Benefit-Cost Analysis Guidance for Discretionary Grant Programs

Office of the Secretary

U.S. Department of Transportation

December 2023

Benefit-Cost Analysis Guidance

Table of Contents

Acronym List **4**

1. Overview and Background **5**

2. What do I Need to Conduct a BCA? **7**

3. Guidelines for Submitting a BCA **8**

4. General Principles **9**

4.1. Baselines and Alternatives 10

4.2. Inflation Adjustments 11

4.3. Discounting 12

4.4. Analysis Period 13

4.5. Scope of the Analysis 14

5. Benefits **15**

5.1. Safety Benefits 15

5.2. Travel Time Savings 17

5.3. Operating Cost Savings 19

5.4. Emissions Reduction Benefits 20

5.5. Facility and Vehicle Amenity Benefits 21

5.6. Health Benefits 25

5.7. Other Benefits 25

5.8. Other Issues in Benefits Estimation 28

6. Costs **32**

6.1. Capital Expenditures 32

6.2. Operating and Maintenance Expenditures 33

6.3. Residual Value and Remaining Service Life 33

6.4. Innovative Technologies and Techniques 34

7. Comparing Benefits to Costs **34**

8. Other Types of Economic Analysis **35**

8.1. Economic Impact Analysis 35

8.2. Financial Impacts 36

8.3. Distributional Effects 36

Appendix A: Recommended Parameter Values **38**

Appendix B: Sample Calculations **52**

Acronym List

BCA	Benefit-Cost Analysis
BCR	Benefit-Cost Ratio
CMF	Crash Modification Factor
CO_2	Carbon Dioxide
dBA	Decibels Adjusted
FEMA	Federal Emergency Management Agency
GDP	Gross Domestic Product
GHG	Greenhouse Gas
MAIS	Maximum Abbreviated Injury Scale
NHTSA	National Highway Traffic Safety Administration
NOAA	National Oceanic and Atmospheric Administration
NO_x	Nitrogen Oxides
NPV	Net Present Value
O&M	Operating and Maintenance
OMB	Office of Management and Budget
PDO	Property Damage Only
PM	Particulate Matter
SO_X	Sulfur Oxide
SOGR	State of Good Repair
U.S.	United States of America
USDOT	United States Department of Transportation
VSL	Value of a Statistical Life
VTTS	Value of Travel Time Savings
YOE	Year of Expenditure

1. Overview and Background

A safe, efficient, and sustainable transportation system is vital to our Nation's economy and the well-being of its people. Infrastructure provides the backbone of that system, and both the public and private sectors have invested substantial resources in its development. Transportation infrastructure also requires ongoing capital improvements to repair, rebuild, and modernize aging facilities and ensure that they continue to meet the needs of a growing population and economy.

This document is intended to provide applicants to USDOT's discretionary grant programs with guidance on completing a benefit-cost analysis[1] (BCA) for submittal as part of their application. The guidance applies to a wide range of surface transportation infrastructure projects in different modes that are eligible under those programs.

BCA is a systematic process for identifying, quantifying, and comparing expected benefits and costs of a potential infrastructure project. A BCA provides estimates of the anticipated benefits that are expected to accrue from a project over a specified period and compares them to the anticipated costs of the project. As described in the respective sections below, costs would include both the resources required to develop the project and the costs of maintaining the new or improved asset over time. Estimated benefits would be based on the projected impacts of the project on both users of the facility and non-users, valued in monetary terms.[2]

USDOT will consider benefits and costs using standard data and qualitative information provided by applicants and will evaluate applications and proposals in a manner consistent with Executive Order 12893 (Principles for Federal Infrastructure Investments, 59 FR 4233), Office of Management and Budget (OMB) Circular A-94 (Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs). OMB Circular A-4 (Regulatory Analysis) also includes useful information and cites textbooks on benefit-cost analysis, if an applicant would like to review additional background material.

While BCA is just one of many tools that can be used to support funding decisions for infrastructure investments, USDOT believes that it provides a useful method to evaluate and compare potential transportation investments for their contribution to the economic vitality of the Nation. USDOT will thus expect applicants to provide analyses that are consistent with the methodology outlined in this guidance as part of their application seeking discretionary Federal support, where required.

This guidance describes a recommended methodological framework for preparing BCAs (see Sections 2, 3, and 4); identifies common data sources, values of key parameters, and additional reference materials for various BCA inputs and assumptions (see Appendix A); and provides sample calculations for some of the quantitative elements of a BCA (see Appendix B). This guidance also describes several potential categories of benefits that may be useful to consider in BCA, but for which USDOT has not yet developed specific guidance on recommended methodologies or parameter values. Future updates of this guidance document

[1] The term "cost-benefit analysis" is sometimes applied to the same process of comparing a project's benefits to its costs. The U.S. Department of Transportation uses "benefit-cost analysis" to ensure consistent terminology and because one widely used method for summarizing the results of an analysis is the benefit-cost ratio.

[2] As described in Section 7 on Comparing Benefits to Costs, however, it may be appropriate to use a slightly different accounting framework than this when comparing the ratio of benefits to costs.

will include improved coverage of these areas as research on these topics is incorporated into standard BCA practices.

Key changes in this version of the guidance include revised discount rates (in accordance with OMB's recently updated Circular A-94); revised values for the social cost of CO_2 emissions; new recommended values for the operating and social costs of train delay; and simplified measures of emission costs per vehicle mile traveled.

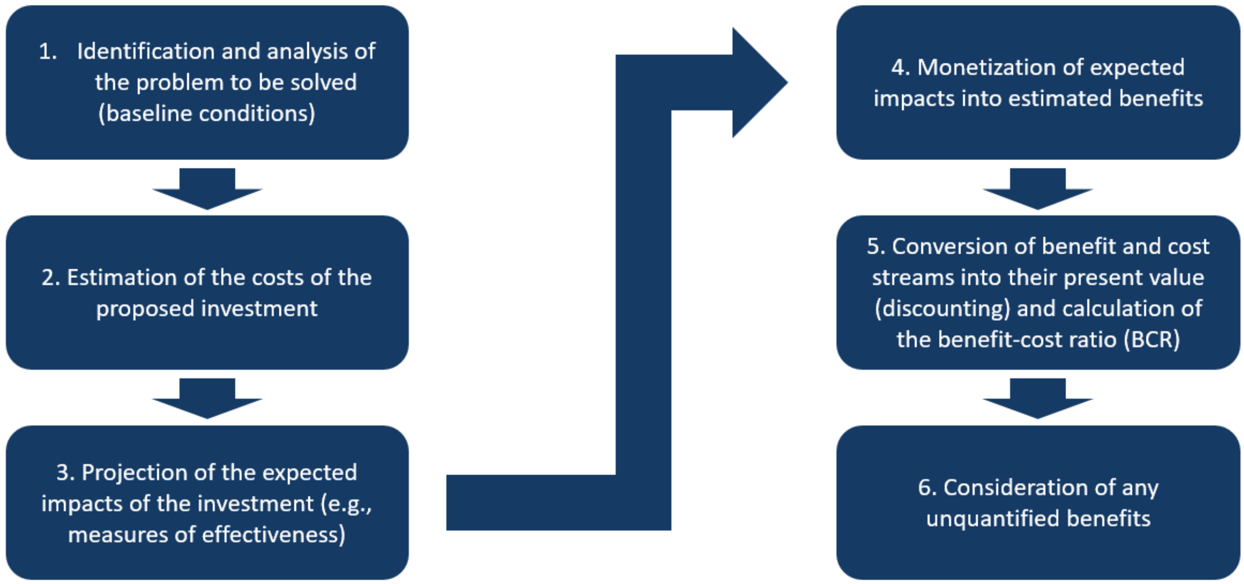
USDOT is sensitive to the fact that applicants face resource constraints, and that complex forecasts and analyses may sometimes be difficult to produce. However, based on its experience on reviewing submittals from applicants of all sizes over several previous rounds of its discretionary grant programs, the Department also believes that a transparent, reproducible, thoughtful, and well-reasoned BCA is possible for all projects, even as the depth and complexity of those analyses may vary according to the type and scope of the project. The goal of a BCA is to provide an objective assessment of a project that carefully considers and measures the outcomes that are expected to result from the investment in the project and quantifies their value.

If, after reading this guidance, an applicant would like to seek additional help, USDOT staff are also available to answer questions and offer technical assistance on BCA methodologies. DOT economists will also provide webinars for potential applicants to specific discretionary grant programs on the preparation of a BCA during the application window for many programs. Applicants are encouraged to attend these webinars (or view their archived recordings), which are usually announced and posted on the relevant program-specific webpages. These BCA webinars discuss the basics of BCA, as well as provide illustrative BCA examples that walk potential applicants through the process of conducting a BCA from start to finish.

Additionally, USDOT has recently released a new BCA spreadsheet template to aid applicants in structuring their BCA and performing certain calculations (such as discounting) that are common to BCAs across a range of project types. The Department has also developed and released a tool for performing BCAs on bridge preservation or replacement projects and plans to develop enhanced versions of the general spreadsheet template in the future geared for specific project types. Applicants are not required to use the optional template or the bridge BCA tool, but they are available to applicants as a resource to help them get started on their analysis, if desired.

2. What do I Need to Conduct a BCA?

Developing a BCA will typically involve the following steps:



The first three steps are the most crucial components of a high-quality benefit-cost analysis, and thus will likely require the most effort on the part of the applicant.

To complete these steps, applicants will need three key pieces of information:

- A well-defined project scope and cost estimate.
- A clear understanding of the problem the project is intended to solve (i.e., baseline conditions), and how specifically the project addresses the problem (i.e., the measures of effectiveness).
- Monetization factors for key project impacts, to allow conversion to dollar-based values.

Applicants should clearly describe the physical elements of the project (project scope) and how much it will cost. Section 4.5 below provides more discussion on the scope of the analysis, while Section 6 discusses how project costs should be calculated and treated in a BCA.

Before pursuing a transportation infrastructure improvement, a project sponsor should be able to articulate the problem that the investment is trying to solve and how the proposed improvement will help meet that objective. This is particularly important when the project sponsor is seeking funding from outside sources under highly competitive discretionary programs. USDOT believes that one of the primary benefits of conducting a BCA is the rigor that it imposes on project sponsors to be able to justify *why* a particular investment should be made, by carefully considering the impact that that investment will have on users of the transportation system and on society as a whole.

Estimates of the potential project impacts that can support the development of benefits estimates may be drawn from a variety of different sources, including planning and engineering documents that describe why a particular approach or design was chosen for the project, as well as industry technical references and analytical tools and Federal, state, and local government datasets. Doing so will help frame the analysis and point toward the types of benefits that are expected to be most significant for a particular project, allowing the applicant to focus its BCA efforts on those areas. Applicants should clearly demonstrate the link between the proposed transportation service improvements and any claimed benefits. It is important that the categories of estimated benefits presented in the BCA be in line with the nature of the proposed improvement and its expected impacts, as any significant discrepancies can undermine the credibility of the results presented in the analysis.

Appendix A provides recommended monetization factors for common types of benefits associated with transportation infrastructure projects. Applicants may also draw on other sources to obtain those values, though such sources should be clearly cited.

For the latter steps, including discounting monetized benefits and costs, as well as estimating the BCR, applicants should consult the relevant sections in this guidance (Section 4.3 and Section 7). Applicants may also wish to review the calculation examples in Appendix B. Lastly, the applicant should discuss the extent to which other benefits (or disbenefits) that were unable to be quantified or monetized would impact the estimated BCR.

3. Guidelines for Submitting a BCA

The BCA submitted by a project sponsor as part of their application to a USDOT discretionary grant program should include both a narrative (such as a technical memo) describing the analysis and a spreadsheet or database showing the detailed calculations themselves. The narrative and calculations should provide enough information to allow USDOT reviewers to understand the analysis and reproduce the results.

The BCA narrative should include a high-level summary of the key components of the BCA, including the benefits, costs, and major assumptions, with accompanying discussion. The applicant should document and describe all data sources in addition to information on how each source feeds into the analysis. Applicants should clearly describe the baseline for the analysis and how the proposed project would alter that baseline. This will naturally require a clear description of the elements of the construction project, including their scope and location (this may also be provided in the application narrative). The BCA narrative should also include a summary of the estimated impacts (both positive and negative) of the proposed project. This description can be presented in a table or within the text, but it should enable the reviewer to clearly tie the project elements to the expected outcomes. If an application contains multiple, distinct projects that are linked together in a common objective, each of which has independent utility, the applicant should provide a separate analysis for each component project. The information may be grouped in any way that the applicant deems logical, but should clearly describe each individual cost and benefit category in a way that ties back to what is being estimated and connects to the expected outcomes of the project.

Benefit-cost analyses submitted by applicants should be sufficiently transparent for a qualified third party to understand all its assumptions and reproduce the analysis with the same results. Applicants should provide the detailed calculations of the analysis in the form of an **unlocked** spreadsheet or database to allow for a detailed review and sensitivity testing of key parameters by USDOT analysts. The workbook should also clearly present key inputs to the analysis, including both parameters and assumptions about the impacts of the project; the sources of those assumptions should also be documented in either the calculations workbook or the BCA narrative. The workbook should also include a summary of the final results for each cost and benefit category. Simply providing summary output tables or unlinked data tables (such as pdf files or hard-coded spreadsheets) does not provide the level of detail needed for a thorough review, and could result in delays as USDOT must reach out to the applicant requests those files from the applicant in order to complete its review.

Note that if an applicant uses a "pre-packaged" economic model to calculate net benefits, the applicant should still provide sufficient information so that a USDOT reviewer can follow the general logic of the estimates and reproduce them, including key underlying assumptions of the model and annual benefit and cost by benefit and cost types. Where BCAs may have been developed using database-based models or other proprietary tools, applicants should consult with USDOT to help determine a mutually acceptable method of providing the needed detailed information.

Prospective benefit-cost analyses of transportation infrastructure investments are subject to varying levels 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, applicants should identify those that are subject to an especially high degree of uncertainty and emphasize which of these has the greatest potential influence on the outcome of the BCA, to assist USDOT reviewers in conducting sensitivity analyses on the results, as necessary and warranted. The applicant may also wish to provide suggested alternative values for key parameters that could be used for such sensitivity testing or provide the results of a broader uncertainty analysis using such methods as Monte Carlo simulation where this has been conducted.

4. General Principles

To compare a project's benefits to its costs, an applicant should conduct an appropriately thorough BCA. A BCA estimates the benefits and costs associated with implementing the project as they occur or are incurred over a specified time period.

To develop a BCA, applicants should attempt to quantify and monetize all the relevant potential benefits and costs of a project to the extent possible. Some benefits (or costs) may be difficult to capture or may be highly uncertain. If an applicant cannot monetize certain benefits or costs, it should quantify them using the physical units in which they naturally occur, where possible. When an applicant is unable to either quantify or monetize such benefits, the project sponsor should discuss them qualitatively, taking care to describe how the project is expected to lead to those outcomes.

In this guidance document, USDOT provides recommended unit values, based on nationwide averages, to estimate or monetize common sources of benefits from transportation projects (see Appendix A). USDOT recognizes that in many cases, applicants may have additional local data that is appropriate or even superior for use in evaluating a given project, particularly for non-monetary inputs. Applicants may (and in some cases are explicitly encouraged to) utilize these localized data alongside national estimates or industry standards for other parameters to complete a more robust analysis, so long as those local values are reasonable and well-documented. However, for some key parameters, including monetization values applied to reducing injuries and fatalities and travel time savings, applicants are asked to apply the recommended national values provided in this guidance document.

The following section outlines general principles of benefit-cost analysis that applicants should incorporate in their submission.

4.1. Baselines and Alternatives

Each analysis needs a well-defined baseline to measure the incremental benefits and costs of a proposed project against. A baseline is sometimes referred to as the "no-build alternative." The baseline defines the world without the proposed project. As the status quo, the baseline should incorporate factors—including future changes in traffic volumes and ongoing routine maintenance—that are not brought on by the project itself and would occur even in its absence.

Baselines should not assume that the same (or similar) proposed improvement will be implemented later. For example, if the project applying for funding were to include the replacement of a deteriorating bridge, it would be incorrect for the baseline to include the same bridge replacement project occurring at a later date. The purpose of the BCA is to evaluate benefits and costs of the project itself, not whether accelerating the schedule for implementing the project is cost-beneficial (note that it is possible that the project would not be cost-beneficial under either timeframe). A more appropriate baseline would thus be one in which the bridge replacement did not occur, but could include the (presumably) increasing maintenance costs of ensuring that the existing bridge stays open or the diversion impacts that could occur if the bridge were to be posted with weight restrictions or ultimately closed to traffic at a future date due to its deteriorated condition.

Similarly, the baseline should not incorporate the costs of an alternative improvement on another mode of transportation that would accomplish roughly the same goal, such as reducing congestion or moving larger volumes of freight. The intent of benefit-cost analysis is to examine whether the proposed project is justified given its expected benefits; simply comparing one capital investment project to another does not provide evidence for whether either project would be cost-beneficial in its own right.

Applicants should also be careful to avoid using "straw man" baselines with unrealistic assumptions about how freight and passenger traffic would flow over the Nation's transportation network in the absence of the project, particularly when alternate modes of travel are considered. Applicants should assume that users would choose the next best (i.e., least costly) alternative, rather than an overtly suboptimal one. For example, if a project would construct a short rail spur from a railroad mainline to a freight handling facility, it is unrealistic to assume that, in the absence of the project, firms would ship cargo only by truck for thousands of miles to its final destination as their only alternative. A more realistic description of current traffic would more likely have current cargo traffic going by rail (the less expensive option for most long-distance freight movements) for most of the trip, and by truck for the relatively short distance over which rail transportation is not available, while also accounting for the costs of any intermodal transfers.

Demand Modeling and Forecasting

Applicants should clearly describe both the current use of the facility or network that is proposed to be improved (e.g., current traffic or cargo volumes) and their forecasts of future demand under both the baseline and the "build case." Forecasts of future economic growth and traffic volume should be well documented and justified, based on past trends and/or reasonable assumptions of future socioeconomic conditions and economic development.[3] Where traffic forecasts are developed from models (such as

[3] The Department recognizes that some transportation improvements may be specifically targeted at supporting future economic development that is not yet "locked in" or underway. This is often particularly the case in rural areas without a strong existing economic base or at potential brownfield or other urban redevelopment sites. In such

corridor-level models or regional travel demand models) that cover areas beyond the improved facility itself, the geographic scope of those models should be clearly defined and justified. Other assumptions used to translate the usage forecasts into estimates of travel time and delay (such as gate-down times at grade crossings) should also be described and documented.

Forecasts should be provided under both the baseline and the improvement alternative. Applicants should take care to ensure that the differences between the two reflect only the proposed project being analyzed in the BCA and not any impacts from other planned improvements. Forecasts should incorporate indirect effects (e.g., induced demand) to the extent possible. Applicants should also be especially wary of using simplistic growth assumptions (such as a constant annual growth rate) over an extended period of time without taking into account the underlying capacity of the facility. It is not realistic to assume that traffic queues and delays would increase to excessively high levels with no behavioral response from travelers or freight carriers, such as shifting travel to alternate routes, modes, or time periods.

Applicants should not simply use traffic and travel information from the forecast year to estimate annual benefits. Instead, benefits should be based on the projected traffic level for each individual year. Given the nature of most traffic demand modeling, in which traffic levels are provided only for a base year and a limited number of forecast years, interpolation between the base and forecast years is likely to be necessary to derive such numbers. However, applicants should exercise extra caution when extrapolating beyond the years covered in a travel demand forecast, given the additional uncertainties and potential errors that such calculations bring; in many cases, it would be more appropriate to cap the analysis period (or at least volumes) at the final year for which a reliable travel growth forecast is available, rather than extrapolating beyond that point. Applicants should always carefully explain, justify, and document the long-term growth assumptions being applied in the analysis (including implicit assumptions reflected in any travel demand modeling results), including through direct comparisons with recent traffic volume growth and regional or project-area population growth trends.

If using travel demand models or other simulation approaches, applicants should provide (1) background information on the model used, (2) the input assumptions, such as assumed build versus no-build average daily traffic or usage, (3) the spatial extent, such as which facilities are included in the modeling, (4) the base year and forecast year average daily traffic, vehicle hours traveled, and vehicle miles traveled, by project segment, where applicable, and (5) discussion and figures explaining where changes in speeds or volumes are occurring. Applicants should avoid providing only aggregate VHT and VMT under the build versus no-build scenario or simulating over geographic areas that are much larger than would reasonably be impacted by the proposed project. Lastly, modeling should apply adjustments for demand elasticity, to avoid strawman baselines where demand is assumed to continue increasing substantially agnostic to large decreases in travel speeds or increased congestion.

4.2. Inflation Adjustments

In order to ensure a meaningful comparison between benefits and costs, it is important that all monetized values used in a BCA be expressed in common terms; however, data obtained for use in BCAs is sometimes

---

cases, and to the extent possible, applicants should document how the specific improvements proposed in the application are expected to facilitate the projected development (such as by lowering travel time costs or operating costs) and how this will lead to increased use of the improved transportation facility, as well as the expected timing of those impacts.

expressed in nominal dollars from several different years.[4] Nominal dollars reflect the effects of inflation over time and are sometimes also called current or year of expenditure (YOE) dollars. YOE dollars are used for budgeting purpose for projects whose expenditures are expected to occur over multiple years in the future. Those values must be converted to real dollars (also referred to as constant dollars), using a common base year[5], to net out the effects of inflation prior to use in BCA. For FY 2024, USDOT recommends that applicants present all cost and benefit values in 2022 dollars.

OMB Circular A-94 recommends using the Gross Domestic Product (GDP) Deflator as a general method of converting nominal dollars into real dollars. 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.[6] Table A-7 in Appendix A provides values based on this index that could be used to adjust the values of any project costs incurred in prior years to 2022 dollars. Appendix B also provides a sample calculation for making inflation adjustments. If an applicant would like to use another commonly used deflator, such as the Consumer Price Index, the applicant should explicitly indicate that and provide the index values used to make the adjustments.

4.3. Discounting

After netting out the effects of inflation to express costs and benefits in real dollars, a second, distinct adjustment must be made to account for the time value of money. This concept reflects the principle that benefits and costs that occur sooner in time are more highly valued than those that occur in the more distant future, and that there is thus a cost associated with diverting the resources needed for an investment from other productive uses in the future. This process, known as discounting, will result in future streams of benefits and costs being expressed in the same present value terms.

In accordance with OMB Circular A-94, applicants to USDOT discretionary grant programs should use a real discount rate (the appropriate discount rate to use on monetized values expressed in real terms, with the effects of inflation removed) of **3.1 percent** per year to discount streams of benefits[7] and costs to their present value in their BCA. Note that this value is significantly lower than the 7 percent discount rate, drawn from the 2003 edition of Circular A-94, that has been recommended in previous iterations of DOT's BCA Guidance; the updated value is consistent with the new (November 2023) edition of the OMB guidance. Applicants **do not** need to present estimates using both the old and new recommended discount rates.

Applicants should discount each category of benefits and costs separately for each year in the analysis period during which they accrue. For FY 2024, USDOT recommends that applicants discount the benefits and costs to 2022 (the same base year recommended above for any inflation adjustments) when producing the final present-value estimates of benefits and costs in their BCA. Appendix B provides more information on the formulas that should be used in discounting future values to present values and presents a simplified

---

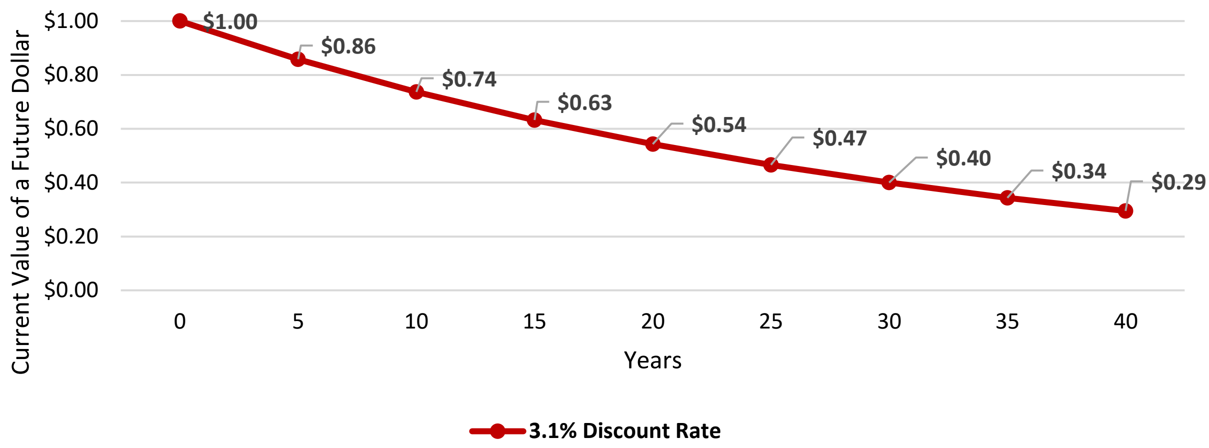
[4] This is particularly common for project cost data. See Section 6.1 below for more discussion of the treatment of project costs in BCA.

[5] A real dollar has the same purchasing power from one year to the next. In a world without inflation, all current and future dollars would be real dollars; however, general inflation can cause the purchasing power of a dollar to erode over time.

[6] 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.

[7] The one exception to this is carbon dioxide (CO_2) emissions, which, if quantified and monetized, should be discounted at 2.0 percent (see Section 5.4 below).

example table. The chart below illustrates how the present value of a future dollar is reduced over time due to discounting.



4.4. Analysis Period

The selection of an appropriate analysis period is a fundamental step in conducting a BCA. By their nature, transportation infrastructure improvements typically involve large initial capital expenditures whose resulting benefits accrue over the many years that the new or improved asset remains in service. Applicants should clearly describe the analysis period used in their BCA, including the beginning and ending years, and explicitly state their rationale for choosing that period.

Analysis periods should typically be tied to the expected useful service life of the improvement, which would in turn reflect the number of years until the same type of action (e.g., reconstruction, capacity expansion, etc.) would be anticipated to be considered again in the future. The analysis period should cover the full development and construction period of the project during which the initial costs are incurred, plus an operating period after the completion of construction during which the ongoing service benefits (and any ongoing costs) of the project can be reflected in the BCA. The appropriate analysis period will depend on both the type of improvement and its magnitude. For example, some types of capital improvements (such as equipment purchases) will have a shorter economically useful life than longer-lived investments such as structures. Repairs or resurfacing would also have a shorter useful life than the full reconstruction or replacement of a facility. Longer analysis periods may also help to capture the full impact of construction programs involving multiple phases or phased-in operations.

There is a limit, however, to the utility of modeling project benefits over very long timescales. 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, USDOT recommends that applicants avoid any analysis periods extending beyond **30 years of full**

operations. Where project assets have useful lifetimes greater than this period,[8] the applicant should consider including an assessment of the value of the remaining asset life (as described in Section 6.3 below).

Suggested expected service life assumptions (and corresponding operating periods) for common types of transportation infrastructure improvements evaluated in BCAs include:

- Projects involving the initial construction or full reconstruction of highways or similar facilities should use an expected service life of 30 years.
- Projects aimed primarily at capacity expansion or addressing other operating deficiencies of existing facilities should use a service life of 20 years (even if the useful physical life of the underlying infrastructure is greater than this). This is intended to correspond to the typical "design year" for such improvements.
- Expected service lives for intelligent transportation systems and similar investments are generally somewhat less than 20 years, and may be as short as 7-10 years for some types of technologies. Similarly, the average service life of transit buses in the U.S. is 14 years. Where these types of investments are the primary capital improvements in the project or otherwise have independent utility, the BCA should use a corresponding operating period. Where these are components of a larger improvement (such as a highway reconstruction project or new bus rapid transit line) that includes longer-lived assets, the analysis should include a recapitalization cost for the shorter-lived assets at the appropriate time within the analysis period.

While these guidelines on service lives are meant to be general rules of thumb, rather than hard and fast requirements, applicants should be sure to clearly justify the use of analysis periods that differ significantly from these recommended service life lengths.

4.5. Scope of the Analysis

In order to properly compare the benefits and costs of a project, the estimates of benefits and costs applied in the BCA must cover the same scope of the project. For example, if the funding request is for a sub-component of a larger project, it would be incorrect to include only the cost of the sub-component but estimate the benefits based on outcomes that depend on the completion of the larger project. In projects with multiple sub-components, the applicant must make clear exactly which estimates of benefits and costs are tied to which portions of the project.

The scope of the estimated benefits and costs should also be large enough to encompass a project that has independent utility, meaning that it would be expected to produce the projected benefits even in the absence of other investments. In some cases, this will mean that the costs included in the BCA may need to incorporate other related investments that are not part of the grant request, but which are necessary for the project to deliver its expected benefits.

USDOT discretionary grant programs often allow for a group of related projects to be included in a single grant application. In many cases, each of these projects may be related, but also have independent utility as individual projects. Where this is the case, each component of this package should be evaluated separately, with its own BCA. Where projects within a package may be expected to have collective benefits that are larger than the sum of the benefits of the individual projects included in the package, applicants should

[8] This would generally be limited to road and rail bridges, tunnels, or other major structures.

clearly explain why this would be the case and provide any data or analyses needed to support that assumption.

5. Benefits

Benefits measure the economic value of outcomes that are reasonably expected to result from the implementation of a project. Benefits typically accrue to the users of the transportation system because of changes to the characteristics of the trips they make and can also be experienced by the public at large.

To the extent possible, all of the benefits reasonably expected to result from the implementation of the project or program should be monetized and included in a BCA. This section describes acceptable approaches for assessing some of the most common types of benefits, but it is not intended to be an exhaustive list of all the relevant benefits that may be expected to result from all types of transportation improvement projects.

Benefits should be estimated and presented in the BCA on an annual basis throughout the entire analysis period. Applicants should not simply assume that the benefits of the project will be constant in each year of the analysis, unless they can provide a clear rationale for doing so. For projects that are implemented in stages, the expected benefits may phase-in over a certain period of time as additional portions of the project are completed. Any phasing and implementation assumptions made by the applicant should be clearly described in the supporting documentation for the BCA.

Some transportation improvements may result in a mix of positive and negative outcomes (such as reduced operational performance of an existing facility during the construction period). In such cases, those negative outcomes would be characterized as "disbenefits" and subtracted from the overall total of estimated benefits, rather than being added to total costs.

Some economic outcomes attributable to transportation improvement projects that may be of interest to policy makers would not be appropriate to include as additive benefits in a BCA. Section 8 below provides more information on these types of analyses and how their approaches differ in important and fundamental ways from BCA.

5.1. Safety Benefits

A key goal of many transportation infrastructure improvements is to reduce the likelihood of fatalities, injuries, and property damage that result from crashes on the facility by reducing the number of such crashes and/or their severity. To estimate safety benefits for a project, applicants should clearly demonstrate how a proposed project targets and is expected to improve safety outcomes. The applicant should include a discussion of any crash causation factors addressed by the project and establish a clear link to how the proposed project will mitigate these risk factors.

To estimate the safety benefits from a project that generates a reduction in crash risk or severity, the applicant should determine both the type(s) of crash(es) the project is likely to affect and the expected effectiveness of the project in reducing the frequency or severity of such crashes. The severity of prevented crashes is measured through the number of injuries and fatalities, and the extent of any property damage. Various methods exist for projecting a project's effectiveness in improving safety. Where possible, those measures should be tied to the specific type of improvement being implemented on the facility; broad assumptions (such as assuming the improvements will result in the facility crash rate dropping to the statewide average crash rate for similar facilities) are generally discouraged.

For road-based improvements, estimating the change in the number of fatalities, injuries, and amount of property damage can be done using crash modification factors (CMFs), which relate different types of safety improvements to crash outcomes. CMFs are estimated by analyzing crash data and types and relating outcomes to different types of road improvements or safety treatments. CMF estimates for many different types of road improvements and safety strategies, based on published research, are available and posted in the online CMF Clearinghouse sponsored by the Federal Highway Administration.[9] If using a CMF from the Clearinghouse, USDOT encourages applicants to verify that the CMF they are using is applicable to the proposed project improvements and to cite the CMF ID # in the BCA narrative. Applicants should ensure that the CMF is matched to the correct crash types, crash severity, and area type of the project. For an example, a CMF specifically associated with a reduction in fatal crashes in an urban setting only would generally be inappropriate to use in monetizing the safety benefits of a project for crash types in a rural area. When the search yields multiple applicable CMFs, applicants should further filter using the quality ratings provided in the Clearinghouse and provide justification as to why the selected CMF is the appropriate one for their project.[10] An example calculation using CMFs is included in Appendix B.

To estimate safety outcomes from the project, the effectiveness rates of safety-related improvements must also be applied to baseline crash data. Such data are generally drawn from the recent crash history on the facility that is being improved, typically covering a period of 3-7 years. Applicants should carefully describe their baseline crash data, including the specific segments or geographic areas covered by that data; links to the source data are also often helpful, where they can be provided. The baseline data should be closely aligned with the expected impact area of the project improvements, rather than reflecting outcomes over a much larger corridor or region.[11]

Valuing Injuries and Fatalities

USDOT-recommended values for monetizing reductions in injuries are based on the Maximum Abbreviated Injury Scale (MAIS), which categorizes injuries along a six-point scale from Minor to Not Survivable. However, crash data that are most readily available to applicants are generally not reported using the MAIS. For example, law enforcement data is frequently reported using the KABCO scale (see Table 1 below), which is a measure of the observed severity of the victim's functional injury at the crash scene. In other cases, available data may be further limited to the total number of accidents in the area affected by a particular project, perhaps also including a breakdown of those that involved an injury or fatality.

[9] http://www.cmfclearinghouse.org/

[10] If a use is considering two or more CMFs that are the same on all major factors (e.g., crash type, crash severity, etc.), the star quality rating can be used to indicate which CMF is the highest quality and therefore should be selected. Further discussion is available at http://www.cmfclearinghouse.org/userguide_identify.cfm.

[11]The Fatality Analysis Reporting System (FARS) provides a useful, nationwide source for data on roadway fatalities. FARS data are available at https://www.nhtsa.gov/research-data/fatality-analysis-reporting-system-fars. Where an applicant is using local safety data that may not be consistent with FARS, it is helpful to explain any reasons for such discrepancies in the BCA narrative.

Appendix A, Table A-1 provides recommended monetization factors for injuries reported on the KABCO injury severity scale, including fatal injuries.[12,13] The table also includes corresponding values for cases in which the available data includes property damage crashes, injury crashes, and fatal crashes more broadly, rather than total injuries and fatalities. These values account for the average number of fatalities and injuries per fatal crash, the average number of injuries per injury crash, and the average number of vehicles involved per property damage only crash. Lastly, for projects whose estimated safety benefits may stem from an overall reduction in highway vehicle travel, rather than improving safety on existing facilities, recommended monetization factors are provided in Appendix A, Table A-14.

For an example calculation of safety benefits, please see Appendix B.

Table 1. The KABCO Injury Severity Scale

Reported Accidents (KABCO or # Accidents Reported)	
O	No injury
C	Possible Injury
B	Non-incapacitating
A	Incapacitating
K	Killed
U	Injured (Severity Unknown)
# Accidents Reported	Unknown if Injured

5.2. Travel Time Savings

Many transportation infrastructure improvement projects may be intended to reduce travel times for users of the transportation system. Such reductions may stem from a number of sources, including improving traffic flow, increasing transit vehicle operating speeds or decreasing transit service headways, or providing new or shorter connections across the transportation network. Estimating the potential travel time savings from a transportation project will depend on engineering calculations, traffic forecasts, and a thorough understanding of how the improvement will affect the operations of the improved facility and the local area

[12] The MAIS-based values found in DOT's Value of a Statistical Life guidance were translated to KABCO values using a conversion matrix provided by the National Highway Traffic Safety Administration (NHTSA). The premise of the matrix is that an injury observed and reported at the crash site may end up being more/less severe than the KABCO scale indicates. Similarly, any crash can – statistically speaking – generate several different injuries for the parties involved. Each column of the conversion matrix represents a probability distribution of the different MAIS-level injuries that are statistically associated with a corresponding KABCO-scale injury or a generic crash.
[13] Applicants using data coded on the MAIS scale should refer to the values provided in DOT's Value of a Statistical Life guidance.

transportation network. Such improvements may reduce the time that drivers and passengers spend traveling, including both in-vehicle travel time and waiting time for passengers. For capacity expansion improvements on congested roadway facilities, the analysis should also account for behavioral responses (i.e., induced demand) that may erode the projected reductions in travel times as new users are drawn to an improved facility.

Applicants should utilize the recommended unit values of travel time savings (VTTS) (presented in dollars per person-hour) that are provided in Appendix A, Table A-2 of this document in their BCA. The table includes values for travel by occupants of passenger vehicles and by commercial vehicle operators. Passenger vehicle travel includes both personal travel and business travel[14]; the table also includes a blended value for cases where the mix of personal and business travel on the facility is unknown. A separate value (twice the rate of personal travel time savings) is provided for reductions in other components or aspects of travel time, including walking, cycling, waiting time, transfer time, and time spent standing in a crowded transit vehicle. Also, where applicants have specific data on the mix of local and long-distance travel on a facility, they may develop a blended estimate using the long-distance VTTS values provided in the table footnotes; however, where applicants do not have this information, they should apply the general in-vehicle travel time values to all travel in their BCA. The travel time savings parameters in Table A-2 should also be applied to all years over the analysis period.

Vehicle Occupancy

Applicants should note that the values provided in Table A-2 are presented on a per-person basis. However, many travel time estimates available as inputs to a BCA are based on vehicle-hours, and thus require additional assumptions about vehicle occupancy to estimate person-hours of travel time. Assumptions about vehicle occupancy factors should be based on localized data or analysis that is specific to the corridor being improved where at all possible, and those sources and values should be documented in the BCA. For other projects where no such data is available, applicants may use the more general, national-level vehicle occupancy factors included in Appendix A, Table A-3. The occupancy factors in Table A-3 include both an overall value for all travel and separate factors that differentiate among weekday peak, weekday off-peak, and weekend travel. The more detailed factors should be applied where applicants have such information about the composition of travel, or where estimated travel time savings resulting from the project would be concentrated in peak periods.

Occupancy rates may also need to be applied to other modes of transportation besides passenger cars. For public transportation (including buses, urban transit rail, and intercity passenger rail), applicants should apply occupancy factors that are typical in the locality, corridor, or service where the proposed improvements would take place. For freight-hauling vehicles, applicants should use typical crew sizes (such as one driver per truck) and apply the appropriate hourly time rates.

Reliability

Reliability refers to the predictability and dependability of travel times on transportation infrastructure. Improvements in reliability may be highly valued by transportation system users, in addition to the value that they may place on reductions in mean travel times.

[14] Business travel includes only on-the-clock work-related travel. Commuting travel should be valued at the personal travel rate.

Although improving service reliability can increase the attractiveness of transportation services, estimating its discrete quantitative value in a BCA can be challenging. Users may have significantly varied 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 and the attendant risk of being late than to how they value reductions in mean trip times. At the same time, heavily congested facilities may experience both longer average travel times and greater variability, as the effects of incidents become magnified under those conditions; as a result, reliability and mean travel times may be correlated.[15] Thus, assessing the value of improving reliability is generally more complex than valuing trip time savings.

At this time, USDOT does not have a specific recommended methodology for valuing reliability benefits in BCA. If applicants should choose to present monetized values for improvements in reliability in their analysis, they should carefully document the methodology and tools used, and clearly explain how the parameters used to value reliability are separate and distinct from the value of travel time savings used in the analysis.

5.3. Operating Cost Savings

Operating cost savings commonly result from transportation infrastructure projects. Freight-related projects that improve roads, rails, and ports frequently generate savings in vehicle operating costs to carriers (e.g., reduced fuel consumption and other operating costs). Project improvements may also lead to efficiencies that reduce other types of operating costs, such as terminal costs (e.g., those associated with the transfer of containers or other cargoes). Passenger-related improvements can also reduce vehicle operating or dispatching costs for service providers and for users of private vehicles. If applicants project these types of savings in their BCA, they should carefully demonstrate how the proposed project would generate such benefits.

Applicants are encouraged to use local data on vehicle operating costs where available, appropriately documenting sources and assumptions. Data related to specific components of vehicle operating costs (such as fuel consumption) are also generally preferred. For analyses where such data is not available, this guidance document provides standard national-level per-mile values for marginal vehicle operating costs based on information from the American Automobile Association (for light duty vehicles) and from the American Transportation Research Institute (for commercial trucks) in Appendix A, Table A-4. These values apply to operating costs that vary with vehicle miles traveled, such as fuel, maintenance and repair, tires, and depreciation. For trucks, these costs may additionally include truck/trailer lease or purchase payments, insurance premiums, and permits and licenses. The values exclude other ownership costs that are generally fixed or that would be considered transfer payments in the context of BCA, such as tolls, taxes, annual insurance, and registration fees. For commercial trucks, the values also exclude driver wages and benefits (which are already included in the value of travel time savings).

Sources of vehicle operating costs savings that are specifically tied to time rather than distance (such as reduced fuel consumption from reduced idle time while waiting at highway-rail grade crossings) may be

[15] Note, however, that measures of travel time reliability should be based on estimates of variability within a given time period, rather than across time periods. Predictable patterns (such as lower travel speeds during weekday AM and PM peak periods) would affect mean travel times, but would not reflect a lack of reliability per se.

valued separately in the analysis. However, distance-based measures should not otherwise be converted into time-based equivalents for projects that affect travel speeds but not travel distances.

For rail infrastructure projects that reduce operational delays or increase connectivity on the rail network, this guidance document provides standard national-level per train-hour values for train operating costs in Appendix A, Table A-5. If applicants have more system-specific or route-specific information on operating costs, they are encouraged to use that information in lieu of the national level estimates, so long as these assumptions are documented.

Other types of operating cost savings should be calculated using facility-specific data where possible. If generic values are used based on other sources, they should be carefully documented, and the applicant should explain why those values are likely to be representative of the operating cost impacts associated with the proposed project.

5.4. Emissions Reduction Benefits

Transportation infrastructure projects may also reduce the transportation system's impact on the environment by lowering emissions of air pollutants that result from combustion of transportation fuels. The economic damages caused by exposure to air pollution represent externalities because their impacts are borne by society as a whole, rather than by the travelers and operators whose activities generate those emissions. Transportation projects that reduce overall fuel consumption will typically also lower emissions, and may thus produce climate-related and other environmental benefits. Conversely, projects that lead to increased vehicle miles traveled, such as through induced demand, may lead to an increase in emissions.

The most common local air pollutants generated by transportation activities that directly affect human health include sulfur oxides (SO_X), nitrogen oxides (NO_X), and fine particulate matter ($PM_{2.5}$).[16] Recommended monetization values for reducing emissions of these pollutants are shown in Appendix A, Table A-6.

Another important type of emissions from the combustion of transportation fuels is greenhouse gases (GHGs), specifically carbon dioxide (CO_2). Recommended economic values for reducing emissions of CO_2 are also shown in Appendix A, Table A-6. Those values have been significantly updated in this edition of the BCA Guidance based on new research by the U.S. Environmental Protection Agency.[17] Importantly, because GHG emissions can have long-lasting, even intergenerational impacts, unlike all other categories of benefits (including reductions in other emissions) and costs, benefits from reductions in CO_2 emissions should be discounted at a **2.0 percent rate**.

Reductions in emissions attributable to transportation infrastructure projects may often stem from operational improvements or investments in technologies (such as electrification) that reduce fuel usage, as well as improvements that lead to reduced highway VMT, either through reduced travel distances or shifting

[16] Applicants should be careful to only use estimates of emissions of fine particulates smaller than 2.5 microns in diameter ($PM_{2.5}$), rather than those for larger particulates such as PM_{10} or particulate matter more broadly (PM).
[17] EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances, November 2023. Available at https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf

passenger or freight to more efficient modes of transportation. Applicants should carefully document their assumptions about emissions rates under both the baseline and the build alternative.[18]

For rail infrastructure projects that reduce operational delays or increase connectivity on the rail network, standard national-level per train-hour values for train emission costs, based on a methodology developed by the Department for evaluating the cost of train delay, are provided in Appendix A, Table A-5. If applicants have more system-specific or route-specific information on rail-related emissions, they are encouraged to use that information in lieu of the national level estimates, so long as these assumptions are documented.

Applicants who wish to include monetized values for additional categories of environmental benefits in their BCA should also provide documentation of sources consulted and the details of those calculations. For an example calculation of emission reduction benefits, please see Appendix B.

5.5. Facility and Vehicle Amenity Benefits

Improvements to pedestrian, cycling, transit facilities, and transit vehicles often provide amenities that can improve the quality or comfort of journeys made by active transportation (e.g., cyclists and pedestrians) and public transportation users. While it can be empirically challenging to assess the economic value of particular amenities or qualities, recent research examining the actual choices (also referred to as revealed preferences) or the stated preferences of system users has allowed for monetization values to be developed for many of them. These values are provided in Appendix A and are discussed in more detail in the following sub-sections. Similar to other types of benefits, applicants should clearly tie the claimed amenity or quality improvements to the project and document current and projected facility and vehicle usage, as the amenity valuations are on a per user trip or person-mile basis.

Pedestrian Facilities

The valuation of pedestrian facilities and amenities is an area of ongoing research in the United States, but recent revealed preference studies have provided empirical estimates that can be used to develop such values. Many projects seek to not only improve travel times for pedestrians via greater connectivity, but also to enhance comfort and ensure greater safety, thus reducing the implicit cost of travel for those users. While safety benefits of such projects should be evaluated using the methodologies previously described in that section above, the valuation of increased comfort from certain key changes to pedestrian infrastructure can also be assessed.

Pedestrian comfort is significantly impacted by ambient noise and exhaust exposure, as well as upslope. Thus, projects that reduce traffic speeds and/or volumes along key pedestrian corridors, as well as those that reduce required elevation gains, can improve the quality of the walking trip. Sidewalk width is another key facility attribute that directly affects the comfort, convenience, and safety of the facility for pedestrian use, principally by increasing the allowance for distances between pedestrians and moving vehicles and among pedestrians themselves, leading to improved safety, decreased noise and exhaust exposure, and increased comfort. Additionally, in more crowded urban environments, wider sidewalks allow for more

[18] Where projects are expected to result in a reduction in freight movement by truck, applicants should first estimate the projected change in truck VMT and apply emissions rates on that basis. Applicants should not apply estimates of emissions on a per-ton-mile basis.

space between individuals, fewer pathing conflicts, and the increased ability and convenience to walk side by side in groups.

Using revealed preference studies, monetization factors have been developed to value reducing adjacent traffic speeds and traffic volumes, elevation gain, and an incremental increase in sidewalk width per pedestrian mile-traveled, and these are included in Appendix A, Table A-8. When using these values, the estimated value per projected pedestrian trip on a proposed facility should be capped at 0.86 miles, the average length of a walking trip in the 2017 National Household Travel Survey, unless the applicant has specific documentation suggesting longer trips (as may be the case when a trip shorter than 0.86 miles is not feasible on the facility in question). In other words, applicants should not assume all pedestrians travel the full distance of a proposed facility if the facility is longer than 0.86 miles, unless they have a clear justification for doing so, such as a detailed demand analysis suggesting a different average trip distance.

Sidewalk width is also subject to diminishing marginal returns. In other words, the value of the first few feet of sidewalk (going from no sidewalk to a six-foot sidewalk, for example) is likely to be higher than marginal increases in sidewalk width to an existing larger facility (going from a 30-foot sidewalk to a 36-foot sidewalk, for example). The average monetization values included in Appendix A are only recommended to be applied to additions on sidewalks with a current maximum width of 30 feet (the largest average sidewalk width in the underlying studies, plus one standard deviation). While expanding sidewalk width beyond 30 feet could have additional benefits, they are likely to be significantly less than the value estimated over the range of sidewalk widths in the study, and thus should simply be described qualitatively.

The installation of marked crosswalks and crossing signals can also provide pedestrians with an increased sense of safety when crossing a roadway facility, as well as potential travel time savings for pedestrians where such a crossing was previously not possible due to traffic volumes and crossing distances. While any travel time savings for pedestrians should be estimated using the methodology laid out in previous sections, there may also be additional perceived safety benefits from improving such crossings. Based on revealed preference research, monetization values were developed to value addition of marked crosswalks and signalized intersections for facilities with volumes greater than 10,000 and 13,000 vehicles per day, respectively, which are included in Appendix A, Table A-8.[19] However, to avoid double-counting, applicants should not include both estimates of pedestrian crash reduction benefits and the crosswalk and these intersection improvement values for the same project components. Applicants may, however, add travel time savings for pedestrians, in the case where a new crosswalk or signalized crossing allows for shorter walking distances than under the no-build scenario. For an example pedestrian infrastructure improvement calculation, please see Appendix B.

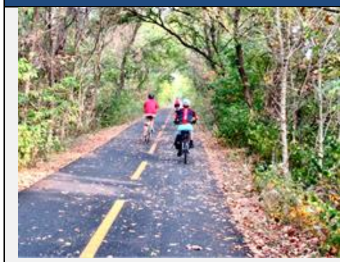
Cycling Facilities

Dedicated cycling facilities can improve journey quality and comfort for cyclists, in addition to any travel time savings they provide. Using revealed preference research, monetization values for common types of cycling infrastructure types were developed that can be applied on a per person-mile cycled basis, and these

[19] While the addition of marked crosswalks and signalized intersections for slow and lower-volume facilities no doubt benefits pedestrians as well, there was not sufficient information in the underlying research to assess the magnitude of the impact for such facilities, but applicants are encouraged to discuss and cite such potential benefits qualitatively.

are included in Appendix A, Table A-9. Table 2 below includes examples of the types of cycling infrastructure referenced in Appendix A for additional clarity.

Table 2: Common Cycling Infrastructure Types

Cycling Path	Dedicated Cycling Lane	Cycling Boulevard / "Sharrow"	Separated Cycle Track
			

The monetization values in Appendix A, Table A-9 should only be applied over project sections for which a comparable parallel facility is not available, and only to miles cycled *on* the proposed project facility. Additionally, the estimated value per projected cyclist on a proposed facility should be capped at 2.38 miles, the average length of a cycling trip in the 2017 National Household Travel Survey, unless the applicant has specific documentation suggesting longer trips (as may be the case when a trip shorter than 2.38 miles is not feasible on the facility in question or on recreation-oriented facilities). In other words, applicants should not assume all cyclists travel the full distance of a proposed facility if the facility is longer than 2.38 miles, unless they have a clear justification for doing so, such as a detailed demand analysis or existing observations suggesting a different average trip distance.

For an example cycling infrastructure improvement calculation, please see Appendix B.

Transit System, Facility, and Vehicle Amenities

Transit facility and vehicle improvements can improve the accessibility, quality, convenience, and comfort of users of transit systems. Using various stated and revealed preference studies, monetization values were developed that can be used in the assessment of various common attribute quality improvements to transit facilities and transit vehicles, and are included in Appendix A, Table A-10 and Table A-11. Applicants should clearly document how the proposed project addresses each claimed amenity addition or improvement value. For an example transit amenity improvement calculation, please see Appendix B.

Revealed preference analysis can also illuminate general differences in trip valuations among transit modes, even after controlling for other factors such as journey time, fares, and headways. These valuations can be expressed as fixed mode-specific constants or time-based in-vehicle equivalents and can be used to capture various qualitative factors associated with particular modes of transit such as station and stop quality, off-board payment, negotiating steps, ride smoothness, mode-specific reliability, acceleration and deceleration characteristics, CCTV, on-board information systems, and other aspects of vehicle ride quality and station comfort. These factors are useful when specific vehicle or stop attribute data or monetization values for specific attributes are not available. Such values are crucial for accurate transportation demand analysis and are used in many planning models, but also have relevance in and applications for certain project types under BCA.

The Federal Transit Administration's Simplified Trips-On-Project Model uses a fixed-guideway parameter that has been calibrated over time with real trip demand data to arrive at imputed estimates of mode-specific constants and in-vehicle travel time equivalents, using standard on-street buses as a reference case. A full fixed-guideway rail system with standard rail vehicles yields a mode specific constant benefit equivalent to approximately 20 minutes for trips that only use that fixed-guideway mode and an in-vehicle travel time reduction-equivalent of approximately 20 percent. However, as many trips do not use only the fixed-guideway mode and involve transfers, often from buses, this value is estimated to drop to approximately five minutes for such trips. This is due to some factors, such as intrinsic reliability, being impacted by the least reliable segment of the total trip.

Using estimates of these in-vehicle travel equivalents and mode specific constants, along with USDOT's value of travel time for all-purpose travel, monetization values have been developed and provided in Appendix A, Table A-12. These values can be used in the assessment of various types of transit improvement projects in which a shift in travel among transit modes is a significant expected project outcome, such as when a new transit mode is made available in an area or corridor where it did not exist previously. Similar to the cycling facility improvement benefits, while the estimated values are scaled using USDOT's value of time parameters, it's important to note that these monetized benefits are separate from, and would be additive to, other potential benefits such as general travel time savings for users. Note, however, that these values should not be used alongside other estimates of benefits for individual transit station or vehicle amenities, as this would represent double-counting. For an example calculation using the mode-specific constants and in-vehicle travel time equivalents, please see Appendix B.

Reduced Facility and Vehicle Crowding

Some transportation projects, particularly those dealing with the expansion or improvement of public transportation systems and facilities, may result in reduced crowding and the necessity of passengers to stand while in transit. To quantify the benefits of reduced standing from increased seating capacity, applicants may apply the net difference ($17.90 per hour) between the personal travel and standing travel values provided in Appendix A, Table A-2 to the travel times that passengers no longer spend standing under the build scenario.

If using this methodology, applicants should clearly document the assumptions used, such as data showing ridership versus seating capacity at specific times of the day and within specific facility sections or portions of transit routes, while providing the differing seating capacity under both the build and no-build scenario. Applicants should be careful not to assume such benefits accrue in cases or times when occupancy is below vehicle seating capacity. For an example calculation of crowding reduction benefits, approximated via reduced standing, please see Appendix B.

Reduced Passenger Transfers

Some transit or intercity passenger rail projects may remove the need for certain passengers to transfer between transit vehicles as a part of their trip. Travel behavior research has found that users who must transfer accrue a cost above and beyond the actual travel time or wait time involved in transferring, with this added portion known as a "transfer penalty." Estimates of the transfer penalty vary by region and system, but observations in the United States have generally placed this penalty as approximately equivalent to between three to seven minutes of all-purpose local travel time. For simplicity, USDOT recommends applying a transfer mitigation benefit equivalent to five minutes of all-purpose local travel time, though applicants may provide information to support an alternative estimate for their specific transit system should they choose to. Note that this benefit would be separate from, and in addition to, any travel time reductions from the elimination of the transfer time, savings which should be monetized using the relevant value in Appendix A, Table A-2. For an example calculation of transit transfer reduction benefits, please see Appendix B.

5.6. Health Benefits

The use of active transportation modes (e.g., walking and cycling) can also lead to improved cardiovascular health and other positive outcomes for users. A key health outcome from increased physical activity is a reduction in mortality risks for those users that are induced to active transportation modes from inactive modes. Appendix A, Table A-13 in provides recommended values for monetizing reduced mortality risks associated with increased walking and cycling, on a per-trip basis. Appendix B includes an example calculation.

In applying this methodology, applicants should clearly document the assumptions and analysis used to produce the projected number of active transportation trips that are expected to be induced by proposed cycling or pedestrian facilities. Also, note that the values in Table A-13 are only applicable to populations within certain age ranges, given the underlying epidemiological research. Applicants should discuss benefits to users outside of the designated age ranges qualitatively, and document any local data used to establish the percentage of expected induced trips falling into the designated age range. Additionally, the values should only be applied to the number of users switching from non-active transportation modes, and applicants should cite any source or data used to estimate this mode share. Absent local data on demographics and mode share, applicants may apply the national averages provided in the footnotes of Appendix A, Table A-13, which also contain other relevant input values and notes for performing calculations.

5.7.Other Benefits

Agglomeration Economies and Land Use

New or improved transportation infrastructure that enhances 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 can 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, communications, and utility networks or hospitals and schools.

USDOT recognizes the potential for agglomeration benefits resulting from transportation projects that impact the size of the labor market and/or future concentration of economic activity at a location. However, the scale, type, and overall potential for such benefits is highly context- and project-specific, and while the Department is conducting research in this area, it has not yet developed guidance on how such impacts should be quantified. Thus, at this time, USDOT recommends that applicants describe any agglomeration-related benefits that might be expected to accrue from the project in qualitative terms, while carefully laying out the expected linkages between the project and those potential outcomes. Applicants should also note that certain infrastructure improvements are likely to result in more dispersed land use and employment patterns, which can result in negative agglomeration economies.

Noise Pollution

Noise pollution occurs from high levels of environmental sound that may annoy, distract or even harm people and animals. Where relevant, applicants may wish to consider whether a proposed project will significantly lower levels of noise generated by current transportation activity, such as by reducing the need to sound train horns at grade crossings, or by reducing roadway noise. The extent to which more frequent service or increased traffic volumes may increase cumulative noise levels could also be considered as a disbenefit.

USDOT does not currently have a recommended methodology for estimating the public value of noise reductions for transportation projects in the U.S., and thus recommends that they be dealt with qualitatively in BCA until more definitive guidance on this issue is developed. Where quantified estimates are included in an applicant's BCA, the underlying methodology and values used should be carefully explained and documented. Where an applicant chooses to present quantified estimates of noise reduction benefits, the analysis should consider both the expected change in noise levels (often measured in decibels adjusted or dBA), and whether the change is expected to occur during the daytime or nighttime. For projects involving modal shift where a reduction in overall vehicle miles traveled is expected to be a significant project outcome, applicants may apply the monetization values shown in Appendix A, Table A-14. Additionally, where projects involve a reduction in vehicle volumes or speeds on facilities where pedestrians are directly affected by the corresponding reduction in noise and other types of exposures, applicants may apply the monetization values shown in Appendix A, Table A-8.

Temporary Loss of Emergency Services

Transportation projects that reduce the frequency of delays to emergency services, such as ambulance and fire services, can create benefits by reducing the damages resulting from those emergencies. For example, highway-rail grade separation projects can reduce or eliminate delays where emergency vehicles must seek alternative routes (or are prevented from accessing locations on the other side of the tracks entirely) when crossing gates are down.

The Federal Emergency Management Agency (FEMA) has a methodology that can aid in the monetization of such benefits.[20] That methodology is based on the observation that delays to fire services can cause a generalizable increase in property damage when fires burn longer.[21] Likewise, delays to ambulance services have a relatively predictable impact on survival rates for victims of cardiac arrest (one of the most common medical emergencies where time is a critical factor).

The FEMA methodology is based on the complete loss of a fire station or hospital, but can be adapted for use in delays to emergency vehicles. However, applicants applying this methodology should take care not to assume unreasonably excessive delays to emergency services in the baseline scenario (for example, assuming an ambulance will wait the entire time for a passing train at crossing gates when another grade-

---

[20] https://www.fema.gov/sites/default/files/documents/fema_standard-economic-values-methodology-report_2023.pdf

[21] Note that the FEMA methodology for estimating damages due to delays in fire services also includes an adjustment factor for indirect losses, injuries, and fatalities; however, USDOT recommends only using the methodology for direct property damage impacts and adjusting those base year 1993-dollar values for inflation.

separated crossing is available nearby will lead to overestimating the expected emergency service delay reduction). Further, applicants should carefully consider the size of the population assumed to be affected by such lapses in emergency services and should thoroughly justify and document the assumptions used in the analysis, such as the location of the emergency service facilities in question as well as the location of affected populations. Finally, the methodology should not be used for situations where traffic may be congested, but emergency vehicles would be given priority access over other vehicles and thus likely be able to maintain service levels.

Stormwater Runoff

Transportation infrastructure projects are often paired with improvements to other public facilities within the footprint of the project, including systems for reducing, collecting, or distributing stormwater runoff. Inadequate existing stormwater facilities may allow pollutants to enter the water supply, with negative impacts on aquatic life or human health, or necessitate additional operating costs for pumping and water treatment to mitigate against such impacts. To the extent that a transportation project also addresses stormwater runoff, the associated benefits may be considered in a BCA for that project.

While USDOT does not currently have recommended methodology for valuing reductions in stormwater runoff, applicants including such benefits in their analysis should clearly document the methodology, sources, underlying data, and any assumptions used in monetizing those impacts. If attempting to monetize impacts to operational costs, applicant should document and cite these costs using information from local utility departments or firms whenever possible, and provide the methodology used to calculate these benefits.

Additionally, applicants should use caution when claiming these benefits for new transportation infrastructure. While new infrastructure may include elements to mitigate the harms of the new project itself, the benefits of those elements should not be included in BCA, as it would incorrectly imply the damages would occur under the no-build scenario. In contrast, when the purpose of the project or project element is to mitigate harms or costs related to existing infrastructure, such benefits would be acceptable to include in the BCA.

Wildlife Impacts

Transportation projects may include elements aimed at reducing certain types of conflicts between the human and natural environment, including by reducing crashes between vehicles and wildlife (such as through the installation of fencing), reducing habitat fragmentation caused by new or existing infrastructure (such as through the construction of a wildlife crossing or underpass), or allowing for net increases in habitat (such as additional space aimed at pollinators). The direct safety impacts to humans of such project elements, in the form of reduced property damage, injuries, and fatalities from crash reduction, should be assessed and monetized in a similar way to other types of safety impacts, as described in Section 5.1 of this guidance. When doing so, applicants should ensure that the baseline crash data only includes those crashes involving wildlife that would be affected by project elements.

There may also be economic benefits from the preservation of wildlife itself, though USDOT does not currently have a recommended methodology for valuing those impacts. Applicants are encouraged to describe these impacts quantitatively if possible (such as estimated wildlife impacts), or qualitatively if such information is not available. If attempting to monetize wildlife impacts, applicants should clearly document the methodology, sources, and underlying data and assumption used.

Repurposed Right-Of-Way

Some types of transportation projects may involve "right-sizing" or reconfiguring infrastructure in a way that ultimately frees up land currently occupied by a transportation facility for other uses. Other projects may create new usable space in the air rights above an existing transportation facility. The value of the repurposed or "created" land may also be considered as a benefit of such a project. In such cases, applicants may assume a one-time benefit of the land sale in the BCA. Importantly, however, if counting such a benefit in the BCA, applicants should ensure that such a value has not already been netted out of the project cost estimate to avoid double-counting.

The per-acre values of repurposed right-of-way may be drawn from local real estate data, such as local land sales of comparable parcels. When using such values, applicants should provide information on the basis for those assumptions. Where the land is to be used for parks or other recreational facilities that may not have comparable transaction data, applicants may alternatively wish to apply a "travel cost method," which involves assessing the reductions in travel costs (both in terms of time and out-of-pocket costs) for expected users of the park relative to their next best alternative under the no-build baseline. For example, adding a park to a neighborhood that does not currently have one negates the need for would-be parkgoers to travel to another neighborhood to visit a similar park.

5.8. Other Issues in Benefits Estimation

Benefits to Existing and Additional Users

The primary benefits from a proposed project will typically arise in the "market" for the transportation facility or service that the project would improve, and would be experienced directly by its users. These include travelers or shippers who would utilize the unimproved facility or service under the baseline alternative, as well as any additional users attracted to the facility due to the proposed improvement.[22]

Benefits to existing users for any given year in the analysis period would be calculated as the change in average user costs multiplied by the number of users projected in that year under the no-build baseline. For additional users, standard practice in BCA is to calculate the value of the benefits they receive at one-half the product of the reduction in average user costs and the difference in volumes between the build and no-build cases, reflecting the fact that additional users attracted by the improvement are each willing to pay less for trips or shipments using the improved facility or service than were original users, as evidenced by the fact that they were unwilling to incur the higher cost to use it in its unimproved condition. See Appendix B for an illustrative sample calculation of benefits to new and existing users.

Modal Diversion

As described in the previous sub-section, benefit-cost analysis should generally focus on the proposed project's benefits to continuing and new users of the facility or mode that is being improved. While improvements to transportation infrastructure or services may draw additional users from alternative routes or competing modes or services, properly capturing the impacts of such diversion within BCA can be

[22] The number of "additional users" would be calculated as the difference in usage of the facility at any given point in the analysis period. Note that this is different from volume growth over time that would be expected to occur even under the no-build baseline.

challenging and must be examined carefully to ensure that such benefits are correctly calculated within the analysis.

First, it is important to note that simply calculating the differences in costs or travel time experienced by travelers or shippers who switch to an improved facility or service is not an appropriate measure of the benefits they receive from doing so, as the generalized costs for using the competing alternatives from which an improved facility draws additional users are already incorporated in the demand curve for the improved facility or service.[23] Applicants should thus avoid such approaches in their BCAs as comparing average operating costs for truck and rail when estimating the benefits of a rail improvement that could result in some cargo movements being diverted from highways to railroads, and instead focus on the calculation of the benefits to additional users of the mode being improved.

Reductions in *external* costs from the use of competing alternatives, however, may represent a source of potential benefits beyond those experienced directly by users of an improved facility or service. The operation of both passenger and freight vehicles can cause negative impacts such as delays to other vehicles during congested travel conditions, increased crash costs, emissions of air pollutants, and noise pollution. These impacts impose costs on occupants of other vehicles and on the society at large that are not part of the generalized costs travelers and freight carriers bear, so they are unlikely to consider these costs when deciding where and when to travel.

A commonly cited source of external benefits from public transit, passenger rail, freight rail, or port improvements is the resulting reduction in highway travel by autos or trucks. Precisely estimating reductions in congestion or other externalities caused by diversion of passenger and freight traffic from highway vehicles to improved rail or transit services is often empirically challenging, usually requiring elaborate regional travel models and detailed, geographically specific inputs. Where such localized modeling and data is not available, applicants may apply the per-VMT monetary values for congestion, noise, and safety[24] costs found in Appendix A, Table A-14. Estimates of net air pollutant emission reductions resulting from diverted or reduced truck or automobile travel may also be incorporated using standard methodologies for doing so, as described in Section 5.4 above.

Work Zone Impacts

Transportation infrastructure construction projects often involve the establishment of work zones that require temporary partial or full closures of existing facilities or impose other restrictions that affect their use, resulting in negative impacts such as increased traffic delay and vehicle operating costs and diminished safety performance. Work zone-related costs may also be a significant component of ongoing costs under

[23] This follows from the usual textbook description of the demand curve for a good or service: it shows the quantity that will be purchased at each price, while holding prices for substitute goods constant.

[24] Note that only a portion of the change in crash costs from reduced highway use should be considered external when estimating benefits associated with modal diversion. Estimates provided in the *1997 Federal Highway Cost Allocation Study Final Report* indicate that roughly 17 percent of crash costs for large trucks are external, while NHTSA's *Technical Support Document: Proposed Rulemaking for Model Years 2024-2026 Light Duty Vehicle Corporate Average Fuel Economy Standards, August 2021* (available at: https://www.nhtsa.gov/sites/nhtsa.gov/files/2021-08/CAFE-NHTSA-2127-AM34-TSD-Complete-web-tag.pdf) estimates that only 10 percent of crash costs associated with light duty vehicles are external. The values provided in Table A-14 reflect the external portion of safety costs only.

a no-build baseline, under which an aging facility might require more frequent and extensive maintenance activities to keep it operational.

Applicants should account for any work zone impacts in their analysis. Where such impacts are expected to be minimal, the analysis should describe the characteristics of the project that or methods that will be used to mitigate any such delays. Work zone impacts should be represented as disbenefits (negative benefits) in the analysis and should be monetized consistent with the values and methodologies provided in this guidance and assigned to the years in which they would be expected to occur.

State of Good Repair

The benefits of projects that replace, repair, or improve existing transportation assets to bring them to a state of good repair (SOGR) 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 or facility reliability and quality. In some cases, a project sponsor may wish to highlight these impacts in their BCA as being related to an improved SOGR. For example, an analysis could consider a construction project's impact on reducing ongoing operations and maintenance costs, relative to the no-build baseline, as a SOGR benefit of the project. However, project sponsors should ensure that these benefits are only included once in the analysis.

Resilience

Some projects are aimed at improving the ability of transportation infrastructure to withstand adverse events such as severe weather, flooding, seismic activity, and other threats and vulnerabilities that can severely damage or even destroy transportation facilities. The resulting costs to users from lost access to the damaged facility (such as additional travel time and vehicle operating costs from detours or delays) or the costs of emergency maintenance or repairs to restore the facility can be significant, and improvements that mitigate those impacts can provide significant benefits through avoiding those costs. Under certain circumstances, natural or manmade hazards may necessitate mass evacuations of vulnerable areas, leading to excessive burdens on existing infrastructure.

Incorporating resilience-related benefits into a BCA requires an understanding of both the expected frequency with which different levels of each stressor are expected to be experienced in the future, and the economic damages that different stressor levels are likely to inflict on specific infrastructure assets. This includes the anticipated frequencies of events such as extreme precipitation, seismic events, or coastal storm surges, as well as the range of potential severities of each event and the estimated cost of the resulting damages to specific assets, expressed as dollar figures. Note that future event frequencies and the severity their consequences may be influenced by factors such as development patterns and climate change, and those factors may be accounted for to the extent that reliable forecasts are available.

Benefits associated with increased resilience may be difficult to calculate due to the unpredictable occurrence of disruptive events, some of which could occur many decades in the future. Applicants may draw on previous experiences with facility outages to calculate the value of restricted infrastructure capacity or service outages, such as costs incurred by travelers when bridge capacity is reduced or if a facility is closed temporarily, and include those potential impacts in their estimates of the user benefits associated with the project.[25] Hydrological and geological data and forecasts of the expected frequency or future incidence of flood and seismic events can also be an important source. However, applicants should be careful to only consider the frequency and magnitude of those events in the area where the proposed improvement is to take place, rather than using frequencies that may apply to a much broader area. The frequency of the event should also be calculated as the expected probability of the disruptive event(s) occurring within a given year within the analysis period, producing a projected benefit stream of the improvement, rather than assuming that such events will occur with certainty at some point during the analysis period.

Geographic Extent

Benefits from transportation investment projects may also accrue to users and non-users at different scales, from local to regional or national impacts. The extent of those impacts may vary for different types of projects or even for different types of benefits. For example, a bike/ped facility may be used primarily by residents in the immediate area, but to the extent that those trips are shifted from motor vehicles, the impacts of the corresponding reductions in vehicle emissions may be felt over a much broader area. Applicants may wish to highlight cases where the benefits of the project may extend beyond the local area, while being careful to ensure that those benefits are properly captured (and only counted once) in the estimate of total project benefits.

Similarly, a larger spatial extent may be necessary to accurately capture benefits and dis-benefits in an analysis. For example, a highway capacity expansion may result in lower congestion levels on the segment being expanded, and thus, depending on the changes in travel speeds, reduce emissions per vehicle mile traveled on that segment. However, induced vehicle miles traveled on the overall network stemming from more or longer trips may result in additional emissions that could offset part, all, or more than all of the congestion-related emission reduction. Applicants should thus carefully assess both project-level and system-level impacts where significant effects are expected beyond the immediate project limits.

Property Value Increases

Transportation projects can also increase the accessibility or otherwise improve the attractiveness of nearby land parcels, resulting in increased property values (specifically, the land value component of property values). However, such increases would generally largely result from reductions in travel times or other user benefits described elsewhere in this guidance. Such benefits should be calculated and monetized directly, rather than being factored into an assumed property value increase benefit; any claimed, monetized benefits based on property values should only capture otherwise unquantified benefits, such as those described elsewhere in this section. Such projections should also count the net increase in land value as a one-time rather than as an annually occurring benefit,[26] and should consider the net effect of both increases in land values induced by the project in some areas and any potential reductions in land values in other areas.

---

[25] The National Oceanic and Atmospheric Administration (NOAA) database on storm surges and floor risks is one possible tool that applicants could use to estimate flood risk potential. See http://www.nhc.noaa.gov/surge/inundation/

[26] In some cases, applicants may have easier access to projections of the increased rental value associated with the land, rather than increases in land prices. As these represent the same effect, the rental values may be used alternatively, with the caveat that they should not reflect any values associated with improvements made on the land itself.

6. Costs

Project costs consist of the economic resources (in the form of the inputs of capital, land, labor, and materials) needed to develop and maintain a new or improved transportation facility over its lifecycle. In a BCA, these costs are usually measured by their market values, as they are directly incurred by developers and owners of transportation assets (as opposed to categories of benefits such as travel time savings that are not directly transacted in the market).

Cost data used in the BCA should reflect the full cost of the project(s) necessary to achieve the benefits described in the BCA. Applicants should include all costs regardless of who bears the burden of specific cost item (including costs paid for by State, local, and private partners, as well as the Federal government). Cost data should include all funded and unfunded portions of the project, even if Federal funding is a relatively small portion of the total cost of the project with independent utility that is to be analyzed in the BCA.

6.1. Capital Expenditures

The capital cost of a project is the sum of the monetary resources needed to build the project. Capital costs generally include the cost of land, labor, material and equipment rentals 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 acquisition, utility relocation, 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, applicants should estimate and report the costs of the various component projects of the program as well as summing those projects into a total cost.[27]

Project capital costs may be incurred across multiple years. All costs of the project (or that sub-component requesting funding if the project is a sub-component of a larger project and has independent utility) should be included, including costs already expended.[28] Capital costs should be recorded in the year in which they are expected to be incurred by the parties developing and constructing the project, regardless of when payment is to be made for those expenses by the project sponsor (such as repayments of any principal and interest associated with financing the project that may occur well after the project has been constructed).

Applicants for USDOT discretionary grant programs should provide capital cost information for the project in three distinct forms:

1) <u>Nominal dollars</u>. The cost estimates provided in the project budget/financial plan included in the application narrative should be stated in YOE dollars, also referred to as nominal dollars, reflecting the actual costs that have previously been or are expected to be incurred in the future.
2) <u>Real dollars</u>. As noted above in Section 4.2, all costs and benefits used in the BCA itself (but not the project budget) should be stated in real or constant dollars using a common base year. Cost elements that were expended in prior years should thus be updated to the recommended base year

[27] Note that where projects are unrelated to each other and do not impact each other's individual benefit streams (also referred to as having independent utility), they should be analyzed using separate BCAs.

[28] While economic decision-making often ignores such costs, treating them "sunk costs" that cannot be recovered, the purpose of including a BCA as part of the grant application for the USDOT discretionary grant programs is to determine whether the cost of project for which funding is being sought is justified by its benefits in its entirety, not whether future expenditures on the project or portion of the project funded by the grant are justified by total benefits of the whole project.

(2022).[29] Costs incurred in future years should be adjusted to base year based on the future inflation assumptions that were used to derive them, and those assumptions should be clearly stated in the analysis.

3) Discounted Real dollars. Any future year constant dollar costs should also be appropriately discounted to the baseline analysis year to allow streams of project benefits and costs to be compared in the final results of the BCA (see Section 4.3).

6.2. Operating and Maintenance Expenditures

Transportation facilities require ongoing operating and maintenance (O&M) in order to provide service and keep the assets in operating condition.

O&M costs should be projected for both the no-build baseline and the build case implementing proposed improvement project over the full length of the analysis period, and the difference between the two should be factored into the BCA. For projects involving the construction of new infrastructure, total O&M costs would be zero in the base case, so net O&M costs would typically be positive, reflecting the ongoing expenditures needed to maintain the new asset over its lifecycle.[30] For projects intended to replace, reconstruct, or rehabilitate existing infrastructure, however, the net change in O&M costs under the proposed project will often be negative, as newer infrastructure requires less frequent and less costly maintenance to keep it in service than would an aging, deteriorating asset. Note also that more frequent maintenance under the baseline could also involve work zone impacts that could be reflected in projected user cost savings associated with the project.

Applicants should describe how O&M costs were estimated in the analysis. Maintenance costs are often somewhat "lumpy" over the course of an asset's lifecycle, with more extensive preservation activities being scheduled at regular intervals in addition to ongoing routine maintenance. Applicants should make reasonable assumptions about the timing and cost of such activities in accordance with standard agency or industry practices.

If the estimated O&M costs are provided to the applicant in year of expenditure dollars, they should be adjusted to base year dollars prior to being included in the BCA. While the net O&M costs between the build and no-build baseline associated with a project may be logically grouped with other project development costs, they should be included in the numerator along with other project benefits when calculating a benefit-cost ratio for a project proposed for funding under the discretionary grant programs (see Section 7 below).

6.3. Residual Value and Remaining Service Life

As noted above, the analysis period used in the BCA should be tied to the expected useful life of the infrastructure asset constructed or improved by the project. However, some transportation 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 the maximum analysis period (covering up to 30 years of operations) recommended by USDOT (see Section 4.4 above). Other projects may have components with varying

[29] Appendix A, Table A-7 provides a list of inflation adjustment factors for such costs going back to 2003.
[30] In some cases, projects that add vehicles to expand service may result in reduced utilization (and thus reduced O&M expenditures) for older existing vehicles, which can also be factored into the analysis. However, those reduced service levels for existing vehicles should also be factored into the calculation of benefits for the project.

useful lives, resulting in remaining service life for the longer-lived assets at the end of the operating period. These differences must be carefully considered when accounting for them in BCA.

Where some or all project assets have several years of useful service life remaining at the end of the analysis period, a "residual value" may be calculated for the project at that point in time. This could apply to both assets with expected service lives longer than the analysis period, and shorter-lived assets that might be assumed to have been replaced within the analysis period.[31] Applicants should carefully document the useful life assumptions that are applied when estimating a residual value in their BCA.

A simple approach to estimating the residual value of an asset is to assume that its original value depreciates in a linear manner over its service life.[32] An asset with an expected useful life of 60 years would thus retain half of its value after 30 years in service, while an asset with a 45-year life would retain one third of its value at that point in time.[33] Those residual values would then be discounted to their present value using the discount rate applied elsewhere in the analysis. An example calculation of residual value is included in Appendix B.

While the projected residual value of a project may be logically grouped with other project development costs, it should be added to the numerator when calculating a benefit-cost ratio for a project proposed for funding under USDOT discretionary grant programs (see Section 7 below).

6.4. Innovative Technologies and Techniques

The application of certain innovative technologies and innovative procurement, design, and construction techniques may lead to efficiencies that can reduce the upfront capital costs of a project and/or its long run maintenance costs over time. For example, some transportation agencies have found that bundling multiple projects of a similar type and design (such as bridge rehabilitation or replacement projects) under a single contract can yield lower overall costs than would be achieved by delivering them on an individual basis.

The savings associated with innovative techniques will generally be reflected in a lower estimate of a project's capital or operating costs, which should be applied when constructing the BCA. If applicants wish to specifically highlight the expected savings from the innovation relative to conventional approaches, they should present both the "with" and "without" costs in their application. However, only the actual projected costs should be used in the BCA. If the use of innovative technologies is expected to also directly benefit users or reduce the external costs of transportation, then those benefits (as measured against a no-build baseline) may also be calculated and included in the analysis.

7. Comparing Benefits to Costs

There are several summary measures that can be used to compare benefits to costs in BCA. The two most widely used measures are net present value and the benefit-cost ratio:

---

[31] For example, a component might be assumed to require replacement every 20 years. If the analysis period covers 30 years post-construction, 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.

[32] Other approaches may also be applied, so long as the methodology used is adequately described and justified in the BCA.

[33] In this example, if the construction period is five years, then the overall analysis period would be 35 years (5 years construction plus 30 years of operations).

Net present value (NPV) is perhaps the most straightforward BCA measure. All benefits and costs over an alternative's life cycle are discounted to the present, and the costs are subtracted from the benefits to yield an NPV. If benefits exceed costs, the NPV is positive and the project may be considered to be economically justified.

The benefit-cost ratio (BCR) is frequently used in project evaluation when funding restrictions apply. In this measure, the present value of benefits (including negative benefits) is placed in the numerator of the ratio and the present value of costs is placed in the denominator. The ratio is usually expressed as a quotient (e.g., $2.2 million/$1.1 million = 2.0).

The elements to be included in the numerator and denominator of the BCR depend on the nature of the BCA and the purposes for which it is being used.[34] Where an agency is using BCA to help evaluate potential projects to implement under a constrained budget, the denominator should only include the upfront costs of implementing the project (i.e., capital expenditures). Since project funding decisions under the discretionary grant programs are being made under similar circumstances, this is the approach that should be used to calculate the BCR in analyses developed pursuant to this guidance. Note that under this treatment, net O&M costs and the residual value would be added to or subtracted from the numerator when calculating the BCR, rather than the denominator.

While applicants are welcome to present estimates of a project's NPV or BCR in their BCA, the estimated benefits and costs provided in the analysis should be sufficient to USDOT analysts to make such calculations independently. What is most important is that applicants clearly present their estimates for each category of benefits and costs in a consistent manner (see Section 3).

8. Other Types of Economic Analysis

BCA is distinct from other types of economic analysis are also frequently employed to assess the potential consequences of transportation improvement projects, including economic development impacts, financial outcomes, and distributional effects. While these analyses can be a useful tool to inform decision makers about certain issues and metrics of interest, it is important to note that they use different approaches and answer different questions than does benefit-cost analysis. Most importantly, the outcomes measured by these analyses generally do not represent categories of benefits that may be added to those addressed in a BCA.

8.1. Economic Impact Analysis

Transportation infrastructure projects can provide high paying jobs and career development opportunities for workers and can support increased economic activity within a region. Common metrics for measuring economic impacts include retail spending, business activity, local tax revenues, and jobs/wage income. Economic impact analyses generally take a strictly positive view, (i.e., increased jobs and spending associated with the investment) and, unlike BCA, do not examine how the resources used for a project might have been put to alternative beneficial uses (i.e., they do not assess the net effect on 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 project sponsor, and does not consider the extent to which positive

[34] Note that this is not a concern for the calculation of net present value, since the results will be the same regardless of which elements are categorized as benefits or costs in that calculation, so long as they are included with the proper sign.

impacts in one region or industry may be accompanied by offsetting losses in another. A project with negative net benefits, as measured by BCA, could generate positive regional economic impacts simply by increasing spending or employment within a specific geographic area even if, from a national standpoint, its overall economic effects would be expected to be negative.

Additionally, to the extent that a transportation improvement may help foster additional economic development in the area, the associated benefits would already be captured by the direct impacts on transportation system users that would lead firms to relocate or increase their business activity. As a result, including these secondary impacts in a BCA would be another form of double counting the same benefit, and should thus also be avoided on these grounds.

8.2. Financial Impacts

Financial analyses are an important and necessary tool for project sponsors to identify sources of revenue that could be used to pay for the costs of the project. In many cases, the project itself may be expected to generate additional revenues (such as fares, tolls, or other facility charges) to the owner or operator from increased use of a transportation facility, either from direct user fees or ancillary revenues (including taxes), which can affect the financial feasibility of the project. While it is thus understandable that project sponsors would be interested in these financial impacts, they should not be confused with the benefits estimated in a BCA. Benefits reflect reductions in real resource usage and overall net benefits to society, while financial impacts represent both a cost to one party and a benefit to the another, and would thus be considered a transfer for the purposes of BCA.

It should be noted, however, that in some cases, reductions in fee rates may reflect reductions in operating costs that are passed onto users, and thus may serve as a proxy for such changes where detailed information on operating costs may not be available. If reductions in fees are treated this way, care should be taken to clearly show that this measure is capturing actual benefits resulting from increased efficiency and not simply a transfer payment between the various parties involved, and to avoid double counting any associated operating cost and fee or fare reductions.

8.3. Distributional Effects and Incidence

In addition to understanding how the overall societal benefits from a project compare to the costs of implementation, policy makers are often especially interested in how the resulting benefits are distributed among different parties or groups. For example, a transportation project may have benefits that are widely shared among the general public, or conversely may be concentrated among private parties such as a private transportation operator or the landowners or commercial enterprises (such as a manufacturing plant) who may be directly served by a new or improved transportation facility. Public investment in transportation may also be targeted to meet the needs of traditionally underserved or disadvantaged population groups, and policy makers may thus be interested in understanding how the benefits of a proposed improvement would be shared by those users. Certain transportation projects may even result in some parties being made worse off, even in cases where the proposed project would deliver positive net benefits in the aggregate.

When a project is expected to have differential effects on subgroups of the population, applicants are encouraged to analyze and discuss these effects, to the extent feasible and appropriate, along with the analysis of discounted benefits and costs. Distributional effects may be analyzed along various dimensions, including income class, geographic region, or demographic group, or by distinguishing between public and private benefits. This information can help USDOT better understand how the project can meet other important public policy goals.

Circular A-94 also discusses the potential use of distributional weights in benefit-cost analysis, specifically where the benefits and costs of a project may accrue differentially to people in different income classes. At this time, USDOT does not have a recommended approach for applying such weights in transportation BCAs. Applying this methodology requires a significant amount of additional information beyond what is typically needed or available for a BCA of a transportation infrastructure project, including detailed data on the incomes of users and others affected by the project; the ultimate incidence of benefits that accrue to business enterprises and are passed through to those firms' owners, workers, and customers; and the incidence of different types of taxes and other revenue sources that may be used to fund a particular project. However, consistent with Circular A-94, the Department's use of nationwide population averages in calculating and applying the key recommended monetization values in this guidance can help to partly or fully address these distributional considerations.

Appendix A: Recommended Parameter Values

The following tables summarize key parameter values for various types of benefits and costs that the Department recommends that applicants use in their benefit-cost analyses, including both monetization values and other key inputs. These standardized values are intended to ensure greater consistency in how various types of projects from across the country are evaluated. They also provide default values that applicants can use in the absence of having more detailed information readily available for their analysis. However, acceptable benefits and costs for BCAs submitted to USDOT are not limited only to these tables. The applicant should provide documentation of sources and detailed calculations for monetized values of additional categories of benefits and costs. Similarly, applicants using different values for the benefit and cost categories presented below should provide sources, calculations, and their rationale for divergence from the recommended values.

The values provided in the tables on the following pages are stated in 2022 dollars, the base year recommended for use in applications submitted pursuant to NOFOs for discretionary grant programs issued in FY 2024.

Table A-1: Value of Reduced Fatalities, Injuries, and Crashes

<table>
<tr><th>Recommended Monetized Value(s)</th><th>References and Notes</th></tr>
<tr><td>

KABCO Level	Monetized Value (2022 $)
O – No Injury	$5,000
C – Possible Injury	$111,700
B – Non-incapacitating	$233,800
A – Incapacitating	$1,188,200
K – Killed	$12,500,000
U – Injured (Severity Unknown)	$217,600

Crash Type	Monetized Value (2022 $)
PDO Crash[1]	$9,100
Injury Crash[1]	$313,000
Fatal Crash[1]	$14,022,900

1) Monetization values for PDO crashes assumed 1.77 vehicles per PDO crash. Monetization values for injury crashes and fatal crashes are based on an estimate of approximately 1.44 injuries per injury crash and 1.09 fatalities per fatal crash, based on an average of the most recent five years of data in NHTSA's National Crash Statistics. The fatal crash value is further adjusted for the average number of injuries per fatal crash.

</td><td>

Treatment of the Economic Value of Preventing Fatalities and Injuries in Preparing Economic Analyses (2022) https://www.transportation.gov/office-policy/transportation-policy/revised-departmental-guidance-on-valuation-of-a-statistical-life-in-economic-analysis

The Economic and Societal Impact of Motor Vehicle Crashes, 2019 (revised February 2023), Page 46, Table 2-9, Incidence Summary, 2019"

Note: The KABCO level values shown result from multiplying the KABCO-level accident's associated MAIS-level probabilities by the recommended unit Value of Injuries for each MAIS level, and then summing the products. Crash data may not be presented on an annual basis when it is provided to applicants (i.e., an available report requested in Fall 2011 may record total accidents from 2005-2010). For the purposes of the BCA, is important to annualize data when possible. For MAIS-based unit values, please see the VSL guidance linked above.

Property damage in PDO crashes inflated to 2022 dollars using the GDP deflator.

</td></tr>
</table>

Table A-2: Value of Travel Time Savings

<table>
<tr><th>Recommended Monetized Value(s)</th><th>References and Notes</th></tr>
<tr><td>
Recommended Hourly Values of Travel Time Savings (2022 $ per person-hour)
<table>
<tr><th>Category</th><th>Hourly Value</th></tr>
<tr><td>General Travel Time
Personal[1]
Business[2]
All Purposes[3]</td><td>
$17.90
$32.30
$19.60</td></tr>
<tr><td>Walking, Cycling, Waiting, Standing, and Transfer Time[4]</td><td>$35.80</td></tr>
<tr><td>Commercial Vehicle Operators[5]
Truck Drivers
Bus Drivers
Transit Rail Operators
Locomotive Engineers</td><td>
$33.50
$36.50
$63.30
$53.50</td></tr>
</table>
1) Values for personal travel based on local travel values as described in USDOT's Value of Travel Time guidance. Where applicants also have specific information on the mix of local versus long-distance intercity travel (i.e., trips over 50 miles in length) on a facility, then the local travel values of time may be blended with the long-distance intercity personal travel value of $25.10 per hour.

2) Weighted average based on a typical distribution of local travel by surface modes (88.2% personal, 11.8% business). Applicants should apply their own distribution of business versus personal travel where such information is available.

3) Note that business travel does not include commuting travel, which should be valued at the personal travel rate. Travel on high-speed rail service that would be competitive with air travel should be valued at $47.70 per hour for personal travel and $80.20 for business travel.

4) Should be applied only when actions affect those elements of travel time.

5) Includes only the value of time for the operator, not passengers or freight.
</td><td>
Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis (2016)
https://www.transportation.gov/office-policy/transportation-policy/revised-departmental-guidance-valuation-travel-time-economic
</td></tr>
</table>

Table A-3: Average Vehicle Occupancy Rates for Highway Passenger Vehicles

Recommended Value(s)	References and Notes
(see nested table and note below)	*2017 National Household Travel Survey*

Vehicle Type	Average Occupancy
Passenger Vehicles (Weekday Peak)[1]	1.48
Passenger Vehicles (Weekday Off-Peak)	1.58
Passenger Vehicles (Weekend)	2.02
Passenger Vehicles (All Travel)	1.67

1) Weekday peak period values calculated for trips starting between 6:00 AM-8:59 AM and 4:00 PM-6:59 PM.

Table A-4: Vehicle Operating Costs

Recommended Monetized Value(s)	References and Notes
(see nested table and notes below)	*American Automobile Association, Your Driving Costs – 2022 Edition (2022)* https://newsroom.aaa.com/wp-content/uploads/2022/08/2022-YourDrivingCosts-FactSheet-7-1.pdf *American Transportation Research Institute, An Analysis of the Operational Costs of Trucking: 2023 Update* https://truckingresearch.org/wp-content/uploads/2023/06/ATRI-Operational-Cost-of-Trucking-06-2023.pdf

Vehicle Type	Recommended Value per Mile (2022 $)
Light Duty Vehicles[1]	$0.52
Commercial Trucks[2]	$1.32

1) Based on an average light duty vehicle and includes operating costs such as gasoline, maintenance, tires, and depreciation (assuming an average of 15,000 miles driven per year). The value omits other ownership costs that are mostly fixed or transfers (insurance, license, registration, taxes, and financing charges).

2) Value includes fuel costs, truck/trailer lease or purchase payments, repair and maintenance, truck insurance premiums, permits and licenses, and tires. The value omits tolls (which are transfers), and driver wages and benefits (which are already included in the value of travel time savings).

Table A-5: Train Operating and Social Costs

Recommended Monetized Value(s)	References and Notes
(see table and notes below)	*Cost of Delay from HAZMAT Rail Incidents (October 2023)* https://www.phmsa.dot.gov/planning-and-analytics/economic-research-and-regulatory-analysis-division/cost-delay-hazmat-rail-incidents Values adjusted from report for changes in wages, fuel costs, emission monetization, and inflation.

	Recommended Value per Hour (2022 $)		
Train and Movement Type	**Operating Costs[1]**	**Non-CO_2 Emission Costs[2]**	**CO_2 Costs[2]**
Idling			
Freight Train	$273	$749	$28
Commuter Train	$299	$102	$26
Amtrak Long-Distance	$747	$102	$26
Amtrak State-Supported	$331	$102	$26
Hauling			
Freight Train	$799	$2,202	$280
Commuter Train	$778	$727	$218
Amtrak Long-Distance	$1,226	$727	$218
Amtrak State-Supported	$810	$727	$218
All Movements			
Freight Railcar	$1.03	*	*

1) Includes fuel cost, depreciation, and labor cost

2) Emissions are based on the current diesel-electric locomotive fleet average, and thus the emission values above should not be applied in cases where new locomotives are being acquired or in cases of electrified rail. The monetization applies the 2035-year emission value to approximate increasing emission damage costs over time.

*Table A-6: Damage Costs for Emissions per Metric Ton**

Recommended Monetized Value(s)	References and Notes
See table below	*Technical Support Document: Estimating the Benefit per Ton of Reducing PM2.5 Precursors from 17 Sectors (February 2018)"* https://www.epa.gov/sites/default/files/2018-02/documents/sourceapportionmentbpttsd_2018.pdf NO_X, SO_X, and $PM_{2.5}$ values are inflated from 2015 to 2022 dollars using the GDP deflator. CO_2 values are inflated from 2020 to 2022 dollars using the GDP deflator. *EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances (November 2023)* **Note:** Fuel saved (gasoline, diesel, natural gas, etc.) can be converted into metric tons of emissions using EPA guidelines available at https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references **Note:** The recommended values for reducing CO_2 emissions reported in Table A-6 represent the values of future economic damages that can be avoided by reducing emissions in each future year by one metric ton. After using per-metric ton values to estimate the total value of reducing CO2 emissions in any *future year*, the result must be further discounted to its present value as of the analysis year used in the BCA, also using a **2.0 percent** discount rate.

Emission Type	NO_X	SO_X	$PM_{2.5}$**	CO_2
2023	$19,800	$52,900	$951,000	$228
2024	$20,100	$53,800	$963,200	$233
2025	$20,300	$54,800	$975,500	$237
2026	$20,600	$56,100	$993,500	$241
2027	$21,000	$57,400	$1,011,900	$245
2028	$21,300	$58,700	$1,030,600	$250
2029	$21,700	$60,100	$1,049,600	$253
2030	$22,000	$61,500	$1,069,000	$257
2031	$22,000	$61,500	$1,069,000	$262
2032	$22,000	$61,500	$1,069,000	$265
2033	$22,000	$61,500	$1,069,000	$270
2034	$22,000	$61,500	$1,069,000	$274
2035	$22,000	$61,500	$1,069,000	$278
2036	$22,000	$61,500	$1,069,000	$282
2037	$22,000	$61,500	$1,069,000	$287
2038	$22,000	$61,500	$1,069,000	$290
2039	$22,000	$61,500	$1,069,000	$294
2040	$22,000	$61,500	$1,069,000	$299
2041	$22,000	$61,500	$1,069,000	$303
2042	$22,000	$61,500	$1,069,000	$308
2043	$22,000	$61,500	$1,069,000	$312
2044	$22,000	$61,500	$1,069,000	$317
2045	$22,000	$61,500	$1,069,000	$321
2046	$22,000	$61,500	$1,069,000	$326
2047	$22,000	$61,500	$1,069,000	$331
2048	$22,000	$61,500	$1,069,000	$336
2049	$22,000	$61,500	$1,069,000	$340
2050	$22,000	$61,500	$1,069,000	$345
2051	$22,000	$61,500	$1,069,000	$349
2052	$22,000	$61,500	$1,069,000	$353
2053	$22,000	$61,500	$1,069,000	$357

*Applicants should carefully note whether their emissions data is reported in short tons or metric tons. A metric ton is equal to 1.1023 short tons.

**Applicants should be careful to not apply the $PM_{2.5}$ value to estimates of total emissions of PM_{10}.

Table A-7: Inflation Adjustment Values

Recommended Value(s)	References and Notes
(see nested table below)	*Bureau of Economic Analysis, National Income and Product Accounts, Table 1.1.9, "Implicit Price Deflators for Gross Domestic Product" (October 2023)* https://apps.bea.gov/iTable/iTable.cfm?reqid=19&step=3&isuri=1&1921=survey&1903=11#reqid=19&step=3&isuri=1&1921=survey&1903=11

Base Year of Nominal Dollar	Multiplier to Adjust to Real 2022 $
2003	1.53
2004	1.49
2005	1.45
2006	1.40
2007	1.37
2008	1.34
2009	1.33
2010	1.32
2011	1.29
2012	1.27
2013	1.24
2014	1.22
2015	1.21
2016	1.20
2017	1.18
2018	1.15
2019	1.13
2020	1.12
2021	1.07
2022	1.00

Table A-8: Pedestrian Facility Improvements Revealed Preference Values

Recommended Monetized Value(s)

Improvement Type	Recommended Value per Person-Mile Walked (2022 $)[1]
Expand Sidewalk (per foot of added Width)[2]	$0.11
Reducing Upslope by 1%	$1.11
Reducing Traffic Speed by 1 mph (for speeds ≤45 mph)	$0.09
Reducing Traffic Volume by 1 Vehicle per Hour (for ADT ≤55,000)	$0.0010
Improvement Type	**Recommended Value per Use (2022 $)[1]**
Install Marked-Crosswalk on Roadway with Volumes ≥10,000 Vehicles per Day	$0.19
Install Signal for Pedestrian Crossing on Roadway with Volumes ≥13,000 Vehicles per Day	$0.51

1) These values assume an average walking trip speed of 3.2 miles per hour. For the mile-based benefits, the estimated value per user should be capped at 0.86 miles, the average length of a walking trip in the 2017 National Household Travel Survey, unless the applicant has specific documentation suggesting longer trips or that a trip shorter than 0.86 miles is not feasible on the facility in question. In other words, applicants should not assume all pedestrians travel the full distance of a proposed facility if the facility is longer than 0.86 miles without a clear justification for doing so.

2) Value for sidewalk width expansion applicable for sidewalks up to approximately 31 feet, benefits for expansions beyond this width should be described qualitatively.

References and Notes

Sidewalk expansion, traffic speed and volume reduction, and upslope reduction valuations based on:

Does the Pedestrian Environment Affect the Utility of Walking? A Case of Path Choice in Downtown Boston (2009)
https://www.sciencedirect.com/science/article/abs/pii/S136192090900039X

A Big Data Approach to Understanding Pedestrian Route Choice Preferences: Evidence from San Francisco (2021)
https://www.sciencedirect.com/science/article/abs/pii/S2214367X21000569

Pedestrian crossing improvement valuations based on:

Pedestrian Route Choice Model Estimated from Revealed Preference GPS Data (2014)
https://trid.trb.org/view/1338221

Table A-9: Cycling Facility Improvement Revealed Preference Values

<table>
<tr><th>Recommended Monetized Value(s)</th><th>References and Notes</th></tr>
<tr><td>

Facility Type	Recommended Value per Cycling Mile (2022 $)[1]
Cycling Path with At-Grade Crossings	$1.57
Cycling Path with no At-Grade Crossings[2]	$1.97
Dedicated Cycling Lane	$1.86
Cycling Boulevard/“Sharrow”	$0.29
Separated Cycle Track	$1.86

1) Values should only be applied over sections for which a comparable parallel facility is not available, and only applies to miles cycled on the project facility. These values assume an average cycling trip speed of 9.8 miles per hour or, in the case of off-street paths with no at-grade crossings, a free-flow cycling speed of 12.1 miles per hour. The estimated value per cyclist should be capped at 2.38 miles, the average length of a cycling trip in the 2017 National Household Travel Survey, unless the applicant has specific documentation suggesting longer trips or that a trip shorter than 2.38 miles is not feasible on the facility in question. In other words, applicants should not assume all cyclists travel the full distance of a proposed facility if the facility is longer than 2.38 miles without a clear justification for doing so.

2) The value for a cycling path with no at-grade intersections is higher due to an assumption of a higher average speed of 12.1 miles per hour, resulting in less time on the facility, which lowers journey quality benefits but increases travel time savings.
</td><td>

Underlying marginal rate of substitution estimates based on:

A GPS-based Bicycle Route Choice Model for San Francisco, California (2011)
https://www.sfcta.org/sites/default/files/2019-03/BikeRouteChoiceModel.pdf

Average cycling speed based on summaries of GPS observations of observed cycling speeds in two datasets from the following studies:

Broach, Dill, & Gliebe, (2012)
Dill, McNeil, Broach, & Ma, (2014)
Broach & Dill, (2016)
Broach, Dill, & McNeil, (2019)
</td></tr>
</table>

Table A-10: Transit Facility Amenity Revealed and Stated Preference Values

Recommended Monetized Value(s)	References and Notes
(see table below)	*Public Transport Customer Amenity Valuation Database (2017)* https://publictransportresearchgroup.info/portfolio-item/best-practice-approaches-to-public-transport-customer-amenity-valuation/ **Note:** The underlying surveys for rail stations contained more facility attributes than those for bus or light rail/streetcar stops. However, the values for rail stations may be used for major bus or light rail transfer facilities as well as intercity bus stations where applicable.

Attribute Type	Recommended Value per User Trip (2022 $)		
	Bus Stop	Light Rail/Streetcar Stop	Rail Station
Clocks	$0.03	$0.03	$0.07
Electronic Real-Time Information Displays	$0.32	$0.16	$0.90
Information /Emergency Button	$0.25	$0.25	$0.11
PA System	$0.32	$0.05	$0.10
Platform/Stop Seating Availability[1]	$0.20	$0.14	$0.13
Platform/Stop Weather Protection[1]	$0.26	$0.17	$0.13
Restroom Availability	$0.15	$0.15	$0.11
Retail/Food Outlet Availability	$0.11	$0.11	$0.06
Staff Availability	$0.08	$0.03	$0.19
Step-Free Access to Station/Stop	$0.33	$0.33	$0.21
Step-Free Access to Vehicle	$0.43	$0.08	$0.07
Surveillance Cameras	$0.32	$0.32	$0.33
Temperature Controlled Environment[1]	$0.65	$0.65	$0.65
Ticket Machines	$0.11	$0.11	$0.07
Timetables	$0.24	$0.10	$0.50
Bike Facilities	*	*	$0.10
Car Access Facilities	*	*	$0.12
Elevator	*	*	$0.07
Escalators	*	*	$0.04
On-Site Ticket Office	*	*	$0.10
Taxi Pickup/Dropoff	*	*	$0.05
Waiting Room[1]	*	*	$0.21

1) Note that seating availability and weather protection refer to seats, canopies, or wind shelters on the platforms themselves, whereas temperature-controlled environment refers to an indoor facility with heating and air conditioning availability. A waiting room refers to a designated indoor environment with seating availability, separate from platform seating, which may or may not be temperature controlled.

Table A-11: Transit Vehicle Amenity Values

Recommended Monetized Value(s)	References and Notes
(see table below)	*Public Transport Customer Amenity Valuation Database (2017)* https://publictransportresearchgroup.info/portfolio-item/best-practice-approaches-to-public-transport-customer-amenity-valuation/

Attribute Type	Recommended Value per User Trip (2022 $)		
	Bus	Light Rail/Streetcar	Rail
Electronic Real-Time Information Displays	$0.23	$0.23	$0.23
Handrails	$0.13	$0.13	$0.32
Luggage Storage	$0.09	$0.09	$0.09
PA System	$0.40	$0.40	$0.41
Surveillance Cameras	$0.23	$0.23	$0.65
Temperature Control	$0.33	$0.13	$0.49
Wheelchair Space	$0.05	$0.05	$0.05
Food Service Availability	*	*	$0.03
Restroom Availability	*	*	$0.20

Table A-12: Transit Mode Ride and Boarding Quality Revealed Preference Values

Recommended Monetized Value(s)

Transit Mode	Boarding Quality Benefit (Per Boarding) (2022 $)[1]	Vehicle Ride Quality Benefit (Per Passenger Hour) (2022 $)[1]
Low-Intensive BRT[2]	$0.33	$0.39
Medium-Intensive BRT[2]	$0.65	$0.78
High-Intensive BRT[2,3]	$1.63	$1.57
Streetcar or On-Street Light Rail Transit	$1.96	$1.96
Off-Street Light Rail Transit	$3.27	$3.53
Heavy Rail	$3.59	$3.92
Commuter Rail	$5.23	$3.92
Ferry[3]	$3.59	$3.92

1\ Values applicable when base case is transit use of standard on-street bus, the reference case used to create these values. When comparing other types of modal shift, the differences between the relevant modal values above should be used.

2\ Low-intensive BRT would include special service branding, low floor vehicles, at least 50 percent of route in dedicated lanes and potentially shared turns and the remainder in mixed-traffic, some signal priority, level boarding, off-board fare collection, and visually distinct stations. Medium-intensive BRT would include features of Low-intensive BRT but have 100 percent of the route in dedicated lanes, traffic signal priority throughout the corridor, and median-running service or right-turn prohibitions. High-intensive BRT would have a completely sealed right-of-way with no traffic interference and traffic signal preemption, akin to a "rubber-tired railroad."

3\ The Capital Investment Grant program has to date not completed a before-and-after study of ridership on a ferry project or a high-intensive BRT as described above, and thus does not have a calibrated estimate for the fixed-guideway setting for those modes. Thus, these values represent the current best estimates, considering average station and ride quality relative to other transit modes.

References and Notes

Federal Transit Administration's Simplified Trips-On-Project Model

https://www.transit.dot.gov/funding/grant-programs/capital-investments/stops

Table A-13: Mortality Reduction Benefits of Induced Active Transportation Values

Recommended Monetized Value(s)

Mode	Applicable Age Range[3]	Recommended Value per Induced Trip (2022 $)[4]
Walking[1]	Ages 20-74	$7.63
Cycling[2]	Ages 20-64	$6.80

1) Based on an assumed average walking speed of 3.2 miles per hour, an assumed average age of the relevant age range (20-74 years) of 45, a corresponding baseline mortality risk of 267.1 per 100,000, an annual risk reduction of 8.6 percent per daily mile walked, and an average walking trip distance of 0.86 miles.

2) Based on an assumed average cycling speed of 9.8 miles per hour, an assumed average age of the relevant age range (20-64 years) of 42, a corresponding baseline mortality risk of 217.9 per 100,000, an annual risk reduction of 4.3 percent per daily mile cycled, and an average cycling trip distance of 2.38 miles.

3) Absent more localized data on the proportion of the expected users falling into the age ranges above, applicants may apply a general assumption of 68% and 59% of overall induced trips falling into the walking and cycling age ranges, respectively, assuming a distribution matching the national average.

4) Applicants should ensure these monetization values are only applied to trips induced from non-active transportation modes within the relevant age ranges for each mode. Absent more localized data on the proportion of induced trips coming from non-active transportation modes, applicants may apply a general assumption of 89% of induced trips falling into that category, assuming a distribution matching the national average travel pattern.

References and Notes

Physical activity risk reduction assumptions based on:

Health Economic Assessment Tool (HEAT) for Walking and For Cycling (2017)
https://www.euro.who.int/__data/assets/pdf_file/0010/352963/Heat.pdf

Average walking speed, average weighted age for those who walk or cycle, average walk or cycling trip distance, and national average active transportation mode distribution based on:

National Household Travel Survey (2017)
https://nhts.ornl.gov/

Baseline mortality risk based on:

National Centers for Health Statistics Underlying Cause of Death 2018-2019 on CDC WONDER Online Database (2020)
https://wonder.cdc.gov/

Estimates of national population falling within applicable age ranges based on:

United States Census Bureau, Current Population Survey, Annual Social and Economic Supplement (2019)
https://www.census.gov/data/tables/2019/demo/age-and-sex/2019-age-sex-composition.html

Assumed average cycling speed based on cycling studies cited in Appendix A, *Table A-9*.

Table A-14: External Highway Use Costs

Recommended Monetized Value(s)

Vehicle Type and Location	Recommended Value of Cost per Vehicle Mile Traveled (2022 $)[1]				
	Cong. Cost	Noise	Safety Cost	Non-CO_2 Emission Cost[2]	CO_2 Emission Cost[2]
Light-Duty Vehicles - Urban	$0.138	$0.0019	$0.017	*	$0.107
Light-Duty Vehicles - Rural	$0.029	$0.0002	$0.096	*	$0.109
Light-Duty Vehicles – All Locations	$0.116	$0.0011	$0.040	$0.012	$0.107
Buses and Trucks - Urban	$0.345	$0.0437	$0.016	*	$0.303
Buses and Trucks - Rural	$0.075	$0.0037	$0.027	*	$0.299
Buses and Trucks – All Locations	$0.236	$0.0220	$0.021	$0.035	$0.301
All Vehicles - Urban	$0.154	$0.0051	$0.017	*	$0.124
All Vehicles - Rural	$0.036	$0.0007	$0.086	*	$0.140
All Vehicles – All Locations	$0.128	$0.0031	$0.038	$0.015	$0.129

1) Congestion costs updated from the 1997 Highway Cost Allocation Study to reflect increased traffic volumes, changes in vehicle occupancy, and increases in the value of time per person-hour since that time. Both congestion and noise costs are also adjusted from 1994 dollars to 2022 dollars using the GDP deflator.

2) Emission rates are based on estimates from EPA's MOVES Model. The monetization applies the 2035-year emission value to approximate increasing emission damage costs over time. Non-CO_2 emission damages should be discounted at 3.1 percent, while CO_2 emission damages should be discounted at 2.0 percent.

References and Notes

Highway Cost Allocation Study (1997)
https://www.fhwa.dot.gov/policy/otps/costallocation.cfm

NHTSA Fatality Analysis Reporting System (2019)
https://www.nhtsa.gov/research-data/fatality-analysis-reporting-system-fars

NHTSA Crash Report Sampling System (2019)
https://www.nhtsa.gov/crash-data-systems/crash-report-sampling-system

EPA MOVES Model (2022)
https://www.epa.gov/moves

Appendix B: Sample Calculations

Example Inflation Adjustment Calculation

Adjusting for inflation requires a value with a known base year and the multiplier to adjust to the desired year dollars. For example, the real value in 2022 of $1,000,000 in expenses incurred in 2003, using the Implicit GDP Deflator multipliers given in Table A-7, would be as follows:

$$\begin{aligned}(2022\ Real\ Value\ of\ \$1{,}000{,}000\ in\ 2003) &= \$1{,}000{,}000\ x\ 1.53 \\ &= \$1{,}530{,}000\end{aligned}$$

Example Discounting Calculation

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 2022 of $5,200 real dollars (i.e., dollars with the same purchasing power as in the 2022 base year) to be received in 2028 would be $4,330 if the real discount rate (i.e., the time value of money) is 3.1 percent per annum:

$$\begin{aligned}PV &= \frac{\$5{,}200.00}{(1+0.031)^6} \\ &= \$4{,}329.64\end{aligned}$$

If the discount rate is estimated correctly, a person given the option of either receiving $5,200 in 2028 or approximately $4,330 in 2022 would be indifferent as to which they might select. If the real discount rate were two percent, the present value of the $5,200 sum would be $4,617. 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.

Applicants should discount each category of benefits and costs separately for each year in the analysis period during which they accrue. Table B-1 provides a simplified example of how this could be done for one category of benefits and one category of costs. Further reading and examples on discounting may be found in OMB Circulator A-94 and OMB Circular A-4.

Table B-1. Example of Discounting

Calendar Year	Project Year	Value of Travel Time Savings (2022 $)	Discounted Travel Time Savings at 3.1%	Construction Costs (2022 $)	Discounted Construction Costs at 3.1%	NPV at 3.1%
2022	1	$0	$0	$38,500,000	$38,500,000	-$38,500,000
2023	2	$0	$0	$15,500,000	$15,033,948	-$15,033,948
2024	3	$23,341,500	$21,958,943	$0	$0	$21,958,942
2025	4	$24,570,000	$22,419,667	$0	$0	$22,419,667
2026	5	$25,061,400	$22,180,446	$0	$0	$22,180,466
2027	6	$26,781,300	$22,989,966	$0	$0	$22,989,966
Total			**$89,549,042**		**$53,533,948**	**$36,015,095**

Example Calculation of Benefits to Existing and Additional Users

Estimating the benefits to existing and additional users requires estimates of the reduction in average costs to users resulting from an improvement as well as forecasts of traffic volumes in a given year both with and without the improvement.

For an illustrative example, assume that the current cost of travel and volume of riders is $75 per trip (reflecting the combined value of travel time costs, vehicle operating costs, safety costs, and other user costs) and that there are 200,000 riders projected in that year. The improvement is projected to reduce that generalized cost of travel to $65 per trip and result in 250,000 riders in that year. First, estimate the benefits for the existing users:

$$\begin{aligned} Existing\ User\ Benefits &= Volume\ of\ Existing\ Users\ x\ Change\ in\ Cost \\ &= V1\ x\ (P1 - P2) \\ &= 200{,}000\ x\ (\$75 - \$65) \\ &= 200{,}000\ x\ \$10 \\ &= \$2{,}000{,}000 \end{aligned}$$

Next, estimate the benefits for the additional users using the rule of half:

$$\begin{aligned} Benefits\ to\ Additional\ Users &= \frac{1}{2} x\ Volume\ of\ Additional\ Users\ x\ Change\ in\ Cost \\ &= \frac{1}{2} x\ (V2 - V1) x\ (P2 - P1) \\ &= \frac{1}{2}\ x\ (250{,}000 - 200{,}000)\ x\ (\$75 - \$65) \\ &= \frac{1}{2}\ x\ 50{,}000\ x\ \$10 \\ &= \$250{,}000 \end{aligned}$$

Summing the two types of consumer benefits, this hypothetical example would generate $2,250,000 in benefits in that year. Note that the values used in this example are purely illustrative.

Example Value of Time Savings Calculation

A transit line is being improved to allow for a time savings of 12 minutes between a particular origin and destination pair. Current transit line demand between the two stations is 100,000 trips per year for all trip purposes, and the applicant 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:

$$
\begin{aligned}
VTTS(existing) &= Value\ of\ Time\ x\ Change\ in\ Trip\ Time\ x\ Affected\ Trips \\
&= \frac{\$19.60}{hr}\ x\ 0.2\ hr\ x\ 100{,}000\ Trips/Year \\
&= \$392{,}000/Year
\end{aligned}
$$

Applicants 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 other reductions in cost) would be expected to attract new passengers (or shippers in the case of freight infrastructure improvements) using transit 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 transit service once the shorter trip time is available. Thus, some portion of the trip time savings was necessary to attract that passenger to the transit 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.

$$
\begin{aligned}
VTTS(new) &= Value\ of\ Time\ x\ \frac{1}{2}\ x\ Change\ in\ Trip\ Time\ x\ Affected\ Trips \\
&= \frac{\$19.60}{hr}\ x\ \frac{1}{2}\ x\ 0.2\ hr\ x\ 10{,}000\ Trips/Year \\
&= \$19{,}600/Year
\end{aligned}
$$

Applicants 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 $411,600 annually in the simplified example above.

Example of Crash Modification Factor Calculation

To use a CMF, an applicant will first need the most recent year estimates of fatalities and injuries along an existing facility, as well as a CMF that correctly corresponds to the safety improvement being implemented. Once these have been collected, the estimated lives saved and injuries prevented are as follows:

$$
\begin{aligned}
Estimated\ Annual\ Lives\ Saved &= Current\ Annual\ Fatality\ Estimate\ x\ [1 - CMF] \\
Estimated\ Annual\ Injuries\ Prevented &= Current\ Annual\ Injury\ Estimate\ x\ [1 - CMF]
\end{aligned}
$$

Assume a project includes implementing rumble strips on a 2-lane rural road. The stretch of road in question is particularly dangerous and has had an annual average of 16 fatalities and 20 non-fatal injuries. For this example, assume a rumble strip has a hypothetical CMF of 0.84 for both fatalities and injuries. Estimating the prevented fatalities and non-fatal injuries would be as follows:

$$
\begin{aligned}
Estimated\ Annual\ Lives\ Saved &= Current\ Annual\ Fatality\ Estimate\ x\ [1 - CMF] \\
&= 16\ x\ [1 - 0.84] \\
&= 2.56/Year \\
Estimated\ Annual\ Injuries\ Prevented &= Current\ Annual\ Injury\ Estimate\ x\ [1 - CMF] \\
&= 20\ x\ [1 - 0.84] \\
&= 3.20/Year
\end{aligned}
$$

Thus, the rumble strip project would be expected to save approximately 2.6 lives per year and reduce injuries by 3.2 annually. These estimates can then be monetized as discussed in Section 5.1 and shown in the following example.

Example Safety Benefits 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 applicant should estimate a baseline crash risk (the existing conditions risk) to measure the risk reduction of the project.

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 applicant may also need to adjust the calculation to consider 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 because of improving a crossing will depend on the location of the project, the objective of the project, and the data available. The applicant 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, USDOT 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 non-incapacitating injury per incident.[35] These fatalities and injuries represent the

[35] For simplicity in this example, USDOT assumes population growth, rail traffic, and highway traffic will remain constant.

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 non-incapacitating injuries annually.

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

$$\begin{aligned} \textit{Safety Benefits} &= \textit{Baseline Risk x Risk Reduction x Expected Consequences} \\ &= 3\ \textit{Crashes/Year x}\ 100\%\ \textit{Risk Reduction x}\ [1\ x\ \$12{,}500{,}000 + 1\ x\ \$233{,}800] \\ &= \$38{,}201{,}400/\textit{Year} \end{aligned}$$

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.

Example Emissions Benefits Calculation

Benefits from reducing emissions 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 in that year. For the example calculation, assume that the project will lower $PM_{2.5}$ by 10 metric tons annually; using the values from Table A-6 above, in 2023 and 2032 this reduction would result in \$9.5 million and \$10.7 million in benefits, respectively:

$$\begin{aligned} PM2.5\ \textit{Reduction Benefit} &= \textit{Quanity Reduced x Monetized Value in given year} \\ &= 10\ \textit{metric tons in}\ 2023\ x\ \$951{,}000/\textit{metric ton} \\ &= \$9{,}510{,}000\ \textit{in}\ 2023 \end{aligned}$$

$$\begin{aligned} PM2.5\ \textit{Reduction Benefit} &= \textit{Quanity Reduced x Monetized Value in given year} \\ &= 10\ \textit{metric tons in}\ 2032\ x\ \$1{,}069{,}000/\textit{metric ton} \\ &= \$10{,}690{,}000\ \textit{in}\ 2032 \end{aligned}$$

Other emissions should be calculated similarly with their respective monetized value in a given year. 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. For non-CO_2 emissions, these values should be discounted at 3.1%, the same as other benefits and costs in the BCA. For CO_2 or CO_2-equivalents, the values should be discounted at 2.0%.

Example Pedestrian Journey Quality Valuation Calculation

In addition to other common benefit categories such as crash reduction or travel time savings, pedestrian infrastructure valuation calculations may apply revealed preference values which assess qualitative differences in comfort or walk quality given the addition or alteration of pedestrian infrastructure. For the example calculation, assume a two-block length of street is receiving a sidewalk width extension of six feet, and the current sidewalk width on both blocks is five feet wide. Assume both blocks are approximately 0.1 miles in length, and that passive counters estimate daily average pedestrian trips on the first and second blocks at 1,000 and 700, respectively. Given this context, and using the values in Appendix A, Table A-8, the benefit to a pedestrian walking on the adjusted sidewalk would be as follows:

$$\begin{aligned} Benefit\ per\ Mile\ Walked &= Sidewalk\ Value\ per\ Foot\ of\ Added\ Width\ x\ Additional\ Width \\ &= \$0.11\ per\ Foot\ of\ Added\ Width\ x\ 6\ Feet \\ &= \$0.66\ per\ Mile\ Walked \end{aligned}$$

Next, using our context of 1,000 and 700 pedestrian trips on the first and second block, respectively, and the 0.1-mile length of both blocks, we estimate the benefit to users of the proposed project on the first and second block as:

$$\begin{aligned} Benefit\ to\ Users\ on\ First\ Block &= \#\ of\ Daily\ Users\ x\ Block\ Length\ x\ Value\ per\ Mile\ Walked \\ &= 1{,}000\ Pedestrians\ x\ 0.1\ Miles\ x\ \$0.66\ per\ Mile\ Walked \\ &= \$66.00\ per\ Day \end{aligned}$$

$$\begin{aligned} Benefit\ to\ Users\ on\ Second\ Block &= \#\ of\ Daily\ Users\ x\ Block\ Length\ x\ Value\ per\ Mile\ Walked \\ &= 700\ Pedestrians\ x\ 0.1\ Miles\ x\ \$0.66\ per\ Mile\ Walked \\ &= \$46.20\ per\ Day \end{aligned}$$

Summing the benefits on both blocks yields a benefit of $112.20 per day. This value would then need to be annualized, based on an assumption of what portion of the year such benefits could be expected. For this example, assume the base pedestrian use data is a daily average taken throughout the year, including weekends. Thus, it should be annualized at 365, yielding an annual benefit of improved walking comfort of $40,953. Additionally, as also noted in Appendix A, Table A-8, the assumed mileage per user should be capped at 0.86 miles, the average walking trip distance in the United States, unless an applicant has a clear rationale and documentation for assuming otherwise.

Example Transit Vehicle and Station Quality Benefit Calculations

Setting up the calculations for estimating the benefits of a new transit mode can be challenging, as such projects often involve multiple simultaneous changes beyond simple stop or vehicle ride quality differences, such as decreases in average travel times. In this example, assume the base case is a one-mile bus line seeing 30,000 trips per day on the segment in question, with an average travel speed of 10 mph on the segment (or six minutes of travel time over the one-mile route segment). Assume the build case is a one-mile extension of an off-street light rail system, which, due to not operating in mixed-traffic, will average 30 mph on the segment (or two minutes of travel time over the one-mile extension). Thus, each traveler would save four minutes (0.067 hours) per day. For the simplicity of this example, assume no passengers are forced to stand under the build or no-build scenario while in transit, assume similar headways, and assume no induced demand. Thus, the three major benefits of the project would thus be (1) decreased travel time, (2) increased station/stop quality, and (3) improved ride quality. Under these conditions and utilizing the monetization values in Appendix A, Table A-2 the value of travel time savings would be calculated as follows:

$$\begin{aligned} VTTS &= Value\ of\ Time\ x\ Change\ in\ Trip\ Time\ x\ Affected\ trips \\ &= \frac{\$19.60}{hr}\ x\ 0.067\ hr\ x\ 30{,}000\ Trips/Day \\ &= \$39{,}396/Day \end{aligned}$$

Increased station/stop quality would be valued on a per-trip basis using the monetization values in Appendix A, Table A-12 as follows:

$$Boarding\ Quality\ (BQ)\ Benefit = [BQ\ (New\ Mode) - BQ\ (Old\ Mode)]\ x\ \#\ of\ Boardings$$
$$= [\$3.27 - \$0.00]\ x\ 30{,}000\ Boardings/Day$$
$$= \$98{,}100/Day$$

Improved ride quality would be valued on a per passenger hour basis, comparing the time spent on the new transit mode under the build scenario that was not spent on the new transit mode under the baseline scenario. From our example above, travelers will spend approximately two minutes on the project in question in the off-street light rail vehicles, or approximately 0.033 hours. Thus, using the monetization values in Appendix A, Table A-12, ride quality benefits would be calculated as follows:

$$Ride\ Quality\ (RQ)\ Benefit = [RQ\ (New\ Mode) - RQ\ (Old\ Mode)]\ x\ Time\ Spent\ on\ New\ Mode$$
$$= [\$3.53 - \$0.00]\ x\ 30{,}000\frac{Boardings}{Day}x\ 0.033\ Hours$$
$$= \$3{,}495/Day$$

Thus, the total benefit per day of the transit mode change in the above example would be \$39,396+\$98,100+\$3,495 = \$140,991. This value would then need to be annualized, with the exact annualization factor depending on what days the underlying demand data was valid for (for example, weekdays, weekends, all days, etc.). Assume for our example the estimate of 30,000 daily boardings is the average for all days of the year, and thus should be annualized at 365, yielding an annual benefit of approximately \$51.5 million.

Applicants should note that there could be other benefits of such a project, such as reduced operating costs or emission reduction, depending on the particulars of the transit modes involved, or a reduction in the need to transfer. This example is not meant to be exhaustive, but illustrative of how to apply particular values in Appendix A.

Example Reduced Crowding Calculation

Some transportation improvements may effectively increase seating capacity and reduce crowding within vehicles. In this example, assume under the baseline that an existing transit line is running ten two-car trains, with each car capable of seating 60 passengers (1,200 total seats on all trains). However, assume during the most congested one-hour period of the morning and afternoon rush hours, the average occupancy rises to 3,000 total passengers on all trains at any given time, with 1,800 standing passengers at any given time. In response, the agency is procuring a third car for each of the ten trains, raising the total seating capacity to 1,800 total seats on all trains, and thus lowering the average number of standing passengers from 1,800 to 1,200 (thus, at any given time, 600 newly seated passengers).

Assume the average time spent on board the train per passenger is 15 minutes, such that each new seat serves four passengers within that hour (2,400 additional seated passengers per hour). Given our scenario above was only relevant during one hour in the morning, and one hour in the afternoon, this brings us to 4,800 additional seated passengers per weekday. Given this context, the calculation for estimating the benefits of increased seating capacity would be as follows:

$$Reduced\ Standing\ Benefit\ = \#\ of\ Passengers\ Affected\ x\ Time\ x\ Monetization\ Value$$
$$= 4{,}800\frac{Passengers}{Day}x\ \left(\frac{15}{60}\right)Hours\ x\ Monetization\ Value$$

$$= 1{,}200 \frac{Hours}{Day} x \ Monetization \ Value$$

Next, the monetization value that would be applied here, taken from Appendix A, Table A-2, would be the value of time spent standing minus the general in-vehicle personal travel time value:

$$\begin{aligned} Reduced \ Standing \ Monetization \ Value \ &= VTTS \ (Standing) - \ VTTS \ (Seated) \\ &= \frac{\$35.80}{Hour} - \frac{\$17.90}{Hour} \\ &= \frac{\$17.90}{Hour} \end{aligned}$$

Thus, combining the number of hours for which passengers are now able to be seated above, combined with the monetization value, our final benefit per weekday would be:

$$\begin{aligned} Reduced \ Standing \ Benefit \ &= 1{,}200 \frac{Hours}{Day} x \frac{\$17.90}{Hour} \\ &= \$21{,}480/Day \end{aligned}$$

Given that, in our hypothetical example above, this level of transit crowding only occurred on weekdays, this value would be annualized by the number of non-holiday weekdays per year (261), which would yield an estimated annual benefit of approximately $5.6 million.

Example Transfer Reduction Calculation

Some transportation improvements may involve the mitigation of the need to transfer between transit vehicles. For the example calculation, assume under the base case that commuter trains from opposite ends of a metropolitan area arrive at a central station, but trains are unable to run through the station and out the other side. This means that any through-traveling passengers must disembark one train on one end of the station, walk to the other end the station, wait, and board a different train to continue their trip. Assume this involves 10,000 daily passengers walking approximately five minutes and waiting ten minutes for another train, for a total of 15 minutes (0.25 hours) spent transferring. Under the build case, the proposed project would include a new track connection that would allow trains to run through the central station and out the other side, meaning through-traveling passengers would no longer need to change trains.

Given this context, the calculation for estimating the benefits of a transfer reduction would include both (1) the travel time saved from no longer needing to transfer and (2) the mitigation of the transfer penalty. Under these conditions and utilizing the monetization values in Appendix A, Table A-2 the value of travel time savings would be calculated as follows:

$$VTTS = Value\ of\ Transfer\ and\ Wait\ Time\ x\ Change\ in\ Trip\ Time\ x\ Affected\ Trips$$
$$= \frac{\$35.80}{hr} x\ 0.25\ hr\ x\ 10{,}000\ Trips/Day$$
$$= \$89{,}500/Day$$

Mitigation of the transfer penalty would be valued on a per-trip basis at the equivalent to five minutes (approximately 0.0833 hours) of local all-purpose travel. Using the monetization values in Appendix A, Table A-2, this would be calculated as follows:

$$Transfer\ Reduction\ Benefit = Value\ of\ Time\ x\ Transfer\ Penalty\ x\ \#\ of\ Transfers\ Reduced$$
$$= \$19.60\ x\ 0.0833\ x\ 10{,}000\ Transfers/Day$$
$$= \$16{,}327/Day$$

Thus, the total benefit per day of the transfer reduction in the above example would be \$89,500+\$16,327 = \$105,827. This value would then need to be annualized, with the exact annualization factor depending on what days the underlying demand data was valid for (for example, weekdays, weekends, all days, etc.). Assume for our example the estimate of 10,000 daily impacted trips is the average for all days of the year, and thus should be annualized at 365, yielding an annual benefit of approximately \$38.6 million.

Example Residual Value Calculation

Residual value should be estimated using the total project cost and the remaining service life at the end of the analysis period. For the example calculation, assume the analysis period is 30 years of operation but the project has a useful service life of 40 years. The total project cost, in real dollars, is \$40 million. The residual value of the project would thus be:

$$RV = \left(\frac{U - Y}{U}\right) x\ Project\ Cost$$
$$= \left(\frac{40 - 30}{40}\right) x\ \$40{,}000{,}000$$
$$= \$10{,}000{,}000$$

Where RV = Residual Value
U = Useful Service Life of Project
Y = Years of Analysis Period Project Operation

It's important to note that this \$10,000,000 in residual value benefits would occur in the final year of the analysis and should be discounted the same as other project benefits and costs in the BCA.

Example Cycling Journey Quality Valuation Calculation

In addition to other common benefit categories such as crash reduction or travel time savings, cycling infrastructure valuation calculations may apply revealed preference values which assess qualitative differences in comfort or ride quality for different types of cycling infrastructure. For the example calculation, assume 1.2-miles of a street which sees 60 daily cyclists is proposed to receive an on-street cycling lane, and that no other parallel facility is currently available for use. Assume that with the proposed project, an additional 10 cycling trips are induced per day. Given this context, and using the values in Appendix A, Table A-9, the daily benefit of adding cycling lanes for existing cyclists would be as follows:

$$\begin{aligned} \textit{Existing User Benefits} &= \#\ \textit{of Cyclists x Bike Lane Value per Cycling Mile x Distance} \\ &= 60\ \textit{Cyclists x}\ \$1.86\ \textit{per Mile x}\ 1.2\ \textit{Miles} \\ &= \$133.92 \end{aligned}$$

Next, estimate the benefits for the additional users using the rule of half:

$$\begin{aligned} \textit{Benefits to Additional Users} &= \frac{1}{2} x\ \#\ \textit{of Cyclists x Bike Lane Value per Cycling Mile x Distance} \\ &= \frac{1}{2} x\ 10\ \textit{Induced Cycling Trips x}\ \$1.86\ \textit{per Mile x}\ 1.2\ \textit{Miles} \\ &= \$11.16 \end{aligned}$$

Summing the benefits for both existing and induced cycling trips, this hypothetical example would generate $145.08 in benefits per day in terms of ride quality and comfort. This value would then need to be annualized, based on an assumption of what portion of the year such benefits could be expected. For example, certain routes, such as those predominantly used for local trips or commuting, may be expected to produce similar benefits each day of the year (thus, should be annualized at 365), while others where use is expected to be predominately long-distance recreation may have more seasonal variation in demand where benefits would be annualized at a lower number of days per year. Additionally, as also noted in Appendix A, Table A-9, the assumed mileage per user should be capped at 2.38 miles, the average cycling trip distance in the United States, unless an applicant has a clear rationale and documentation for assuming otherwise.

In addition, because the above hypothetical project has likely induced a portion of users to take active transportation trips, there are also monetizable benefits accruing from mortality reduction, which are described in the next example.

Example Active Transportation Mortality Reduction Benefit Calculation

Certain improvements to infrastructure may induce more users to take additional trips via active transportation modes such as walking and cycling. Such modal shift is likely to lead to additional physical activity for these induced users, which correlates with reduction in mortality, a benefit that can be monetized for inclusion in BCA. In the example above, a bike lane addition was assumed to lead to 10 additional daily cycling trips on the improved facility. To perform the benefit estimate, applicants must first identify the portion of induced trips for which the mortality reduction values are applicable. For the hypothetical project above, only trips diverted from non-active transportation modes would be applicable, and only those within the age range (20-64 in the case of cycling) for which the mortality reduction values are applicable should be used in the calculation. Applicants may have project specific or local estimates for these assumptions, which should be applied. However, absent more local data, the general parameters given in Table A-13 may be used, which would yield the following calculation for daily trips for which mortality reduction estimation would be applicable:

$$\begin{aligned} New\ Trips\ Meeting\ Criteria &= \#\ of\ Induced\ Trips\ x\ \%\ in\ Age\ Range\ x\ \%\ from\ Non\ AT\ Modes \\ &= 10\ Induced\ Cycling\ Trips\ x\ 59\%\ x\ 89\% \\ &\approx 5.3\ Trips\ Meeting\ Criteria \end{aligned}$$

Using this estimate, the active transportation mortality benefits would be as follows:

$$\begin{aligned} Mortality\ Reduction\ Benefit &= \ \#\ of\ Induced\ Trips\ Meeting\ Criteria\ x\ \$\ per\ Induced\ Trip \\ &= \ 5.3\ Induced\ Cycling\ Trips\ Meeting\ Criteria\ x\ \$6.80 \\ &= \$36.04 \end{aligned}$$

Applicants should note that, unlike the estimate in the previous section, the calculation does not depend on the facility length, but rather the number of trips induced (which of course may indirectly depend on the size and type of proposed facility improvement). The reason for this is that the trip quality benefits depend on the portion of the trip actually being taken on the proposed facility, whereas the mortality reduction benefits depend on the trip itself being taken, whether or not the entire induced trip takes place on the new proposed facility. As with the previous benefit calculation, the value estimated above would need to be annualized, based on the proportion of the year for which the estimate is assumed to be applicable for the amount of use of a proposed facility. Applicants should clearly state and document these assumptions.