service lives. If such treatments would be projected to occur outside of the analysis period window, then the discounted costs of those activities should also be accounted for as part of the residual value calculation.

Project sponsors interested in applying the residual value methodology in their BCA should detail their useful life assumptions in carrying out these cost estimates, including their reasoning for any expected variations from typical useful life assumptions that reflect project-specific criteria (e.g., local climate conditions, quality of asset used, expected usage levels, etc.).

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[44] For example, an asset might be assumed to require replacement every 20 years. If the analysis period is 30 years, the BCA would have assumed the cost of replacing the asset at year 20, and would have 10 years of remaining service life at year 30.

[45] Other approaches would also be allowed, so long as the methodology used is adequately described and justified in the BCA.

[46] In this example, if the construction period is five years, then the overall analysis period would be 40 years (5 years construction plus 35 years of operation).

7. Net Benefits and Benefit-Cost Ratio

The goal of undertaking a BCA is to determine if the estimated benefits of the project outweigh the estimated costs of the project. Net benefits are defined as the total estimated benefits less the total estimated costs of the project. Because of the need to conduct an "apples to apples" calculation, the aggregation of benefits and costs, and the final calculation, should be conducted after discounting all future benefits and costs to their present values. The sum of the discounted stream of benefits minus costs is sometimes referred to as the net present value (NPV) of the project. A positive value for net benefits indicates that the sum of its quantified benefits exceeds the costs, whereas a negative net benefit indicates that its costs exceed the expected benefits. A project that has a positive net benefit represents an overall positive use of resources. BCAs also provide the ratio between the present value of total benefits and total costs, referred to as the benefit-cost ratio. Both equations are given below:

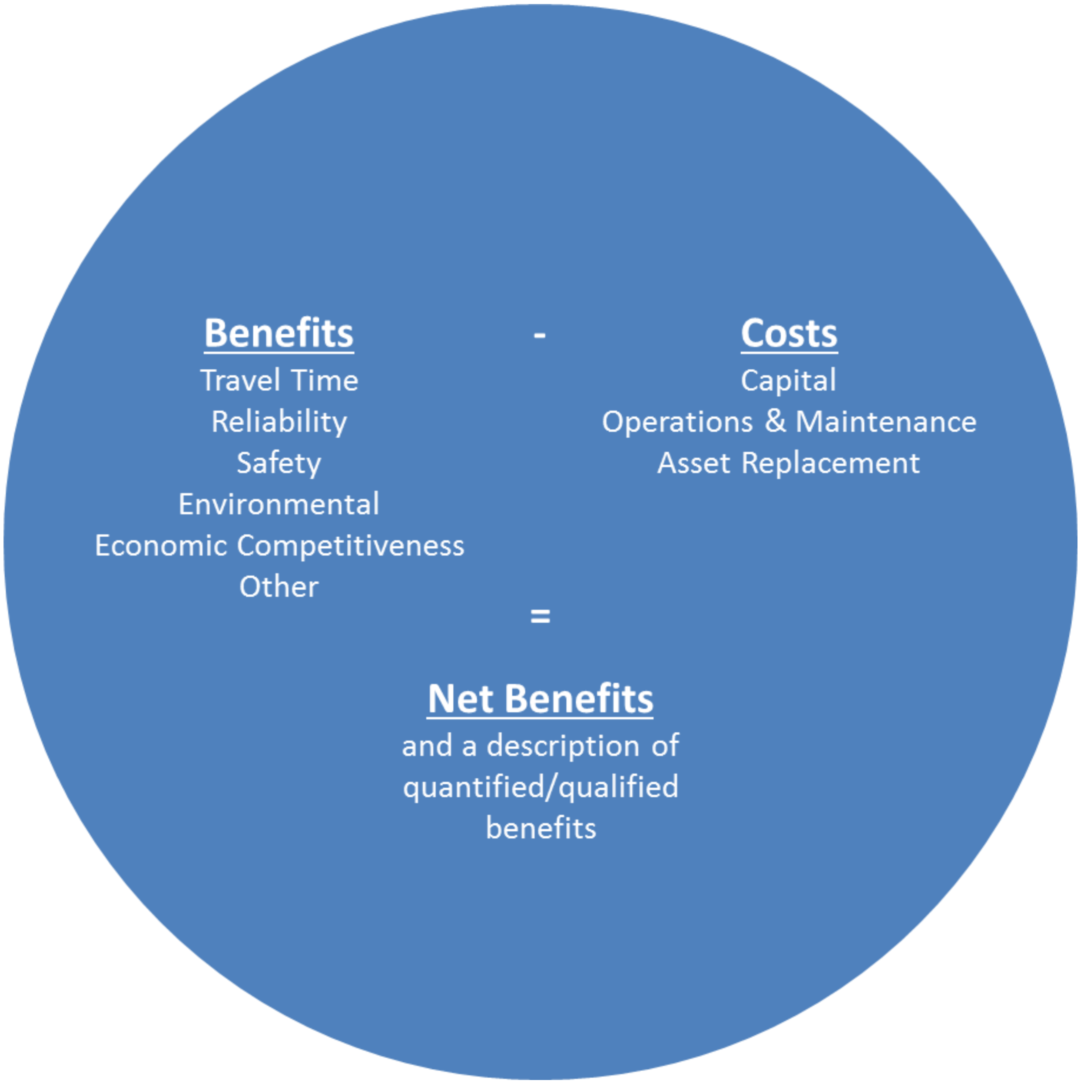
$$\sum(Discounted\ Benefits) - \sum(Discounted\ Costs) = \textit{Net Benefits (or NPV)}$$

$$\frac{\Sigma(Discounted\ Benefits)}{\Sigma(Discounted\ Costs)} = Benefit\text{-}Cost\ Ratio$$

The FRA recognizes that some types of benefits may not be readily expressed as monetary values. Where possible, project sponsors should nevertheless quantify these benefits using physical or other measures to show the full magnitude of expected benefits. If a project sponsor is unable to quantify and monetize the benefits, the project sponsor should include a qualitative description of these benefits.

For projects that do not have a net positive benefit, the FRA expects project sponsors to provide a compelling argument to justify the cost of the project. Project sponsors in this situation should show that the project generates sizable non-monetizable benefits and convincingly demonstrate the societal benefit from these investments.

The diagram below summarizes the net benefits calculation. Not all projects will generate all of the categories of benefits and costs illustrated by the figure; aggregated values should only include those related to the project.


Benefits
Travel Time
Reliability
Safety
Environmental
Economic Competitiveness
Other
-
Costs
Capital
Operations & Maintenance
Asset Replacement
=
Net Benefits
and a description of
quantified/qualified
benefits