Appendix A: Additional Information on Benefit-Cost Analysis

Each applicant should provide evidence that the expected benefits of the project *justify* the costs (recognizing that some costs and benefits are difficult to quantify). If it is clear that the benefits do not justify the costs, the Department will not award a TIGER Discretionary Grant to the project. Benefits include the extent to which residents of the United States as a whole are made better off as a result of the project.

The best applications are often prepared by transportation agencies that have used in-house economic expertise and benefit-cost analysis (BCA) to influence the design of the project from the beginning. All Applicants should also consult the TIGER BCA Resource Guide available on the USDOT TIGER website (http://www.dot.gov/highlights/TIGER/tiger-bca-resource-guide) that will provide supplemental information, standard monetized values (where available), and updates for preparing a BCA. If, after reading this appendix, applicants need additional help, DOT staff are available to answer questions and offer technical assistance until the final application deadline has passed.

This appendix provides general information and guidance on conducting an analysis. In addition to this guidance, applicants should refer to OMB Circulars A-4 and A-94 in preparing their analysis (http://www.whitehouse.gov/omb/circulars/). Circular A-4 also cites textbooks on benefit-cost analysis (e.g., Mishan and Quah[1]) if an applicant wants to review additional background material.

In the Executive Summary for any benefit-cost analysis, applicants should provide a project matrix describing the project and what it changes (see below). This can be either in Word or in Excel. The first column provides a description of the current infrastructure baseline (including anticipated changes over the analysis period) and identifies the problem that the

[1] E.J. Mishan and Euston Quah, *Cost-Benefit Analysis*, 5th edition (New York: Routledge, 2007).

project will address. The second column describes how the project would change the current infrastructure baseline. The third and fourth columns describe the impact of that change and the corresponding population that it affects. The fifth column identifies the economic nature of those benefits. The last columns summarize the results and reference where in the analysis the benefits are calculated. The matrix below provides an example of a completed matrix.

Current Status/Baseline & Problem to be Addressed	Change to Baseline/ Alternatives	Type of Impacts	Population Affected by Impacts	Economic Benefit	Summary of Results	Page Reference in BCA
Stop light at lightly used (non-peak) rural intersection / excess waiting time and safety hazard	Replace with roundabout /signal phasing improvement	Reduce wait time for vehicles (non-peak) & reduce accidents (peak)	Number of drivers with reduced wait time & number of accidents/fatalities & injuries per year	Monetized value of reduced travel times, emissions, and accident costs	Estimated dollar value of time savings, reduced pollution, and safety benefits	pp. 15-18 and p.19

If an application contains multiple separate projects (but that are linked together in a common objective), each of which has independent utility, the applicant should provide a separate matrix (and analysis) for each project. The Executive Summary should also include the full cost of a project, including Federal, State, local, and private funding, as well as expected operations and maintenance costs, and not simply the requested grant amount or the local amount.

In addition to the matrix, the applicant should summarize all pertinent data and quantifiable benefit and cost calculations in a single spreadsheet tab (or table in *Word*). It should also summarize all other benefits that are difficult to quantify, and the applicant would also present this at the beginning of the BCA. The following provides a simplified example for expository purposes of discounted benefits and costs from a road project providing travel time savings to local travelers only over the course of five years. In practice, applicants must estimate both benefits and costs for each year after the project's start date and for a period of time of *at least* 20 years in the future (or the project's useful life if it is shorter). If the project will continue

to have benefits beyond the end of the analysis period, applicants can include a residual value of the project at the end of the analysis period, and treat that as an additional benefit, discounted from the end of the analysis period. Applicants may also discount the benefits and costs separately and calculate a present value of each.

Calendar Year	Project Year	Affected Drivers	Travel Time Saved (hours)[1]	Total Value of Time Saved ($2008)[2]	Initial Costs ($2008)	Operations & Maintenace Costs ($2008)[3]	Undiscounted Net Benefits	Discounted at 7%
2011	1				$38,500,000	$6,000,000	-$44,500,000	-$41,588,785
2012	2	80,000	1,040,000	$14,248,000		$700,000	$13,548,000	$11,833,348
2013	3	95,000	1,235,000	$16,919,500		$700,000	$16,219,500	$13,239,943
2014	4	100,000	1,300,000	$17,810,000		$700,000	$17,110,000	$13,053,137
2015	5	102,000	1,326,000	$18,166,200		$700,000	$17,466,200	$12,453,159
2016	6	109,000	1,417,000	$19,412,900		$700,000	$18,712,900	$12,469,195
NPV								$21,459,998
1. Number of drivers times three minutes a day (3/60 hours) over 260 workdays								
2. Hours at $13.70 per hour ($2008)								
3. Includes costs from delays to users during construction								

The following sections will help guide applicants through the matrix. This is useful both to fill out the matrix (and in the process to adequately scope and outline the analysis) and to actually carry out the analysis.

Baselines

Applicants should measure costs and benefits of a proposed project against a baseline (also called a “base case” or a “no build” case). The baseline should be an assessment of the way the world would look if the project did not receive the requested TIGER Discretionary Grant funding. Sometimes, it is reasonable to forecast that that baseline world resembles the present state. However, it is important to factor in any projected changes (e.g., baseline economic growth, increased traffic volumes, or completion of already planned and funded projects) that would occur even in the absence of the requested project.

Baseline assumptions need to incorporate the transportation options with the highest net benefits that would be available in the absence of the project. Baselines should incorporate

accurate descriptions of current traffic/shipping patterns. It is also important that the applicant assume the continuation of reasonable and sound management practices in establishing a baseline. Assuming, for example, a baseline scenario in which the owner of the facility does no maintenance on the facility and ignores traffic problems and maintenance is not realistic and will lead to the overstatement of project benefits and will affect the rating of the BCA.

Applicants must demonstrate that the proposed project has independent utility. Sub-components of a larger project may have little or no transportation value in the absence of the other components. For example, a ramp to an undeveloped site does not have much utility if the site does not get developed. While the project may increase the likelihood of development of the site, the application must be realistic in assessing the probability that transportation improvements will actually induce development. Applicants should estimate benefits both with and without anticipated development.

Baselines also need to be realistic in the transportation assumptions that they make. If a project would construct a short freight rail spur from a railroad mainline to a particular facility, it is unrealistic to assume that, in the absence of the project, individuals would ship cargo by truck for thousands of miles, whereas they would ship the same cargo by rail with the project. A realistic description of current traffic would more likely have current cargo traffic going by rail for most of the distance, and then by truck for the relatively short distance over which rail transportation is not available.

The applicant must make clear exactly what portions of the project form the basis of the estimates of benefits and costs. It is incorrect to claim benefits for the entire project but only count as costs the costs of the portion of the project funded by the TIGER Discretionary Grant. Thus, it would be incorrect to attribute all the benefits from a new port facility to a TIGER

Discretionary Grant when the costs that are counted only cover the portion of the project funded by the TIGER Discretionary Grant, for example, paving a loading area.

There are cases where a grant may accelerate completion of the project that an applicant already was going to build. The benefits and costs in this case should thus be limited to the marginal benefits (and marginal costs) of completing the project in a shorter period of time and including the cost of expending resources on the project sooner than otherwise planned (i.e., a "now versus later" comparison).

Alternatives

An applicant should present and consider reasonable alternatives in the analysis. Applicants should evaluate smaller-scale and more focused projects for comparison purposes. For example, if an applicant is requesting funds to replace a pier, it should also analyze the alternative of rehabilitating the current pier. Similarly, if an applicant seeks funds to establish a relatively large streetcar project, it should also evaluate a more focused project serving only the more densely populated corridors of an area. A careful evaluation of the baseline will yield several alternative actions. The analysis should demonstrate that the proposed project is the most cost-effective option of all the alternatives considered.

Affected Population & Types of Impacts

Applicants need to carefully identify the different impacts that a project will have. For example, the rationale for many highway projects is to relieve peak-hour congestion which, in turn, reduces travel times and vehicle emissions. Other highway projects can improve road safety and, in turn, reduce accidents and corresponding property damage, injuries, and fatalities. It is important that applicants then match the types of impacts to the corresponding affected population (group and number of affected entities). For example, for a passenger project

applicants should measure the number of passengers and for a freight project the amount of freight affected.

Applicants should measure affected passenger and freight traffic in passenger-miles and freight ton-miles (and possibly value of freight). If, as is often the case (e.g., projected growth in highway traffic), the affected population is not the same for all years, then the applicant needs to break out affected population annually. Measures of freight traffic might include growing levels of port calls. In some cases, the relevant population is the volume of traffic that the project diverts from one mode to another. Applicants should be realistic as to how the project affects these populations.

Benefits – Long Term Outcomes

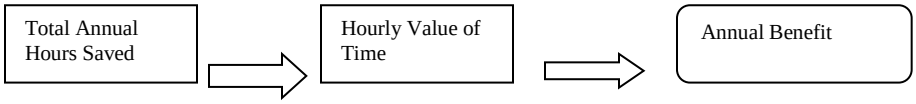
Each application must include in its analysis estimates of the project's expected benefits with respect to each of the five long-term outcomes that DOT specified in Section II (A) *(Selection Criteria).* We recognize that it may in some cases be unclear in which of these categories of outcomes an applicant should list a benefit. In these cases, it is less important in which category an applicant lists a benefit than to make sure that it lists and measures it (but only once). The following table provides examples of some of the types of benefits that might be listed under each of the long-term outcomes. These are some of the primary benefit categories, but this is not an exhaustive list. We describe these categories later.

Long-Term Outcome	Types of Societal Benefits
Livability	Land Use Changes that Reduce VMT Increased Accessibility Property Value Increases
Economic Competiveness	Travel Time Savings Operating Cost Savings
Safety	Prevented Accidents (Property Damage), Injuries, and Fatalities
State of Good Repair	Deferral of Complete Replacement Maintenance & Repair Savings

	Reduced VMT from Not Closing Bridges.
Environmental Sustainability	Environmental Benefits from Reduced Emissions

Types of Societal Benefits

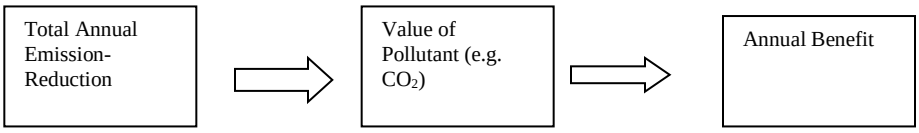
Travel time savings can result from transportation improvements whose purpose is to expand capacity or improve state of good repair. Where this is the case, applicants should clearly demonstrate how the travel time savings are experienced by the affected population. If travel time savings vary over time, the applicant must clearly show savings by year. The applicant must also be careful to estimate savings solely from the project funded by the requested grant, and not from other related projects not funded by the requested grant. Once the applicant generates its estimate of hours saved, it should apply the Department's guidance on the value of time to those estimates (http://www.dot.gov/office-policy/transportation-policy/guidance-value-time) to monetize them for both business and non-business travelers.



Operating cost savings frequently occur from both freight-related and passenger-related projects. Freight-related projects that improve roads, rails, and ports frequently generate savings to carriers (e.g., fuel savings and other operating cost savings) that they may pass on in whole or in part to shippers by way of lower freight rates. Shippers may, in turn, pass on, in whole or in part, these savings to consumers. Passenger-related projects can also reduce operating costs for passengers by providing lower-cost alternatives to the use of private vehicles or by reducing the operating costs of those vehicles. If applicants are projecting these savings as benefits, they need to carefully demonstrate how the proposed project would generate such benefits. However, applicants must be careful to count the value of the fuel and other operating cost savings

(however allocated among carriers, shippers, and consumers) only once in the benefit-cost analysis; it cannot be re-counted in full each time it transfers from one group to the other, as this would entail double-counting of the same benefit.

Transportation can generate environmental costs in the form of emissions of "criteria pollutants" (e.g., SOx, NOx, and particulates) and from the emission of greenhouse gases, such as carbon dioxide (CO_2). Increased traffic congestion results in increased levels of these emissions. Transportation projects that reduce congestion can reduce these emissions and produce *Environmental Benefits* given reduced idling and otherwise constant vehicle-miles travelled. Also, transportation projects that encourage transportation users to shift from more-polluting modes to less-polluting modes can similarly reduce emissions. Applicants claiming these types of benefits must clearly demonstrate and quantify how the project will reduce emissions. Once an applicant has adequately quantified levels of emission reductions, it should estimate the dollar value of these benefits. For sources of information on the social benefits of reducing criteria pollutant emissions, applicants should refer to the online BCA Resource Page (http://www.dot.gov/highlights/TIGER/tiger-bca-resource-guide).

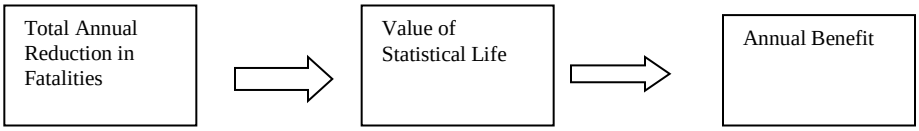


Many infrastructure projects that improve the state of good repair of transportation infrastructure can *reduce long-term maintenance and repair costs*. These benefits are in addition to the benefits of reductions in travel time, shipping costs, and crashes which the applicant should account for separately. Applicants should include these maintenance and repair savings as benefits. Improving state of good repair may also reduce operating costs and congestion by

reducing the amount of time that the infrastructure is out of service due to maintenance and repairs, or may prevent a facility (such as a bridge) from being removed from service entirely. The application should also consider differences in maintenance and repair costs when comparing different project alternatives. For example, an applicant can compare the maintenance costs that would be required after rehabilitating an existing pier with those that would be required after building a new one. As part of the data that go into estimating the benefits of improving the state of good repair, applicants should provide accepted measures for assessing an asset's current condition. For example, applicants can use Present Serviceability Ratings (PSR) or the International Roughness Index to discuss pavement condition and bridge sufficiency ratings to discuss the condition of a bridge. As discussed in the section on costs, the Department expects applicants to consider the life-cycle costs of the project when making these comparisons.

Projects can also improve the *Safety* of transportation. A well-designed project can reduce fatalities and injuries as well as reduce other crash costs. The applicant should clearly demonstrate how the project will improve safety. For example, to claim a reduction in fatalities, an applicant must clearly demonstrate how the existence of the project would have prevented the types of fatalities that commonly occur in that area. Applicants should use crash causation factors or similar analyses of causes of crashes to show the extent to which the type of improvements proposed would actually reduce the likelihood of the kinds of crashes that actually had occurred. Alternatively, when only a few cases are involved, the applicant should provide a description of the incidents and demonstrate the linkage between the proposed project and crash reduction. In some cases, safety benefits may occur because of modal diversion from a less safe mode to a safer mode. When applicants claim this type of benefit, they should provide a clear analysis of why the forecasted modal diversion will take place. Once the applicant has

established a reasonable count of the incidents that the project will likely prevent, it should apply the Department's guidance on value of life and injuries (http://www.dot.gov/office-policy/transportation-policy/guidance-treatment-economic-value-statistical-life) to monetize them. This and other relevant information on Abbreviated Injury Scale (AIS) are available at the TIGER BCA Resource Guide (http://www.dot.gov/highlights/TIGER/tiger-bca-resource-guide)**.**



Applicants must carefully net out other effects before taking benefits from *Property Value Increases* (e.g. from a transit station). For example, if the property value goes up by the exact same value as the developer's investment then this is not a benefit. Property value increases over and above the developer's investment may potentially be a benefit from the project. The analysis should also consider to what extent an increase in land values induced by the project in one area causes a reduction in land values in some other area. Applicants must also net out any property value increases that result from time savings or other benefits that have already been counted. Applicants can only count the net increase in land value as a benefit. Simply asserting that there is a property value increase net of time savings is inadequate. The Department expects any applicant claiming these types of benefits to provide a rigorous justification of the benefit. Applicants should note that any claimed societal benefit from a property value increase is only a one-time "stock" benefit. Applicants can not treat it as a stream of benefits accruing annually. To the extent possible, applicants should use survey methods to estimate the value of the estimate the value of the expected property value increase from transit or other transportation improvements. If an applicant uses benefit transfer methods, it should

take great care to satisfy the selection criteria and the disqualifying criteria noted in OMB Circular A-4 (p. 25). Meeting all of these criteria is difficult, but an applicant should satisfy most of them before applying this approach.

Transit and bicycle paths may provide greater accessibility to alternative transportation modes, but they will not actually enhance livability unless people use them, and the desire to use them will depend in part on where these modes go and on the amenities provided with them. If there is mode shift from vehicles to a bicycle path, then there will be benefits from reduced congestion for remaining drivers, time savings for mode-shifters (if applicable), savings from reduced vehicle operating costs (to some extent offset by any bicycle-related costs), and Sustainability benefits from reduced vehicle emissions. The applicant should estimate the number of people taken off the roads and then calculate the corresponding benefits. Transit and bicycle paths can also induce land use changes that result in greater density of development and more mixed-use development, thus reducing the number of passenger-miles of transportation needed to access jobs, schools, shopping, and recreational opportunities.

Other

Transfers are not benefits. Analysis should distinguish between real benefits and transfer payments. Benefits reflect reductions in real resource usage and overall benefits to society, while transfers represent payments by one group to another and do not represent a net increase in societal benefits. In the case of job creation, for example, every job represents both a cost to the employer (paying a wage) and a benefit to the employee (receiving a wage), so it is a transfer payment, rather than a net benefit. While wages are a transfer payment, increases in the productivity of the labor force, measured by increases in how much workers produce per hour, can be included as a benefit of the project, but these benefits must be carefully measured and

justified to be included. With respect to economic development, providing estimates of capital investments or property tax revenues are not legitimate benefits in a benefit-cost analysis. For example, while the tax is a benefit to the tax assessor it is a cost to the taxpayer. These transfers are commonly included in "economic impact analyses;" an economic impact analysis is not acceptable as a substitute for a benefit-cost analysis. Other examples of transfers include port/rail projects whose purpose is to take away business from competitors. However, the transportation cost savings (if any) and the like from shifting traffic to a more convenient location would be a benefit. Applicants should not include employment or output multipliers that purport to measure secondary effects as societal benefits because these secondary effects are generally the same (per dollar spent) regardless of what kind of project is funded.

As noted above, the estimate of *Costs* must pertain to the same project as the estimate of benefits. If the TIGER Discretionary Grant is to pay for only part of the project, but the project is indivisible (i.e., no one part of the project would have independent utility), then the applicant should compare the benefits of the whole project to the costs of the whole project, including costs paid for by state, local, and private partners other than the federal government. In general, applicants should use a life-cycle cost analysis approach in estimating the costs of the project. The Department expects applicants to include operating, maintenance, and other life-cycle costs of the project, along with capital costs. In addition to construction costs, other direct costs may include design and land acquisition. If the time period considered in the analysis is long enough to require the rehabilitation of the facility during the period of analysis, then the costs of that rehabilitation should be included. Applicants should consider external costs, such as noise, increased congestion, and environmental pollutants resulting from the use of the facility or related changes in usage on other facilities in the same network in the analysis. Additionally,

applicants should include, to the extent possible, costs to users during construction, such as delays and increased vehicle operating costs associated with work zones or detours. The applicant should correctly discount annual costs to arrive at a present value of the project's cost.

Applicants should *discount future benefits and costs* to present values using a real discount rate (i.e., a discount rate that reflects the opportunity cost of money net of the rate of inflation) of 7 percent, following guidance provided by OMB in Circulars A–4 and A–94 (http://www.whitehouse.gov/omb/circulars_default/). Applicants may also provide an alternative analysis using a real discount rate of 3 percent. They should use the latter approach when the alternative use of funds to be dedicated to the project would be for other public expenditures, rather than private investment. In presenting these year-by-year streams, applicants should measure them in constant (or "real") dollars prior to discounting. Applicants should not add in the effects of inflation to the estimates of future benefits and costs prior to discounting.

Benefit-cost analyses of transportation projects almost always depend on *forecasts* of projected levels of usage (road traffic, port calls, etc.). When an applicant is using such forecasts to generate benefit estimates, it must assess the reliability of these forecasts. If the applicant is using outside forecasts, it must provide a citation and an appropriate page number for the forecasts. Applicants should incorporate indirect effects into their forecasts where possible (e.g., induced demand). Applicants should also take great care to match forecasts of usage levels to the corresponding year. For example, using projected traffic levels for 2030 to generate benefits for all the earlier years is incorrect. For more information on forecasting, applicants can refer to the forecasting section of FHWA's Economic Analysis Primer (http://www.fhwa.dot.gov/infrastructure/asstmgmt/primer06.cfm). While produced for analysis

of highway projects, the primer is a good source of information on issues related to all transportation forecasting.

Applicants should make every effort to make the results of their analyses as *transparent and reproducibl*e as possible. A Department reviewer reading the analysis should be able to understand the basic elements of the analysis and the way in which the applicant derived the estimates. It is inadequate for the applicant only to provide links to large documents or spreadsheets as sources. The Department expects applicants to clearly cite all outside data sources with the corresponding page number (or cell number, for a spreadsheet). For more detailed documentation, applicants must include a thorough verbal description of how they did the calculation. This should include references to tabs and cells in the spreadsheet. This verbal description should include specific sources for all the numbers in the spreadsheet (i.e. those that the spreadsheet itself does not calculate). If an applicant uses a "pre-packaged" economic model to calculate net benefits, the applicant should provide annual benefits and costs by benefit and cost type for the entire analysis period (including forecast year traffic volumes). In any case, applicants must provide a detailed explanation of the assumptions used to run the model (e.g., peak traffic hours and traffic volume during peak hours, mix of traffic by cars, buses, and trucks, etc.). The applicant must provide enough information so that a Department reviewer can follow the general logic of the estimates (and, in the case of spreadsheet models, reproduce them).