Tools for Assessing the Wider Economic Benefits of Transportation (C11)
Implementation Assistance
Lead Adopter Incentive

Evaluation of EconWorks Wider Economic Benefits Analysis Tools Use for Benefit-Cost Analysis

By
Southeast Regional Planning and Economic Development District (SRPEDD)

For

Federal Highway Administration (FHWA)

and

American Association of State Highway and
Transportation Organizations (AASHTO)

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INTRODUCTION AND PROJECT GOALS

The fundamental goal of this project was to determine the feasibility for mid-sized regional planning agencies, including Metropolitan Planning Organizations (MPOs), to quantify the wider economic benefits of highway transportation projects using EconWorks Wider Economic Benefits (W.E.B.) analysis tools. This report documents SRPEDD's process and experience using the W.E.B. analysis tools, including demands on staff time and the budget necessary to develop institutional capacity to apply the tools, interpret results, and determine what resources would be necessary to deploy the tools to the full portfolio of long range transportation plan and TIP projects on an ongoing basis. Another key component of the study was an organization-wide examination of ways the tools could be used at various stages of the planning process, and an estimate of what the different resource needs would be for use at the different stages.

Wider economic benefits are not meant to be analyzed alone, but rather as part of a comprehensive economic analysis that also captures standard travel benefits ("user benefits"). Comprehensive economic analysis could take the form of Benefit-Cost Analysis (which quantifies all the benefits and all the costs expressed as a benefit-cost ratio of dollars of benefit per dollars of cost), Economic Impact Analysis (which traces the flow of monetized benefits through the economy as measured by jobs, business income, and wages, including multiplier effects), or a Multi-criteria Analysis (which includes economic and non-economic factors such as environmental impacts and social justice impacts).

Through organizational discussions at the outset of the project, SRPEDD determined that benefit-cost analysis would be most useful for evaluating the economic implications of planned and proposed transportation projects with economic development goals (versus those being undertaken largely for safety, environmental, or other non-economic/non-monetary purposes). Moreover, a benefit-cost ratio allows projects to be compared on an "apples to apples" basis; this is because all the same elements of cost and benefit are captured for each project and then are "standardized" by taking the ratio of benefit to cost. By including wider economic benefits, the benefit cost analysis will more fully reflect economic development potential.

This report documents how SRPEDD developed: (1) the requisite theoretical understanding of the wider economic benefits of transportation improvements; (2) the necessary technical understanding of the W.E.B. analysis tools; and (3) a framework for incorporating wider economic benefits of transportation into a benefit-cost analysis. It compares the results of the W.E.B. analysis tools to the results from another widely available benefit-cost analysis tool, then discusses the feasibility of incorporating such benefit-cost analysis (with wider economic benefits) into SRPEDD's process for evaluating TIP and RTP projects.

Project Context

About EconWorks Wider Economic Benefits (W.E.B) Analysis Tools

The stated goal of FHWA's SHRP2 Capacity focus area "is to develop approaches and tools for systematically integrating environmental, economic, and community requirements into the analysis, planning, and design of new highway capacity".[1] Traditional transportation economic analysis has focused on traveler benefits (also called user benefits) - direct effects on travel time, vehicle operating cost, and collision incident cost. While these direct benefits are real and important, planners and economists have long understood that impacts of transportation infrastructure on the economy are much broader and more dynamic, with far-reaching effects on supply chain management, business location decisions, and economic development competitiveness.

Direct traveler benefits are often fed into an input-output model to quantify some of the multiplier impacts of that time/cost savings[2]. Yet because the indirect/induced economic impacts are calculated from the limited concept of direct traveler benefits, this approach still ignores wider economic benefits that result from firms responding to improved transportation infrastructure by *fundamentally changing the way they do business*. That is to say, the new infrastructure allows firms to improve their internal productivity – their business output increases while still using the same level of input as before the investment.

More recently, transportation economists have begun to quantify these wider economic benefits in a systematic way. Under SHRP2 Project C11, FHWA and AASHTO developed a set of user-friendly, spreadsheet-based, sketch-level planning tools to assess the wider economic benefits of highway transportation capacity projects called Wider Economic Benefits (W.E.B.) analysis tools. Specifically, they addressed the following three classes of project benefits beyond traditional traveler benefits:

• **Travel time reliability benefits.** These benefits are the result of reductions in non-recurring delay (variable congestion due to differing levels of traffic and high crash rates), improving travel time reliability for both passengers and freight.

• **Intermodal connectivity benefits.** Shippers and receivers benefit when a highway project significantly reduces access time to key transfer facilities such as airports and marine ports and terminals.

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[1] Forward, Report S2-C11-RW-1 Development of Tools for Assessing Wider Economic Benefits of Transportation.
[2] Indirect and induced impacts characterized as additional business spending, personal income, and jobs.

• **Market access benefits**. Improved highway access to consumer/supplier markets and labor markets for truck deliveries commuters respectively can generate measurable benefits in terms of regional economic growth.

The W.E.B suite of analysis tools consists of a Travel Time Reliability Tool, Intermodal Connectivity Tool, two tools to assess Market Access Benefits (one for Labor Markets and one for Consumer/Supplier Markets), plus a benefit-cost accounting framework. The accounting framework is designed to help organize relevant benefit streams, including standard travel benefits as well as one or more types of wider economic benefits as part of a more complete economic analysis, such as a benefit-cost analysis, economic impact analysis, or multi-criteria analysis. The tools are hosted online by AASHTO at https://planningtools.transportation.org/75/analysis-tools.html.

About SRPEDD

Originally established in the 1950s as a voluntary regional planning consortium with 15 municipal members, today's Southeast Regional Planning and Economic Development District (SRPEDD) was formalized in the 1960s, with mandatory membership eventually encompassing 27 jurisdictions. Governed by a Commission of local officials and citizens, SRPEDD plans for the region's land use, transportation, economy, and environment while assisting member cities and towns to operate more efficiently through municipal partnerships and regionalization initiatives.

SRPEDD's official mission is to plan for the future of southeastern Massachusetts that includes expansion of economic opportunity, protection of natural and historic resources and development of excellent physical and cultural amenities. The region is a mix of urban, suburban and rural communities with a population of over 600,000.

In its role as MPO, SRPEDD is responsible for developing the region's long-range transportation plan, as well as its Transportation Improvement Program (TIP), which is then incorporated into the statewide TIP. A number of factors motivate SRPEDD to evaluate projects using objective, empirical criteria when feasible; for example, the TIP is fiscally constrained and projects face statewide competition for declining federal and state transportation dollars.

Objective project evaluation, including quantitative measures of economic impact, is of increasing importance to federal and state transportation agencies, which are the primary sources of transportation project funds. The federal transportation authorization bill of 2012, MAP-21, calls for a shift towards performance-based planning and programming and introduces seven goal areas. The Freight Movement and Economic Vitality goal area specifically highlights "support of regional economic development". Presumably, this trend towards performance-based programming will continue under the 2015 Fixing America's Surface Transportation (FAST) Act.

Likewise, MassDOT is implementing a project prioritization formula and framework that represents "a more uniform, data-driven, and transparent project selection process" for its 5-year Comprehensive Transportation Plan (Capital Improvement Plan, CIP) and the TIP projects that it includes. For highway modernization and highway capacity projects (two of the six sets of criteria), this framework includes two economic criteria to be evaluated quantitatively: cost effectiveness and economic impact. (Please note that a benefit-cost ratio is a measure of cost effectiveness).

In response to this shift toward performance-based and data-driven planning and programming at the state and federal levels, SRPEDD is exploring development of a more standardized, quantitative process by which to evaluate economic aspects of projects being considered for integration into the Regional Transportation Plan and TIP. Historically, the organization has identified the presence of potential economic benefits based on input from affected communities, the experience of town, and the assessment of SRPEDD transportation planning and economic development staff. However, this "TIP Evaluation Criteria" process has not always involved formal analysis or quantification, and has instead been more anecdotal in nature, and measured in terms of "yes/no" or "high/moderate/low". SRPEDD's TIP development process is discussed in greater detail in the final section of this report.

Selection of Projects for Analysis

For this study, SRPEDD selected two projects to assess using W.E.B analysis tools. These projects, the proposed Middleborough Rotary realignment and replacement of the Fairhaven-New Bedford Bridge, were selected because they (1) are of regional significance, (2) affect key local roadways used by trucks and commuters, and (3) reflect a typical level of complexity representative of projects in SRPEDD's portfolio. Both projects are in the planning phases, though at different stages and, coincidentally, both are subjects of ongoing planning and engineering consulting studies for MassDOT.

APPROACH & METHODOLOGY

This chapter first discusses SREPDD's general approach to developing a theoretical understanding of the wider economic benefits of transportation improvements. It proceeds to describe the process SRPEDD followed to understand the technical aspects of the W.E.B analysis tools. Finally, it introduces the methodology staff developed based on this theoretical and technical understanding.

Identifying and Leveraging User Guide Materials

This section summarizes the resources SRPEDD reviewed before beginning data collection and analysis. These documents are available to all analysts wishing to use the W.E.B analysis tools. This list is not meant to be comprehensive, but instead includes the documents most helpful in developing our methodology.

W.E.B Analysis Tool User Manual. The document "SHRP2 Capacity Research: Development of Tools for Assessing Wider Economic Benefits of Transportation" details the development of the W.E.B analysis tools and includes a technical guide that documents underlying concepts, calculations, and assumptions, as well as an explanation of the accounting matrix which helps the user conceptualize and organize the results of the tools in the broader context that also includes standard travel benefits. It also contains a step-by-step user guide for each tool, including data collection needs, inputs, screen shots of input and output screens, as well as interpretation of outputs.

While one could use the W.E.B analysis tools with the User Manual alone, there are a number of supplementary resources that are particularly useful for analysts new to the concept of wider benefits of transportation, for those facing complex or non-traditional highway transportation projects, and for organizations wishing to explore how best to use wider economic benefits in their transportation infrastructure decision-making process. These resources are summarized below.

Assessing Productivity Impacts of Transportation Investments: Final Report and Guidebook (Project NCHRP 02-24). This report, prepared for the National Cooperative Highway Research Program, is essentially a primer on how to understand and quantify the role of productivity and transportation infrastructure. Encompassing all modes of transportation, it places the wider economic benefits of transportation within the context of the complete analytical process, be it benefit-cost analysis, economic impact study, or multi-criteria analysis.

True to the "guidebook" in its name, it provides a step-by-step guide to quantifying wider economic benefits, including worksheets and rubrics to help screen for

productivity impacts, selecting the appropriate analytical tool, and using productivity impacts at different stages of the decision-making process. It contains an overview of available analytical tools – including the W.E.B analysis tools – and discusses the particular strengths of each and how to approach a custom productivity analysis for projects or project components not addressed by existing tools. Finally, it provides guidance on identifying potential sources of benefits and how to avoid double counting them. This resource is an essential companion to the official User Guide. The methodology detailed in therein formed the basis for the methodology we employed in our analyses, as discussed in the methodology section below.

SHRP2 Project C32: Application of the SHRP2 C11 Tools to a Sample of Existing TPICS Cases. This report presents the results of applying the W.E.B analysis tools to a set of nine EconWorks case studies (formerly called Transportation Project Impact Case Studies, or TPICS, hence the document title). The cases were selected, based on their project motivations, to correspond to the three drivers of wider economic benefits captured by the W.E.B analysis tools: Accessibility, Connectivity (intermodal), and Reliability. The purpose of the study was to demonstrate the relationship between the wider benefits captured by the W.E.B analysis tools relative to the economy-wide benefits captured by the EconWorks case studies. The report is also of use to analysts wishing to utilize W.E.B analysis tools in two important ways: (1) It clearly shows how data is gathered and organized for use as tool inputs, and (2) it helps illustrate the three different categories of wider benefits.

W.E.B Analysis Tool Webinar. EconWorks, a collaboration between AASHTO and SHRP2, sponsored a Wider Economic Benefit Analysis Tool Training webinar presented by the EDR Group staff who led the W.E.B. analysis tool development project. The webinar took place in March 2015, and all materials including full audio and slideshow, as well as a PDF version of the slides, are available at https://planningtools.transportation.org/361/economic-analysis-training.html (choose "Take the SHRP2 Wider Economic Benefits Analysis tools online training course to learn more about the tools" at the bottom of the page). The training provides a helpful overview of wider economic benefits, how they fit into different types of transportation economic analysis, and a brief tour of available resources that provide a more in-depth understanding of the different sources of wider economic benefits and when and how to capture them.

Developing A Methodology

This section describes how we used the technical knowledge gained from the various resources described above to develop a methodology to implement the tools. We began using the basic steps and screening tools laid out in the NCHRP 02-24 report, as follows[3]:

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[3] "Assessing Productivity Impacts of Transportation Investments", NCHRP 02-24, page 32.

Step 1: Screen to Identify the Likelihood of Productivity Impacts – Assess whether productivity analysis is appropriate for a given project with these sub-tasks:

- Collect basic project information such as that shown in Figure 7 in NCHRP 02-24, reproduced in the Appendix of this report as Table 22;
- Review "Classification of Transportation Projects by Form of Productivity Impact" (Table 1 in NCHRP 02-24, reproduced in the Appendix of this report as Table 23);
- Apply the Screening Decision Table Tool presented in NCHRP 02-24, reproduced in the Appendix as Table 24, to determine whether available analysis tools can be utilized.

Step 2: Select Applicable Tools – Use Step 1 information with an Analysis Tool Selection Table (such as NCHRP 02-24 Table 6, reproduced in the Appendix of this report as Table 25) to determine the types of transportation impact factors that need to be analyzed and to identify the analysis tools available for measuring them.

Step 3: Measure Standard Traveler Benefits – Assemble transportation data and calculate direct effect on travel-related business costs.

Step 4: Calculate Wider Transportation Benefits and Calculate Productivity Elements – Use data from Step 3 with tools from Step 2 to calculate reliability, market access or intermodal connectivity impact; apply coefficients and elasticities to Step 4 results to calculate impacts on cost or output scale for directly affected businesses. The NCHRP methodology, which is not tool-specific, breaks this into two steps, the first captures hours of non-recurring delay (in the case of projects that affect reliability, as we are analyzing here) and translates those hours into cost. However, the W.E.B analysis tools perform both functions with one set of inputs, so we were able to combine these tasks into one step.

Step 5: Interpret Productivity Results – Use results in project evaluation processes: Multi-Criteria Analysis, Benefit-Cost Analysis, Economic Impact Analysis or "stand-alone presentation." For our analysis, we have chosen to integrate the results into a benefit-cost analysis.

APPLYING THE W.E.B. RELIABILITY TOOL TO SELECTED SRPEDD PROJECTS

This section provides a description of each transportation project analyzed, the socioeconomic context of the project, a detailed account of how the screening tools were applied and their implications, discussion of how data was collected and inputs developed, and the results of the W.E.B reliability tool runs.

Figure 1. Middleborough Rotary – Existing Alignment

Project Description

Middleborough Rotary is the intersection of Route 44, Route 18, and Route 28, just 0.3 miles from the I-495/Route 44 interchange (exit 6) in Middleborough. The rotary experiences high traffic volumes from nearby commercial development (hotels, retail centers, a car dealership, and restaurants), and significant truck traffic from the light industrial and distribution centers nearby, resulting in traffic congestion even during off-peak hours, queues that back up onto I-495 during morning and evening peak periods, and a higher than average incidence of crashes[4].

Various alternatives were evaluated and a preferred alternative has been selected which meets congestion reduction and safety/crash reduction goals, while also satisfying the environmental constraints (primarily due to adjacent wetlands). The concept plan for the preferred alternative is shown below in   . A key element of the realignment is a "flyover" bridge that allows through traffic on Route 44 to bypass the rotary. The alternatives analysis is part of a larger study being conducted by MassDOT consultants, which includes engineering and other elements that provided much of the data needed to run the W.E.B. Reliability tool, including travel speeds, times, and vehicle counts (and trucks as a percentage of total vehicles) for the no-build and build scenarios.

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[4] The rotary has a crash rate of approximately 4.15, 11% higher than average for urban minor arterials (2012).

Figure 2. Middleborough Rotary Preferred Alternative Concept Plan

CONCEPT PLAN

FST

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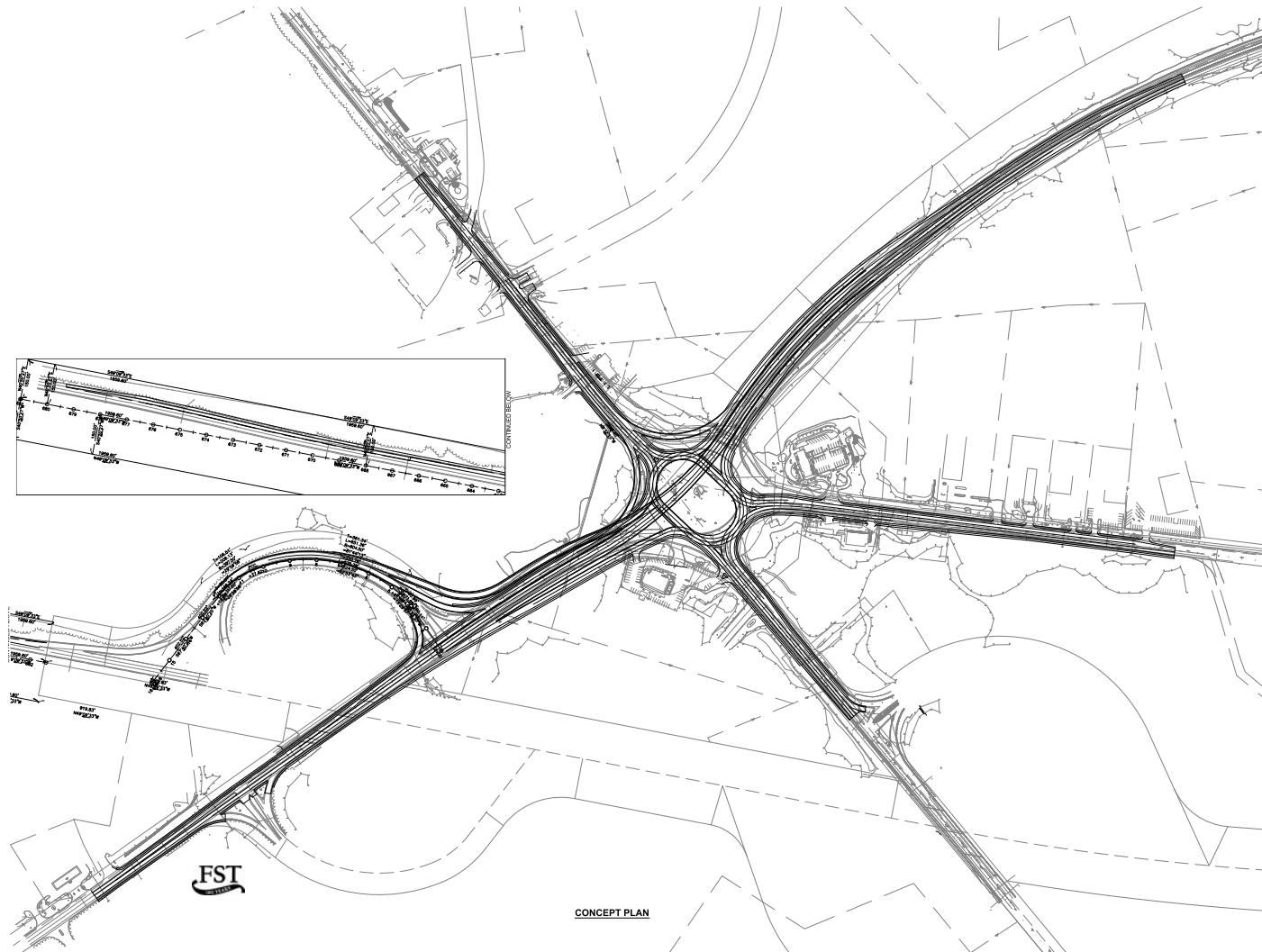
Socioeconomic Context

Middleborough had a population of approximately 23,500 as of the 2014 American Community Survey (5-year). This was an increase of approximately 1.8 percent over the community's 2010 Census population, reflecting an annual average growth rate of less than 0.5 percent per year. Between the 2000 and 2010 Censuses, population increased at an average of 1.5 percent per year.

Productivity benefits (which drive wider economic benefits of transportation projects) are generated by business travel in the form of freight/truck trips, on-the-clock business travel, and to some extent, workforce commute trips, so it is important to understand the size and industry composition of the local economy.[5] Middleborough had employment of nearly 8,500 in 2013, a slight decline (about 1 percent) since 2008.[6] Manufacturing has a significant presence in the economy, accounting for nearly 19 percent of jobs (statewide, manufacturing accounts for 7.6 percent of employment). Additionally, the following sectors account for greater shares of employment in Middleborough than they do in the Massachusetts economy as a whole: wholesale trade; management of companies and enterprises, administrative and waste services; accommodation and food services; and other services. Between 2008 and 2013, manufacturing shed nearly 160 jobs, a decrease of 9 percent (for comparison, manufacturing in the statewide economy contracted by more than 12 percent). Among other economic base industries, Middleborough has experienced growth in wholesale trade; transportation and warehousing; information; professional and technical services; management of companies; and administrative and waste services. All of these industries could experience productivity benefits from the proposed projects, particularly manufacturing, and the growing wholesale trade, and transportation and warehousing industries which have a higher than average reliance on transportation.

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[5] A bedroom community with few businesses would not benefit as much from a transportation project as one with many businesses that are heavily dependent on sending and receiving shipments, sales reps, customers, and (to a more limited extent) workers.

[6] Executive Office of Labor and Workforce Development.

Table 1. Middleborough Employment by Industry, 2008 & 2013

	Middleborough					Massachusetts			LQ[3]
	2008	2013	% of 2013 Jobs	% Change	CAGR[1]	% of 2013 Jobs	% Change	CAGR[1]	
Total, All Industries[2]	8,579	8,484	100.0%	-1.1%	-0.2%	100.0%	1.6%	0.3%	--
11 - Agriculture, Forestry, Fishing & Hunting	45	44	0.5%	-2.2%	-0.4%	0.2%	9.1%	1.7%	2.4
21 - Mining	n/a	n/a	n/a	n/a	n/a	0.0%	-29.8%	-6.8%	n/a
23 - Construction	593	358	4.2%	-39.6%	-9.6%	4.1%	-7.3%	-1.5%	1.0
31-33 - Manufacturing	1,753	1,595	18.8%	-9.0%	-1.9%	7.6%	-12.5%	-2.6%	2.5
22 - Utilities	n/a	n/a	n/a	n/a	n/a	0.4%	0.1%	0.0%	n/a
42 - Wholesale Trade	384	425	5.0%	10.7%	2.0%	3.7%	-9.5%	-2.0%	1.3
44-45 - Retail Trade	806	819	9.7%	1.6%	0.3%	10.5%	-0.2%	0.0%	0.9
48-49 - Transportation and Warehousing	249	282	3.3%	13.3%	2.5%	3.0%	-2.7%	-0.5%	1.1
51 - Information	41	52	0.6%	26.8%	4.9%	2.8%	-3.7%	-0.7%	0.2
52 - Finance and Insurance	535	473	5.6%	-11.6%	-2.4%	5.0%	-7.9%	-1.6%	1.1
53 - Real Estate and Rental and Leasing	65	26	0.3%	-60.0%	-16.7%	1.3%	-1.1%	-0.2%	0.2
54 - Professional and Technical Services	212	268	3.2%	26.4%	4.8%	8.5%	6.2%	1.2%	0.4
55 - Management of Companies and Enterprises	121	323	3.8%	166.9%	21.7%	2.0%	4.6%	0.9%	2.0
56 - Administrative and Waste Services	505	609	7.2%	20.6%	3.8%	5.1%	0.4%	0.1%	1.4
61 - Educational Services	720	780	9.2%	8.3%	1.6%	10.3%	6.2%	1.2%	0.9
62 - Health Care and Social Assistance	820	661	7.8%	-19.4%	-4.2%	17.7%	16.5%	3.1%	0.4
71 - Arts, Entertainment, and Recreation	21	22	0.3%	4.8%	0.9%	1.7%	5.8%	1.1%	0.1
72 - Accommodation and Food Services	855	927	10.9%	8.4%	1.6%	8.6%	10.0%	1.9%	1.3
81 - Other Services, Ex. Public Admin	439	431	5.1%	-1.8%	-0.4%	3.4%	-13.6%	-2.9%	1.5
92 - Public Administration	391	362	4.3%	-7.4%	-1.5%	4.1%	-1.2%	-0.2%	1.0

[1] CAGR = Compound annual growth rate.

[2] Total for all industries is greater than the sum of individual industries due to suppression for confidentiality.

[3] LQ = location quotient (ratio of the % of total jobs in that industry in Middleborough to the % of total jobs in that industry in Massachusetts as a whole).

Source: Covered Employment and Wages (ES-202) from MA Office of Labor & Workforce Development Labor Market Information.

Analysis of Wider Economic Benefits

This section details Steps 1 through 5 as applied to analysis of the Middleborough Rotary realignment project.

Step 1: Screen for Possible Productivity Impacts

Using the project information described above, we completed the Project Classification Form provided in NCHRP 02-24, shown in the Appendix in Table 22 (it is Figure 7 in the NCHRP document). Much of the necessary project information was available from the MassDOT feasibility studies, as well as documents submitted to SRPEDD and MassDOT as part of the TIP review process, such as the Project Need Form (PNF), Project Initiation Form (PIF), and Transportation Evaluation Criteria (TEC) document. We then reviewed this project information in the context of NCHRP 02-24 Table 1 "Classification of Transportation Projects by Form of Productivity Impact" to determine which of the following three categories the project corresponds to:

1. Projects with little or no productivity benefits, in which case no further analysis would be necessary);
2. Projects with productivity benefits driven by traditionally measured user benefits (vehicle miles traveled, vehicle hours traveled), in which case use of W.E.B. analysis tools would not be necessary; or
3. Projects with wider business benefits not all captured by traditional user benefit assessment.

The Middleborough Rotary corresponds to the third type of project; moreover, it fits neatly into category C1 of NCHRP 02-24 Table 1- "Projects that can Enhance Reliability (and reduce time cost) for Business-Related Travel" in terms of reduction in peak period congestion bottlenecks, reduction in incidence of interfering activities (particularly through the flyover bridge project element), reduction in incidence of collisions, and proximity to active commercial/industrial areas suggesting that benefits would indeed accrue to businesses. This project was advanced to the next screen.

Step 2: Select Applicable Tools

To identify what type of analysis tool would be appropriate for the Middleborough Rotary, we turned to the "Analysis Tool Selection Table" shown in the Appendix in Table 25 (Table 6 on page 39 of the NCHRP report). This table uses project objective and threshold factors by mode to help users select the appropriate type of analysis tool.

The objective of the Middleborough Rotary project is to enhance capacity for congestion reduction. The threshold factor for roadway projects with this objective is a facility with a level of service (LOS) of D, which the Middleborough Rotary satisfied. As a result, it was determined that a reliability analysis tool would appropriately capture the WEBs of

the project, in addition to a standard transportation analysis which would capture traditional user benefits.

The NCHRP document provides summaries of analysis tools by category of wider economic benefit (market access, intermodal connectivity, and reliability), including the W.E.B. Reliability Tool. We selected this tool to analyze the Middleborough Rotary project.

Step 3: Measure Standard Travel Benefit

Standard travel benefits are based on reductions in travel time (VHT), distance (VMT), and crashes which result in savings of vehicle operating costs and operator time. To measure the standard travel benefits that would result from the redesigned Middleborough Rotary, we collected the following data for build and no-build scenarios:

- Vehicle trips and % of trucks in traffic
- Vehicle miles traveled (VMT)
- Travel time (VHT)
- Reduction in crash rate

Though the MassDOT consultant, FST, provided total AADT, travel times were only available for AM and PM peak traffic. To avoid overstating travel savings, which would occur if peak hour time savings were applied to total/24-hour AADT, we calculated time savings using AM/PM peak trips only. By definition, the majority of reliability benefits accrue during peak congestion periods, so understatement of benefits should be minor. However, the proportion of peak trips to total trips in 2014 (8,000 ÷ 47,000 = 17.02%) appears surprisingly low; the understatement of benefits may therefore be more significant. In the future, SRPEDD will attempt to acquire both off peak travel times/speeds and peak travel times/speeds to enable a more complete calculation.

Standard travel benefit inputs for use within the Accounting Matrix were developed as follows:

1. **AM/PM Peak Trips** were based on build and no-build AM/PM peak trips estimated using 2014 actual counts and 2036 forecast trips (provided by FST), and applying the implied average annual growth rate of 0.28% to intervening years to determine 2020 and 2040 trips. Note that the build scenario does not induce trips so build and no build trips are the same.
2. **Passenger and Freight Trips/VMT/VHT** were allocated 95% to passenger vehicles (commute, personal, business), 5% to freight based on the percent of trucks in the vehicle count provided by FST.
3. **Vehicle miles** were based on AM/PM peak trips estimated above and length of facility (build and no build facility length assumed to be the same);

4. **Vehicle hours** were based on AM/PM peak trips estimated above and AM/PM peak travel times for build and no build scenarios provided by FST.
5. **No-Build scenario crash rate** based on current crash rate provided by FST, applied to total average daily trips (not just AM/PM peak trips).
6. **Build scenario crash rate** assumed to be average for facility type (MassDOT), applied to total average daily trips (not just AM/PM peak trips).
7. **Multiplier values** for operating cost and persons per trip supplied by EDR Group as part of the Accounting Framework worksheet. Multiplier values for value of time and reliability ratios were taken from the W.E.B. Reliability tool to ensure consistency.

The costs and benefits of a major transportation project accrue over time, thus in calculating the benefit-cost ratio, it is important to use an appropriate analysis period (typically 20-30 years) and ensure that all future benefits are presented in constant dollars. The W.E.B. tools do not perform this function, thus this calculation must be performed by the user separately. An analysis period of 20 years was used for this study. The Accounting Matrix provides a single year value for standard travel benefits. To obtain two time points, the tool was run once with travel characteristics for the first year of the analysis period, and then a second time with travel characteristics for the last year of the analysis period (2040).

When calculated for the beginning of the analysis period, with travel characteristics for 2020, the result is $8.9 million in benefits (Table 2). When calculated for the end of the analysis period, 2040, the result is $9.4 million in benefits (Table 3). Results are presented in constant 2015 dollars. Benefits accrue each year throughout the analysis period. To estimate benefits for years between 2020 and 2040, the implied average annual growth rate of 0.29% was applied to each year, as shown in Table 4 which presents complete results, both undiscounted and discounted to reflect the opportunity cost of capital at 3%, 5% and 7%.[7] As shown, undiscounted standard travel benefits for the analysis period are approximately $192.5 million (2015 $), or $125.2 million when discounted at 3%, $96.2 million at 5% and $75.3 million at 7%.

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[7] These rates were selected to reflect the range of rates typically preferred by state and Federal transportation agencies.

Table 2. Middleborough Rotary Realignment Standard Travel Benefits – Beginning of Analysis Period (2020)

Benefit Category	Benefit Element	No Build Scenario	Build Scenario	Diff	Multiplier Value[5]	Persons per Trip	Value of Total Benefit
Trips	AM/PM Peak Trips (Passengers - Commute, Personal or Business)[1]	2,684,059	2,684,059				
Trips	AM/PM Peak Trips (Freight) [1]	141,266	141,266				
Operating Cost	Vehicle-Miles (Passengers- Commute, Personal, or Business) [2]	1,960,705	1,960,705	0	$0.44	--	$0
Operating Cost	Vehicle-Miles (Freight) [2]	103,195	103,195	0	$0.95	--	$0
Value of time	Vehicle-Hours (Passengers- Commute, Personal, or Business) [3]	282,692	33,823	-248,869	$22.90	1.5	$8,548,650
Value of time	Vehicle-Hours (Freight) [3]	14,879	1,780	-13,099	$23.70	1.1	$341,491
Safety	Crash reduction (crashes) (Passengers & Freight) [4]	54.8	49.4	-5.4	$3,285	--	$17,772
						Total ----->	$8,907,913

[1] AM/PM peak hour trips (allocated 95% to passenger vehicles, 5% to trucks based on the percent of trucks in the vehicle count).

[2] Vehicle miles based on AM/PM peak hour trips and length of facility (allocated 95% to passenger vehicles, 5% to trucks based on the percent of trucks in the vehicle count).

[3] Vehicle hours based on AM/PM peak hour trips and travel times (allocated 95% to passenger vehicles, 5% to trucks based on the percent of trucks in the vehicle count).

[4] Current crash rate (used for No-Build scenario) from FST. Build scenario crash rate assumed to be average for facility type (MassDOT).

[5] Multiplier values for operating cost and persons per trip supplied by EDR Group as part of the Accounting Framework worksheet. Multiplier values for value of time and reliability ratios were taken from the W.E.B. Reliability tool to ensure consistency.

Source: FST, MassDOT, and EDR Group with SRPEDD calculations.

Table 3. Middleborough Rotary Realignment Standard Travel Benefits – End of Analysis Period (2040)

Benefit Category	Benefit Element	No Build Scenario	Build Scenario	Diff	Multiplier Value[5]	Persons per Trip	Value of Total Benefit
Trips	AM/PM Peak Trips (Passengers - Commute, Personal or Business)[1]	2,840,723	2,840,723				
Trips	AM/PM Peak Trips (Freight)[1]	149,512	149,512				
Operating Cost	Vehicle-Miles (Passengers- Commute, Personal, or Business)[2]	2,075,148	2,075,148	0	$0.44	--	$0
Operating Cost	Vehicle-Miles (Freight)[2]	109,218	109,218	0	$0.95	--	$0
Value of time	Vehicle-Hours (Passengers- Commute, Personal, or Business)[3]	299,193	35,797	-263,396	$22.90	1.5	$9,047,653
Value of time	Vehicle-Hours (Freight)[3]	15,747	1,884	-13,863	$23.70	1.1	$361,408
Safety	Crash reduction (crashes) (Passengers & Freight)[4]	65.3	58.9	-6	$3,285	--	$21,188
						Total ----->	$9,430,249

[1] AM/PM peak hour trips (allocated 95% to passenger vehicles, 5% to trucks based on the percent of trucks in the vehicle count).

[2] Vehicle miles based on AM/PM peak hour trips and length of facility (allocated 95% to passenger vehicles, 5% to trucks based on the percent of trucks in the vehicle count).

[3] Vehicle hours based on AM/PM peak hour trips and travel times (allocated 95% to passenger vehicles, 5% to trucks based on the percent of trucks in the vehicle count).

[4] Current crash rate (used for No-Build scenario) from FST. Build scenario crash rate assumed to be average for facility type (MassDOT).

[5] Multiplier values for operating cost and persons per trip supplied by EDR Group as part of the Accounting Framework worksheet. Multiplier values for value of time and reliability ratios were taken from the W.E.B. Reliability tool to ensure consistency.

Source: FST, MassDOT, and EDR Group with SRPEDD calculations.

Analysis Year	Year	Millions of 2015 $ (undiscounted)	Discounted at:		
			3%	5%	7%
Year 0	2020	$8.91	$7.68	$6.98	$6.35
Year 1	2021	$8.93	$7.48	$6.67	$5.95
Year 2	2022	$8.96	$7.28	$6.37	$5.58
Year 3	2023	$8.98	$7.09	$6.08	$5.23
Year 4	2024	$9.01	$6.91	$5.81	$4.90
Year 5	2025	$9.04	$6.72	$5.55	$4.59
Year 6	2026	$9.06	$6.55	$5.30	$4.31
Year 7	2027	$9.09	$6.37	$5.06	$4.03
Year 8	2028	$9.11	$6.21	$4.83	$3.78
Year 9	2029	$9.14	$6.04	$4.62	$3.54
Year 10	2030	$9.17	$5.88	$4.41	$3.32
Year 11	2031	$9.19	$5.73	$4.21	$3.11
Year 12	2032	$9.22	$5.58	$4.02	$2.92
Year 13	2033	$9.24	$5.43	$3.84	$2.73
Year 14	2034	$9.27	$5.29	$3.67	$2.56
Year 15	2035	$9.30	$5.15	$3.50	$2.40
Year 16	2036	$9.32	$5.01	$3.35	$2.25
Year 17	2037	$9.35	$4.88	$3.20	$2.11
Year 18	2038	$9.38	$4.75	$3.05	$1.98
Year 19	2039	$9.40	$4.63	$2.92	$1.85
Year 20	2040	$9.43	$4.50	$2.78	$1.74
Total		**$192.50**	**$125.16**	**$96.21**	**$75.26**
CAGR 2020-2040		**0.29%**			

Note: Results based on AM/PM peak travel.
Source: SRPEDD.

Step 4: Calculate Wider Transportation Benefits & Productivity Impacts

The W.E.B. Reliability Tool calculates wider transportation benefits in the form of hours of delay (recurring due to congestion and non-recurring due to crashes), and applies cost factors to translate hours of delay into productivity impacts expressed in dollars. To run the W.E.B. Reliability Tool, we collected basic project information (highway type, number of lanes, segment length) and facility performance data (free flow speed, AADT) to develop the inputs shown below in Table 5. The numbers in the far left-hand column correspond to notes below the table that contain data sources and assumptions.

Table 5. W.E.B. Reliability Tool Inputs for the Middleborough Rotary Realignment Project

Source Notes	Reliability Inputs	No-Build	Redesigned Rotary w/Flyover
1	Time Horizon (# years)	20	20
2	Analysis Period (time of day)	6am-7pm	6am-7pm
3	Highway Type	Signalized	Signalized
4	Beg. Milepoint	1	1
4	End Milepoint	2	2
5	Number of Lanes (one-way)	1	2
6	Free Flow Speed	45.85	47.54
7	AADT (2020)	49,800	49,800
8	Annual Traffic Growth Rate	0.97%	0.97%
9	% Trucks in traffic	5%	5%
10	Peak Capacity (pcphpl, one-way) / terrain	Flat	Flat
11	Travel Time Unit Cost (per vehicle hr, 2015 $) - Personal	$20.21	$20.21
12	Travel Time Unit Cost (per vehicle hr, 2015 $) - Business	$36.68	$36.68
13	Reduction in Incident Frequency (%)	n/a	11%
14	Reduction in Incident Duration (%)	n/a	n/a

Source Notes:

1   Consistent with analysis period for FST traffic data/forecast.

2   This field is a pull-down menu offering several pre-determined time-of-day ranges. Traffic data provided was for a full 24-hour period. The 6am-7pm range was selected because it most closely approximated the full day period.

3   Observed.

4   Facility has no mile markers. Facility is roughly 3/4 a mile, but input field accepts only integers. Review of the formulas indicates this measure is used in calculating incident delay, thus choosing a 1-mile interval was sufficient.

5   Existing conditions from Environmental Notification Form (ENF) and future alignment (FST Consulting)

6   Existing conditions from Environmental Notification Form (ENF) and future alignment (FST Consulting) (weighted average of all segments)

7   Based on AADT for 2014 and 2034 provided by FST.

8   Annualized from ADT provided by FST.

9   FST.

10   Used terrain pull-down menu as capacity estimate was not available for the existing rotary (neither the Highway Capacity Manual nor existing transportation models are able to determine capacity of rotaries, which are rare, differ substantially from roundabouts, and are virtually non-existent outside New England).

11   Default value of $19.86 in 2013 dollars (model default) adjusted to 2015 dollars using US Bureau of Labor Statistics (BLS) inflation calculator.

12   Default value of $36.01 in 2013 dollars adjusted to 2015 dollars using BLS inflation calculator.

13   Crash rate assumed to drop from current rate to current average for facility type.

14   Data not available.

Table 6 shows summary results based on the complete W.E.B. Reliability Tool outputs shown in Table 7. The difference between the total incident equivalent delay for the no-build and build scenario is the number we need for the benefit cost analysis. The tool does not calculate these differences, they are calculated by the user (Table 6). At the beginning of the analysis period, this figure is $1,014,874. This means that in the first year of build scenario traffic conditions, the redesigned rotary saves businesses more than $1,000,000 in the form of reduced need to pad travel times to meet delivery schedules ("reliability"), compared with the no-build scenario. The figure for the last year of the analysis period is $915,326 (with benefits decreasing over time due to traffic growth).

Table 6. Middleborough Rotary - Summary of Reliability Benefits for 2020 and 2040 (nominal $)

Non-Recurring Delay - Hours	No-Build (hours)	Build (hours)	Reliability Benefits[1] (hours)
Total Incident Equivalent Delay - 2020	**67,788**	**13,912**	**53,876**
Subtotal – Hours of Passenger Delay	67,306	13,808	53,498
Subtotal – Hours of Commercial Delay	482	104	378
Total Incident Equivalent Delay - 2040	**73,568**	**21,123**	**52,446**
Subtotal – Hours of Passenger Delay	73,046	20,966	52,080
Subtotal – Hours of Commercial Delay	523	157	366
Value of Non-Recurring Delay – 2015 $	No-Build (2015 $)	Build (2015 $)	Value of Reliability Benefits[1]
Total Incident Equivalent Delay - 2020	$1,383,815	$368,940	$1,014,874
Subtotal – Value of Passenger Delay	$1,366,107	$364,109	$1,001,998
Subtotal – Value of Commercial Delay	$17,708	$4,832	$12,876
Total Incident Equivalent Delay - 2040	$1,501,818	$586,492	$915,326
Subtotal – Value of Passenger Delay	$1,482,600	$578,848	$903,752
Subtotal – Value of Commercial Delay	$19,218	$7,644	$11,574

[1] Difference between no-build and build scenario.
Source: W.E.B. Reliability Tool output with SRPEDD calculations.

The complete results shown in Table 7 include various travel time indexes (TTI), recurring and non-recurring delay (in vehicle hours), as well as the cost of recurring and non-recurring delay, for two points in time. The tool automatically labels these sections "Current year – 2015" and "Future year – 2022" (the latter reflecting a labeling error discussed in greater detail below), however we wanted our analysis period to begin in 2020 and end in 2040. Though we were unable to change the labels, we were able to obtain the desired outputs by entering initial AADT for 2020. The tool automatically applies the annual traffic growth rate to "current" AADT (which should be thought of as

"starting", rather than current) for the number of years consistent with the analysis period entered by the user (in our case, 20 years). Thus the results labeled "2022" in our output actually correspond to 2040.

Table 7. W.E.B. Reliability Tool Output (taken directly from the Tool, itself)

Current year - 2015	Middleborough	Middleborough
Congestion Metrics		
Overall mean TTI	2.68	1.47
TTI_{95}	4.52	2.25
TTI_{80}	3.52	1.72
TTI_{50}	2.53	1.39
Pct. trips less than 45 mph	86.83%	40.32%
Pct. trips less than 30 mph	61.53%	18.02%
Total Annual Weekday Delay (veh-hrs)		
Total Equivalent Delay	284172	86929
Recurring Equivalent Delay	216385	73018
Passenger Delay	215265	72622
Commercial Delay	1120	396
Incident Equivalent Delay	67788	13912
Passenger Delay	67306	13808
Commercial Delay	482	104
Total Annual Weekday Congestion Costs ($)		
Total Equivalent Delay	$5,669,594	$1,734,508
Recurring Equivalent Delay	$4,285,779	$1,365,568
Passenger Delay	$4,245,753	$1,352,386
Commercial Delay	$40,025	$13,182
Incident Equivalent Delay	$1,383,815	$368,940
Passenger Delay	$1,366,107	$364,109
Commercial Delay	$17,708	$4,832

Future year - 2022	Middleborough	Middleborough
Congestion Metrics		
Future year - 2035	2.68	1.66
TTI_{95}	4.52	2.69
TTI_{80}	3.52	2.02
TTI_{50}	2.53	1.57
Pct. trips less than 45 mph	86.85%	52.53%
Pct. trips less than 30 mph	61.53%	25.45%
Total Annual Weekday Delay (veh-hrs)		
Total Equivalent Delay	308405	131990
Recurring Equivalent Delay	234836	110868
Passenger Delay	233621	110269
Commercial Delay	1215	599
Incident Equivalent Delay	73568	21123
Passenger Delay	73046	20966
Commercial Delay	523	157
Total Annual Weekday Congestion Costs ($)		
Total Equivalent Delay	$6,153,062	$2,633,555
Recurring Equivalent Delay	$4,651,244	$2,047,063
Passenger Delay	$4,607,805	$2,027,482
Commercial Delay	$43,439	$19,581
Incident Equivalent Delay	$1,501,818	$586,492
Passenger Delay	$1,482,600	$578,848
Commercial Delay	$19,218	$7,644

Source: W.E.B. Reliability Tool output.

As with standard travel benefits, reliability benefits accrue each year throughout the analysis period. To estimate benefits for years between 2020 and 2040, we applied the implied average annual growth rate of -0.51% to each year, as shown under "Reliability Benefits" in Table 9. As shown, reliability benefits total approximately $20.3 million in undiscounted dollars, or $13.3 million discounted at 3%, $10.3 million at 5%, and $8.1 million at 7%.

Table 8. Reliability Benefits, 2020-2040, millions (2015 $)

Analysis Year	Year	Millions of 2015 $ (undiscounted)	Discounted at:		
			3%	5%	7%
Year 0	2020	$1.01	$0.88	$0.80	$0.72
Year 1	2021	$1.01	$0.85	$0.75	$0.67
Year 2	2022	$1.00	$0.82	$0.71	$0.63
Year 3	2023	$1.00	$0.79	$0.68	$0.58
Year 4	2024	$0.99	$0.76	$0.64	$0.54
Year 5	2025	$0.99	$0.74	$0.61	$0.50
Year 6	2026	$0.98	$0.71	$0.58	$0.47
Year 7	2027	$0.98	$0.69	$0.55	$0.43
Year 8	2028	$0.97	$0.66	$0.52	$0.40
Year 9	2029	$0.97	$0.64	$0.49	$0.38
Year 10	2030	$0.96	$0.62	$0.46	$0.35
Year 11	2031	$0.96	$0.60	$0.44	$0.32
Year 12	2032	$0.95	$0.58	$0.42	$0.30
Year 13	2033	$0.95	$0.56	$0.39	$0.28
Year 14	2034	$0.94	$0.54	$0.37	$0.26
Year 15	2035	$0.94	$0.52	$0.35	$0.24
Year 16	2036	$0.93	$0.50	$0.34	$0.23
Year 17	2037	$0.93	$0.49	$0.32	$0.21
Year 18	2038	$0.92	$0.47	$0.30	$0.20
Year 19	2039	$0.92	$0.45	$0.29	$0.18
Year 20	2040	$0.92	$0.44	$0.27	$0.17

Total		$20.25	$13.28	$10.26	$8.07
CAGR 2020-2040		-0.51%			

Analysis Year	Year	Undiscounted 2015 $	2015 $ Discounted at:		
			3%	5%	7%
Year 0	2020	$1.01	$1.01	$1.01	$1.01
Year 1	2021	$1.01	$0.98	$0.96	$0.94
Year 2	2022	$1.00	$0.95	$0.91	$0.88
Year 3	2023	$1.00	$0.91	$0.86	$0.82
Year 4	2024	$0.99	$0.88	$0.82	$0.76
Year 5	2025	$0.99	$0.85	$0.77	$0.71
Year 6	2026	$0.98	$0.82	$0.73	$0.66
Year 7	2027	$0.98	$0.80	$0.70	$0.61
Year 8	2028	$0.97	$0.77	$0.66	$0.57
Year 9	2029	$0.97	$0.74	$0.62	$0.53
Year 10	2030	$0.96	$0.72	$0.59	$0.49
Year 11	2031	$0.96	$0.69	$0.56	$0.46
Year 12	2032	$0.95	$0.67	$0.53	$0.42
Year 13	2033	$0.95	$0.65	$0.50	$0.39
Year 14	2034	$0.94	$0.62	$0.48	$0.37
Year 15	2035	$0.94	$0.60	$0.45	$0.34
Year 16	2036	$0.93	$0.58	$0.43	$0.32
Year 17	2037	$0.93	$0.56	$0.41	$0.29
Year 18	2038	$0.92	$0.54	$0.38	$0.27
Year 19	2039	$0.92	$0.45	$0.29	$0.18
Year 20	2040	$0.92	$0.44	$0.27	$0.17
Total		**$20.25**	**$15.25**	**$12.95**	**$11.18**
	CAGR	-0.51%			

Source: SRPEDD.

Conceptual and Technical Issues with Interpretation of Results

It is unclear from either the tool itself or the user guide materials whether results are in nominal dollars or constant dollars, however, in direct correspondence with the tool developer, EDRG has indicated that all dollar amounts are based on default value of time inputs that are in 2013 dollars and outputs are unadjusted for inflation. Default inputs for value of time can be replaced with custom values, which allows the user to change the constant dollar year.

The current year of 2015 and future year of 2035 were arbitrarily chosen by the tool. Though the tool developers have indicated that these values are chosen by the user, we can find no place to input or adjust them. It is unclear why the tool would choose 2015 as the "current year". Though that might be useful for analyzing the performance of existing facilities, most W.E.B. analysis tool users will want to evaluate the benefits of future proposed projects which may not be constructed for 5, sometimes 10 years. The data we entered was for 2020, so it is disconcerting not to be able to change the label to reflect this. Note that the label "Future Year – 2022" (appearing in red at the top of the green shaded section of tool outputs) appears to be a superficial error, as the results returned by the tool do reflect a 20-year analysis period (consistent with the annual traffic growth rate), and not a 7-year period as 2022 would imply.

Step 5: Incorporate Wider Economic Benefits into Benefit Cost Analysis

The benefit-cost analysis consists of both benefits and costs. Table 9 shows standard travel benefits, reliability benefits, and the sum of both for the 2020-2040 Analysis period with the total discounted to reflect the opportunity cost of capital at 3%, 5%, and 7%. Undiscounted, benefits total $212.8 million, or $138.4 million when discounted at 3%, $106.5 million at 5%, and $83.3 million at 7%.

Table 9. Total Benefits Calculations, 2020-2040, millions (2015 $)

Analysis Year	Year	Standard Travel Benefits	Reliability Benefits	Total (undiscounted)	Total Benefits Discounted at:		
					3%	5%	7%
Year 0	2020	$8.91	$1.01	$9.92	$8.56	$7.77	$7.07
Year 1	2021	$8.93	$1.01	$9.94	$8.33	$7.42	$6.63
Year 2	2022	$8.96	$1.00	$9.96	$8.10	$7.08	$6.20
Year 3	2023	$8.98	$1.00	$9.98	$7.88	$6.76	$5.81
Year 4	2024	$9.01	$0.99	$10.00	$7.67	$6.45	$5.44
Year 5	2025	$9.04	$0.99	$10.02	$7.46	$6.15	$5.10
Year 6	2026	$9.06	$0.98	$10.05	$7.26	$5.87	$4.77
Year 7	2027	$9.09	$0.98	$10.07	$7.06	$5.61	$4.47
Year 8	2028	$9.11	$0.97	$10.09	$6.87	$5.35	$4.19
Year 9	2029	$9.14	$0.97	$10.11	$6.68	$5.11	$3.92
Year 10	2030	$9.17	$0.96	$10.13	$6.50	$4.87	$3.67
Year 11	2031	$9.19	$0.96	$10.15	$6.33	$4.65	$3.44
Year 12	2032	$9.22	$0.95	$10.17	$6.15	$4.44	$3.22
Year 13	2033	$9.24	$0.95	$10.19	$5.99	$4.24	$3.02
Year 14	2034	$9.27	$0.94	$10.21	$5.83	$4.04	$2.82
Year 15	2035	$9.30	$0.94	$10.24	$5.67	$3.86	$2.65
Year 16	2036	$9.32	$0.93	$10.26	$5.51	$3.68	$2.48
Year 17	2037	$9.35	$0.93	$10.28	$5.36	$3.51	$2.32
Year 18	2038	$9.38	$0.92	$10.30	$5.22	$3.35	$2.17
Year 19	2039	$9.40	$0.92	$10.32	$5.08	$3.20	$2.04
Year 20	2040	$9.43	$0.92	$10.35	$4.94	$3.06	$1.91
Total		**$192.50**	**$20.25**	**$212.75**	**$138.44**	**$106.47**	**$83.33**

Source: W.E.B. Reliability Tool and Accounting Matrix with SRPEDD calculations.

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Ongoing capital costs are the same for the build and no-build scenarios, so they cancel out. The no-build has an initial cost of $590,000 while the build has a cost of $51.6 million, with a net of $51.0 million (all in 2015 $).

Based on the benefits and costs presented above, Table 10 presents net benefits and benefit-cost ratios at the 3%, 5% and 7% discount rates. The benefit-cost ratio of 2.7 for benefits discounted at 3% indicates that for every dollar of project cost, the build scenario produces $2.70 in benefits.

Table 10. Summary of Total Cost, Net Benefits, and Benefit Cost Ratios

	Undiscounted	@ 3%	@5%	@7%
Total Cost (2015 millions)	$51.0			
Benefits	212.8	$138.4	$106.5	$83.3
Net Benefits	$161.8	$87.4	$55.5	$32.3
Benefit-Cost Ratio	n/a	2.7	2.1	1.6

New Bedford/Fairhaven Bridge Replacement

Project Description

The Fairhaven/New Bedford Bridge spans New Bedford Harbor between the Town of Fairhaven and City of New Bedford, via Route 6. Comprised of three bridges that connect the mainland across two mid-harbor islands (Fish Island and Pope's Island), the central bridge segment is a moveable swing-span that allows boats to pass through into the northern harbor area. Now more than 100 years old, the bridge is considered functionally obsolete. Despite extensive maintenance and repairs, it suffers from long-term deterioration. Machinery and operating systems are in poor condition and require frequent corrective maintenance and replacement of critical parts. Its slow operation and frequent breakdowns (where the bridge must be held open until it can be repaired, sometimes for weeks at a time) result in extensive traffic delays.

Furthermore, the relationship of the existing bridge to the hurricane barrier creates frequent, lengthy delays for container ships accessing the northern waterfront area within the designated New Bedford harbor. According to the 2010 New Bedford-Fairhaven Municipal Harbor Plan, the future development of harbor activities north of Route 6 (including expansion of refrigerated cargo operations, short sea shipping operations, ferry, cruise ship and excursion/shuttle boat operations, etc.) is constrained by the clearances of the existing swing span bridge and the width of the channel.

Though this project is a top local priority, it is not yet reflected in the TIP. A feasibility study is currently underway by MassDOT to determine a viable replacement for the existing bridge. Once a viable replacement has been identified and a financing plan is approved, the project can be added to the TIP.

MassDOT hired the firm HDR to complete a feasibility study of the Fairhaven/New Bedford Bridge (New Bedford-Fairhaven Bridge Corridor Study), which was underway during the data collection process for this study. The New Bedford-Fairhaven Bridge Corridor Study was the source for much of the data needed to develop inputs for the W.E.B. Reliability tool including AADT and travel speeds/times, as well as other data needed for other elements of the benefit cost analysis such as construction and operating costs.

The corridor study developed and analyzed seven build alternatives and a no-build alternative, and recommended modified versions of two of the original seven for advancement to the project development stage: Alternative 1T: Tall Vertical Lift Bridge; and Alternative 3D: Double-Leaf Dutch Bascule Bridge. Both alternatives have the same surface and marine transportation impacts, which means they generate the same transportation benefits. The estimated costs are also virtually the same, with an estimated range of $100-130 million for the former and $100-125 million for the latter.

Furthermore, annual operations and maintenance costs are the same for both bridges, estimated at about $490,000/year.
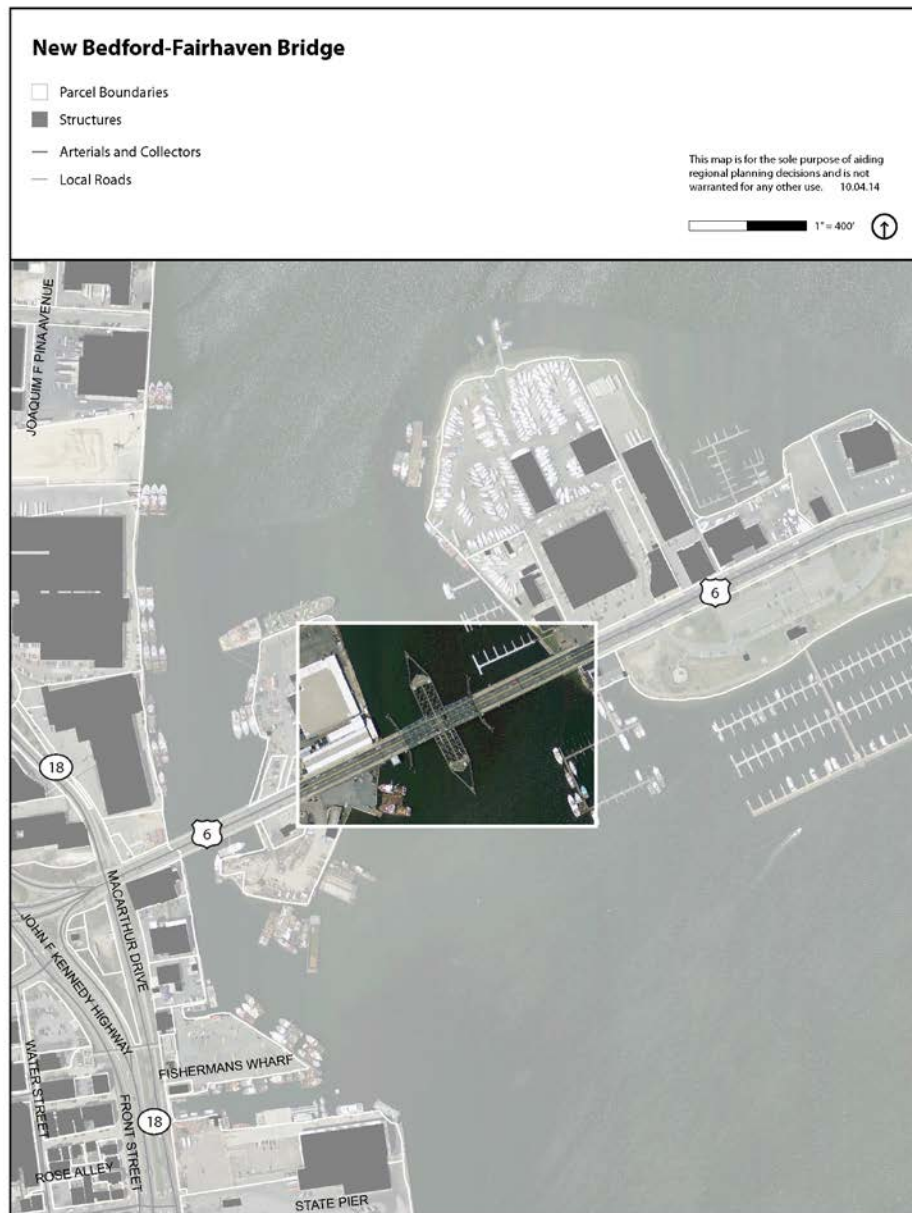
Socioeconomic Context

The Fairhaven/New Bedford Bridge connects the two communities and their economies. New Bedford has a population of approximately 95,000, a slight increase since 2000 (population 93,800) but a notable decrease since 1990 (99,900). New Bedford's population has declined slowly but steadily since the 1920s, following rapid growth throughout the 1800s and early 1900s.

As shown in Table 11, there were approximately 36,800 jobs in New Bedford in 2013 (the most recent year for which data is available). Between 2008 and 2013, employment

experienced a slight gain of about 370 jobs, an increase of about 1 percent. Gains accrued primarily to transportation and warehousing; administrative and waste services; health care and social assistance; and arts, entertainment, and recreation industry. Despite a 20 percent drop in employment in the manufacturing sector during that period, manufacturing remains well represented in New Bedford's economy when compared with employment in Massachusetts as a whole, with an LQ of 2.1 (indicating twice the state-wide proportion of employment in manufacturing). New Bedford also shows higher than average concentrations of employment in fishing (all New Bedford's employment in NAICS 11 Ag., Forestry, Fishing & Hunting is in fishing), wholesale trade, and administrative services.

Fairhaven has a population of about 16,000, which has remained relatively stable since the 1970s, following rapid growth during the first half of the 20th Century (US Census Bureau).

Fairhaven had about 7,500 jobs in 2013, a 22 percent increase of more than 1,350 jobs since 2008 (Table 13), mostly in the health care and social assistance industry (1,000 new jobs). The construction; professional and technical services; and administrative and waste services industries also experienced notable gains during the period.

Despite some losses in the Fishing industry since 2008, it continues to be important to the regional economy and is strongly represented in Fairhaven relative to the Massachusetts economy as a whole. Fairhaven has two other economic base industries with higher shares of employment relative to their shares in the commonwealth as a whole: Manufacturing and accommodation and food services. Health care and social assistance is also strongly represented (26 percent of employment in Fairhaven compared with 18 percent in the statewide economy), though as a population-serving (non-economic base industry), it plays a somewhat different role in the economy.

Table 11. New Bedford Employment by Industry, 2008 & 2013

NAICS Industry	New Bedford					Massachusetts			LQ[3]
	2008	2013	% of 2013 Jobs	% Change '08-'13	CAGR[1] '08-'13	% of 2013 Jobs	% Change '08-'13	CAGR[1] '08-'13	
Total, All Industries[2]	36,431	36,798	100.0%	1.0%	0.2%	100.0%	1.6%	0.3%	--
11 - Agriculture, Forestry, Fishing & Hunting	954	777	2.1%	-18.6%	-4.0%	0.2%	9.1%	1.7%	9.8
21 - Mining	n/a	n/a	n/a	n/a	n/a	0.0%	-29.8%	-6.8%	n/a
23 - Construction	1,141	946	2.6%	-17.1%	-3.7%	4.1%	-7.3%	-1.5%	0.6
31-33 - Manufacturing	7,272	5,760	15.7%	-20.8%	-4.6%	7.6%	-12.5%	-2.6%	2.1
22 - Utilities	302	304	0.8%	0.7%	0.1%	0.4%	0.1%	0.0%	2.0
42 - Wholesale Trade	1,717	1,642	4.5%	-4.4%	-0.9%	3.7%	-9.5%	-2.0%	1.2
44-45 - Retail Trade	2,675	3,023	8.2%	13.0%	2.5%	10.5%	-0.2%	0.0%	0.8
48-49 - Transportation and Warehousing	1,021	1,158	3.1%	13.4%	2.6%	3.0%	-2.7%	-0.5%	1.1
51 - Information	644	446	1.2%	-30.7%	-7.1%	2.8%	-3.7%	-0.7%	0.4
52 - Finance and Insurance	928	829	2.3%	-10.7%	-2.2%	5.0%	-7.9%	-1.6%	0.4
53 - Real Estate and Rental and Leasing	361	317	0.9%	-12.2%	-2.6%	1.3%	-1.1%	-0.2%	0.7
54 - Professional and Technical Services	743	749	2.0%	0.8%	0.2%	8.5%	6.2%	1.2%	0.2
55 - Management of Companies and Enterprises	n/a	92	0.3%	n/a	n/a	2.0%	4.6%	0.9%	0.1
56 - Administrative and Waste Services	1,036	2,217	6.0%	114.0%	16.4%	5.1%	0.4%	0.1%	1.2
61 - Educational Services	2,703	2,752	7.5%	1.8%	0.4%	10.3%	6.2%	1.2%	0.7
62 - Health Care and Social Assistance	8,107	9,903	26.9%	22.2%	4.1%	17.7%	16.5%	3.1%	1.5
71 - Arts, Entertainment, and Recreation	344	371	1.0%	7.8%	1.5%	1.7%	5.8%	1.1%	0.6
72 - Accommodation and Food Services	2,241	2,478	6.7%	10.6%	2.0%	8.6%	10.0%	1.9%	0.8
81 - Other Services, Ex. Public Admin	1,950	1,277	3.5%	-34.5%	-8.1%	3.4%	-13.6%	-2.9%	1.0
92 - Public Administration	1,931	1,758	4.8%	-9.0%	-1.9%	4.1%	-1.2%	-0.2%	1.2

[1] CAGR = Compound annual growth rate.
[2] Total for all industries is greater than the sum of individual industries due to suppression for confidentiality.
[3] LQ = location quotient (ratio of the % of total jobs in that industry in New Bedford to the % of total jobs in that industry in Massachusetts as a whole).
Source: Covered Employment and Wages (ES-202) from MA Office of Labor & Workforce Development Labor Market Information.

Table 12. New Bedford Employment - Manufacturing Sector, 2013

NAICS		Industry	Employment	% of Total Employment
31-33		Manufacturing	5,760	100.0%
311		Food Manufacturing	807	14.0%
	3117	Seafood Product Preparation & Packaging	712	12.4%
	3118	Bakeries and Tortilla Manufacturing	69	1.2%
313		Textile Mills	181	3.1%
	3133	Textile and Fabric Finishing and Fabric	137	2.4%
314		Textile Product Mills	419	7.3%
	3149	Other Textile Product Mills	413	7.2%
323		Printing and Related Support Activities	164	2.8%
	3231	Printing and Related Support Activities	164	2.8%
325		Chemical Manufacturing	98	1.7%
326		Plastics & Rubber Products Manufacturing	414	7.2%
331		Primary Metal Manufacturing	448	7.8%
332		Fabricated Metal Product Manufacturing	163	2.8%
	3323	Architectural and Structural Metals	23	0.4%
	3325	Hardware Manufacturing	44	0.8%
333		Machinery Manufacturing	60	1.0%
334		Computer and Electronic Product Mfg	529	9.2%
	3344	Semiconductor and Electronic Components	512	8.9%
336		Transportation Equipment Manufacturing	112	1.9%
	3366	Ship and Boat Building	46	0.8%
339		Miscellaneous Manufacturing	1,647	28.6%
	3391	Medical Equipment and Supplies Mfg	819	14.2%

Source: Covered Employment and Wages (ES-202) from MA Office of Labor & Workforce Development Labor Market Information.

Table 13. Fairhaven Employment by Industry, 2008 & 2013

	Fairhaven					Massachusetts			LQ[3]
	2008	2013	% of 2013 Jobs	% Change '08-'13	CAGR[1] '08-'13	% of 2013 Jobs	% Change '08-'13	CAGR[1] '08-'13	
Total, All Industries[2]	6,168	7,520	100.0%	21.9%	4.0%	100.0%	1.6%	0.3%	--
11 - Agriculture, Forestry, Fishing & Hunting	150	115	1.5%	-23.3%	-5.2%	0.2%	9.1%	1.7%	7.1
21 - Mining	n/a	n/a	n/a	n/a	n/a	0.0%	-29.8%	-6.8%	n/a
23 - Construction	289	392	5.2%	35.6%	6.3%	4.1%	-7.3%	-1.5%	1.3
31-33 - Manufacturing	857	875	11.6%	2.1%	0.4%	7.6%	-12.5%	-2.6%	1.5
22 - Utilities	n/a	n/a	n/a	n/a	n/a	0.4%	0.1%	0.0%	n/a
42 - Wholesale Trade	115	103	1.4%	-10.4%	-2.2%	3.7%	-9.5%	-2.0%	0.4
44-45 - Retail Trade	1,202	1,175	15.6%	-2.2%	-0.5%	10.5%	-0.2%	0.0%	1.5
48-49 - Transportation and Warehousing	n/a	31	0.4%	n/a	n/a	3.0%	-2.7%	-0.5%	0.1
51 - Information	166	105	1.4%	-36.7%	-8.8%	2.8%	-3.7%	-0.7%	0.5
52 - Finance and Insurance	171	186	2.5%	8.8%	n/a	5.0%	-7.9%	-1.6%	0.5
53 - Real Estate and Rental and Leasing	n/a	13	0.2%	n/a	n/a	1.3%	-1.1%	-0.2%	0.1
54 - Professional and Technical Services	144	469	6.2%	225.7%	26.6%	8.5%	6.2%	1.2%	0.7
55 - Management of Companies and Enterprises	183	n/a	n/a	n/a	n/a	2.0%	4.6%	0.9%	n/a
56 - Administrative and Waste Services	121	264	3.5%	118.2%	16.9%	5.1%	0.4%	0.1%	0.7
61 - Educational Services	n/a	n/a	n/a	n/a	n/a	10.3%	6.2%	1.2%	n/a
62 - Health Care and Social Assistance	988	1,956	26.0%	98.0%	14.6%	17.7%	16.5%	3.1%	1.5
71 - Arts, Entertainment, and Recreation	126	131	1.7%	4.0%	0.8%	1.7%	5.8%	1.1%	1.0
72 - Accommodation and Food Services	826	888	11.8%	7.5%	1.5%	8.6%	10.0%	1.9%	1.4
81 - Other Services, Ex. Public Admin	296	211	2.8%	-28.7%	-6.5%	3.4%	-13.6%	-2.9%	0.8
92 - Public Administration	181	168	2.2%	-7.2%	-1.5%	4.1%	-1.2%	-0.2%	0.5

[1] CAGR = Compound annual growth rate.

[2] Total for all industries is greater than the sum of individual industries due to suppression for confidentiality.

[3] LQ = location quotient (ratio of the % of total jobs in that industry in Fairhaven to the % of total jobs in that industry in Massachusetts as a whole).

Source: Covered Employment and Wages (ES-202) from MA Office of Labor & Workforce Development Labor Market Information.

New Bedford and Fairhaven's existing economic profile has two key implications for the analysis of wider economic benefits. First, since wider economic benefits are a form of productivity improvement, and productivity is a measure of business efficiency, the strong presence of economic base (traded) industries that involve the physical movement of goods, including agriculture, manufacturing and wholesale trade indicates that there is economic activity taking place that could potentially be affected by the transportation project, and subsequently captured by this analysis. A second important aspect is the significant presence of agricultural and seafood manufacturing. These industries tend to involve transport of frozen and perishable goods, which are more sensitive to delay than the average commodity mix particularly for marine cargo, which is generally less sensitive to delay than truck or air freight. The transportation cost factors in the W.E.B. Reliability tool assume an average commodity mix. The user could adjust the cost to reflect a different commodity mix if necessary, if data is available regarding the cost of shipping delays in the dominant industries.

Analysis of Wider Economic Benefits

Step 1: Screen for Possible Productivity Impacts

As with the previous analysis, we began by gathering key project information to complete the Project Classification Form provided in NCHRP 02-24. We reviewed the project information in the context of NCHRP 02-24 Table 1 "Classification of Transportation Projects by Form of Productivity Impact" to determine which of the following three categories our selected project corresponds to:

1. Projects with little or no productivity benefits, in which case no further analysis would be necessary);
2. Projects with productivity benefits driven by traditionally measured benefits, in which case use of W.E.B. analysis tools would not be necessary; or
3. Projects with wider business benefits not all captured by traditional benefit assessment.

We determined that the road element of the proposed Fairhaven-New Bedford replacement could meet the criteria to generate enhanced reliability benefits depending on (1) whether or not the traffic analysis identified congestion reduction; and/or, (2) whether or not the engineering analysis indicated a "reduction in the incidence of interfering activities", either in the form of crashes or of bridge openings/closings. This determination would be made during the data collection phase following the initial screening process, and this project element was advanced to the next screen.

To determine whether analysis of wider economic benefits is warranted, we applied the Screening Decision Table, using information from the Project Classification Form regarding facility type, dominant project objectives, dominant project impact area, and trip purpose served to help the analyst determine whether or not a productivity analysis

is warranted, and if so, whether it can be performed using available tools or if it requires a custom productivity analysis.

From the perspective of traffic traversing the bridge, the project is a road project, in an urban area, but undertaken to satisfy the dominant project objective preservation/rehabilitation, with a secondary objective of reducing closures/detours, and primarily to serve personal travel. This suggests that a productivity analysis may not be warranted. Furthermore, data from the traffic analysis indicated virtually no change to vehicle travel times/distances under any bridge configuration (including no change to bridge open-close-open cycle). However, one element of the project – the ITS improvements - does have the dominant project objective of congestion reduction/reliability and does generate a travel time savings. Therefore, for the surface travel element of the Bridge replacement project, we focused our data collection and analysis on capturing the reliability benefits of the ITS component.

The Screening Decision Table indicated that existing tools would be unable to capture the wider economic benefits of the marine component of the Fairhaven-New Bedford Bridge replacement project. Though the marine element greatly improves reliability for cargo ships accessing New Bedford Harbor's North Terminal, the W.E.B. analysis tools are designed to capture the reliability, intermodal connectivity, and/or market access benefits of highway travel. The tools do not capture benefits of other modes. If the New Bedford-Fairhaven Bridge project were to improve the surface connection to the port, one of the W.E.B. analysis tools might be able to capture those benefits (the appropriate tool would depend on the nature of the improved surface connection and the port's relationship to other modes of travel and/or markets). However, in this case, the surface connection to the port facility remains unchanged. As a result, application of the W.E.B. analysis tool is restricted to the surface transportation aspects of the project.

Step 2: Select Applicable Tools

To identify what type of analysis tool would be appropriate for the surface transportation element of the Fairhaven-New Bedford Bridge project, we turned to the "Analysis Tool Selection Table" which uses project objective, and threshold factors by mode to help users select the appropriate type of analysis tool.

The determination for the Fairhaven-New Bedford Bridge was ambiguous. The proposed ITS improvements would more efficiently alert travelers when the bridge was open, allowing more travelers to divert to alternate routes during bridge openings, reducing congestion due to bridge openings. Travel times for the two principle diversions, a "short" diversion and a "long" diversion, are only slightly longer than traversing the closed bridge, and represent an appreciable savings over waiting for a full bridge open-close-open cycle. However, the threshold factor for capacity enhancement/congestion reduction projects, level of service D, was met by only one intersection of the bridge route/diversions, and LOS at that intersection is unaffected by the build scenarios.

As a result, it is unclear whether this project sufficiently meets the criteria for analysis using an available reliability tool. However, it does represent a level of complexity typical of planned and proposed projects in SRPEDD's jurisdiction. We decided to proceed with the analysis to determine whether or not we could successfully use the W.E.B. Reliability tool to capture wider economic benefits for a project that only marginally meets threshold criteria for analysis, and what the pitfalls and challenges might be.

As noted above, the Analysis Tool Selection Table indicated that the marine freight component of the Fairhaven-New Bedford Bridge project was beyond the scope of the W.E.B. tools and would need a custom tool. In discussions with EDR Group, the firm that authored the NCHRP report and also led the development of the W.E.B. analysis tools, we learned that an additional analysis tool had been developed capable of capturing WEBs of marine freight projects. The tool is called MBCA (multi-modal benefit cost analysis). It is a module of TREDIS, developed by EDR Group. While the complete TREDIS suite is a paid-subscription product, MBCA is available free online as a stand-alone module. Upon exploring the tool and associated user guide materials, we determined that it would be suitable for capturing the WEB associated with the marine component of the Fairhaven-New Bedford Bridge project. This gave us the opportunity to explore how the W.E.B. Reliability tool could be used in conjunction with other tools (see "Other Tools" below).

Step 3: Measure Standard Traveler Benefit

As discussed previously, standard travel benefits are based on cost savings due to travel time savings, reductions to vehicle operation cost, and reduction in crashes. In this case, standard travel benefits accrue to the 1,080 additional vehicles that choose to divert (rather than wait for the bridge to open/close) under the enhanced ITS elements.

Travelers wishing to divert to avoid a bridge/open close cycle have two basic choices. Travelers can take a "short diversion" using Main St, Coggeshall St, and Purchase St (a route which is slightly longer in terms miles and drive time compared with traversing the bridge), or a "long diversion" using Route 140, I-195, and Route 240 (which is long in terms of miles, but has a short travel time due to significantly higher travel speeds).

As shown below in Table 14, if half the diverted vehicles take the "short" diversion and half take the "long", total user benefits (cost savings) are approximately $1,032,300 per year, compared with the no-build scenario where these vehicles are not diverted and instead wait for the bridge to open/close. If all vehicles choose the short diversion, net user benefit is $79,100. In choosing the "long" diversion, vehicles incur greater operating costs due to the greater VMT (distance), however this is more than offset by savings to VHT (time savings), with a net benefit of $1,985,600 per year. These are single-year cost savings in 2013 dollars. Because the number of diverted vehicles does not increase throughout the analysis period, benefits remain the same in each year.

Table 14. New Bedford/Fairhaven Bridge Standard Traveler Benefits (2013 $)

Average of Short/Long Diversions

Benefit Category	Benefit Element	No Build Scenario	Build Scenario	Diff	Multiplier Value	Persons per Trip	Value of Total Benefit
Operating Cost	Vehicle-Miles (Passengers- Commute, Personal, or Business)	1,583,028	3,600,051	2,017,023	$0.44	--	($887,490)
Operating Cost	Vehicle-Miles (Freight)	48,960	111,342	62,382	$0.95	--	($59,263)
Value of time	Vehicle-Hours (Passengers- Commute, Personal, or Business)	153,587	97,293	-56,294	$22.90	1.5	$1,933,699
Value of time	Vehicle-Hours (Freight)	4,750	3,009	-1,741	$23.70	1.1	$45,388
Safety	Crash reduction (crashes) (Passengers & Freight)	0.0	0.0	0.0	$3,285	--	$0
						Total:	**$1,032,334**

All Vehicles Use Short Diversion

Benefit Category	Benefit Element	No Build Scenario	Build Scenario	Diff	Multiplier Value	Persons per Trip	Value of Total Benefit
Operating Cost	Vehicle-Miles (Passengers- Commute, Personal, or Business)	1,583,028	2,408,956	825,928	$0.44	--	($363,408)
Operating Cost	Vehicle-Miles (Freight)	48,960	74,504	25,544	$0.95	--	($24,267)
Value of time	Vehicle-Hours (Passengers- Commute, Personal, or Business)	153,587	140,310	-13,277	$22.90	1.5	$456,065
Value of time	Vehicle-Hours (Freight)	4,750	4,339	-411	$23.70	1.1	$10,715
Safety	Crash reduction (crashes) (Passengers & Freight)	0.0	0.0	0.0	$3,285	--	$0
						Total:	**$79,105**

All Vehicles Use Long Diversion

Benefit Category	Benefit Element	No Build Scenario	Build Scenario	Diff	Multiplier Value	Persons per Trip	Value of Total Benefit
Operating Cost	Vehicle-Miles (Passengers- Commute, Personal, or Business)	1,583,028	4,791,146	3,208,118	$0.44	--	($1,411,572)
Operating Cost	Vehicle-Miles (Freight)	48,960	148,180	99,220	$0.95	--	($94,259)
Value of time	Vehicle-Hours (Passengers- Commute, Personal, or Business)	153,587	54,276	-99,311	$22.90	1.5	$3,411,333
Value of time	Vehicle-Hours (Freight)	4,750	1,679	-3,071	$23.70	1.1	$80,061
Safety	Crash reduction (crashes) (Passengers & Freight)	0.0	0.0	0.0	$3,285	--	$0
						Total:	**$1,985,563**

Source: VMT and VHT based on data from HDR with SRPEDD calculations; default multiplier values and persons per trip contained in tool.

Sources: Estimate of diversions, drive times and drive distances from HDR; multipliers from Accounting Framework (EDR Group); calculations by SRPEDD.

Step 4: Calculate Wider Transportation Benefits & Productivity Impacts

As noted above in Steps 1 and 2, we were not certain that the W.E.B. Reliability tool would be able to capture the benefits of this project. The reliability tool relies heavily on traffic growth and capacity to determine productivity impacts. However, there is no projected traffic growth, and capacity remains the same. The only difference is an increase in vehicles choosing to divert cycles due to enhanced ITS that better informs drivers of bridge open/close cycles. As a result, basing the inputs on total ADT and capacity would not accurately reflect build/no-build conditions. Instead, we developed inputs based on only the additional diverted vehicles. Under the no-build, these vehicles do not divert, and under the build scenario they choose one of two diversions. To establish the upper and lower bounds of the range of possible benefits (which depends entirely on how many cars choose each alternate route), we ran the model as if all vehicles took the long diversion and all took the short, and compared the results to the no build where all vehicles waited for the bridge to open/close. Unfortunately, the model returned no results (all results fields contained zeros). This is not a shortcoming of the W.E.B. reliability tool, but rather an affirmation of the lack of wider economic benefits from the surface element of the project.

As a result, we were unable to incorporate wider economic benefits from the W.E.B. reliability tools into a benefit-cost analysis of this project.

Table 15. W.E.B. Reliability Tool Inputs for the New Bedford/Fairhaven Bridge Replacement Project

Source Notes	Reliability Inputs	No Build (Wait for Bridge	Alt. 1 Short Diversion	Alt. 2 Long Diversion
1	Year	2015	2015	2015
2	Time Horizon (# years)	20	20	20
3	Analysis Period (time of day)	AM/PM Peak	AM/PM Peak	AM/PM Peak
4	Highway Type	Signalized	Signalized	Signalized
5	Number of Lanes (one-way)	2	1	2
6	Free Flow Speed (mph)	21.74	28.15	52.05
7	AADT	1,080	1,080	1,080
8	Annual Traffic Growth Rate	0.0%	0.0%	0.0%
9	% Trucks in traffic	3.00%	3.00%	3.00%
10	Peak Capacity (pcphpl, one-way)	850	850	1,388
11	Reduction in Incident Frequency	none	none	none
12	Reduction in Incident Duration	none	none	none

Source Notes:

1. Approximation based on New Bedford-Fairhaven Bridge Corridor Study Study Advisory Group (SAG) Meeting Summary June 24, 2015 (estimates construction to begin in 7-10 years)

2. MassDOT study by HDR used a 20 year time frame. 20 years is sufficient for construction to be complete and operations to have stabilized (20-30 years is a typical analysis period).

3. Based on traffic data available from HDR

4. Model provides these choices: Freeway (access controlled); multilane (non-signalized, non-access controlled); signalized; and rural two-lane.

5. New Bedford-Fairhaven Bridge Corridor Study

6. Based on traffic data from HDR (see calculations on "speed" tab).

7. Represents additional diverted traffic due to improved ITS (even though in the "base" scenario, these vehicles do not divert). Based on traffic data from HDR (see calculations on "diversions" tab).

8. New Bedford-Fairhaven Bridge Corridor Study

9. Assumption based on US average.

10. SRPEDD transportation staff provided estimates for interstate highway (2000 pcphpl) and urban principal arterial (800-900 pcphpl) based on NCHRP Report 387 – "Planning Techniques to Estimate Speed and Service Volumes for Planning Applications". 850 pcphpl was used for the bridge route and short diversion (the average of 800 and 900) because they are comprised entirely of urban principal arterials. Weighted average capacity (weighted by length of segment) was used for the long diversion, which includes both urban principal arterials and an interstate highway.

11 New Bedford-Fairhaven Bridge Corridor Study indicates no change in incident frequency.

12. New Bedford-Fairhaven Bridge Corridor Study indicates no change in incident duration.

OTHER TOOLS

One objective of the Lead Adopter Incentive grant was to compare the W.E.B. analysis tools with other available tools, both in terms of outputs/results as well as ease of use. Also, SRPEDD wanted to find a tool that could analyze the marine component of the New Bedford/Fairhaven Bridge project. The Multimodal Benefit-Cost Analysis Tool (MBCA) is a free online analysis tool that performs benefit-cost analysis including wider economic benefits from reliability[8] for all transportation modes and combinations of modes (road, rail, air, marine, pedestrian, bicycle). MBCA is part of the subscription-based TREDIS analysis suite developed by EDR Group.

MBCA is designed to work with sketch-level project data. It did not require significant additional data collection over and above what the W.E.B. Reliability tool required, though it did require some of the data be used to develop different inputs. For example, the W.E.B. Reliability tool required AADT as an input, while MBCA required annual vehicle trips, VMT (which required collection of travel distance), and VHT (which required collection of average travel time). It also requires project cost estimates, including initial construction and annual operations/maintenance costs.

While the W.E.B. tools produce only wider economic benefits, plus the ability to calculate standard travel benefits using the accounting framework, the MBCA tool reports standard travel benefits and wider economic benefits of reliability (combined), shipper/logistics benefits, and environmental benefits (CO_2 and greenhouse gas reduction), for each year of the analysis period and the total (undiscounted and discounted). Furthermore, it discounts results at user-defined rates, and calculates a benefit cost ratio for the chosen analysis period, requiring no off-line calculations on the part of the user. The tool was designed to be consistent with USDOT benefit-cost analysis guidelines.

Overview of MBCA

This section provides an overview of MBCA data needs, inputs, and results reports. Once the user logs in, a "Project" screen appears which allows the user to name the project. This screen also allows the user to copy projects, making it easy to run multiple scenarios of a given project without having to re-enter redundant data.
The user then clicks on each of the gold arrow-shaped boxes across the top of the screen to set up the project and enter all relevant inputs.

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[8] The free MBCA tool is only able to capture the wider economic benefits of reliability projects. However, the subscription-based TREDIS product is able to capture market access and intermodal connectivity projects (in addition to reliability).

The next screen, "Analysis Type" requires the user to select the type of analysis. The choices shown cover the full TREDIS package of tools, however, with the free subscription, only "Single Project" is available.

Moving to the next tab, "Modes", the user checks boxes for each mode affected by the project, which automatically sets up the "Cost" and "Travel Characteristics" input pages to ask for the relevant inputs.

The next tab, "Timing" allows the user to enter construction and operations periods, an analysis year, constant dollar year, appropriate discount rate, and anticipated annual average travel growth rate. It also lets you name your analysis period, which allows the user to use custom periods such as monthly or bi-annual.

The next tab, "Study Region" is grayed out and unavailable, as is the "Market Access" tab. These are not used for reliability analysis; they are only used for other analysis types, such as intermodal connectivity and labor market access, which are only available with the paid TREDIS subscription.

The "Alternatives" tab lets the user re-label the no-build and build scenarios with custom names.

Under "Costs", the user has the option of a basic mode or advanced mode input screens. The basic mode provides rows for total construction and operations & maintenance for the no-build and build scenarios, with columns for each mode previously selected on the "Mode" tab.

The advanced mode allows the user to break costs down into property acquisition, engineering and design, right of way, transportation structures, terminal, vehicles, ongoing operations, maintenance and rehabilitation. This level of detail is not relevant to a benefit cost analysis with reliability impacts, but could be used to improve the accuracy of an economic impact analysis (as each cost category acts differently with respect to how much is spent and re-spent locally versus outside the local economy, and is therefore associated with different multipliers).

The advanced mode[9] allows the user to enter additional assumptions regarding trip origin/destination (fraction of trips internal, incoming, outgoing, through, which is not relevant to benefit-cost analysis but is important to economic impact analysis), federal and state taxes, and other fees.

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[9] There is also a basic mode which allows the user to enter only annual vehicle counts, VMT, and VHT for build and no-build scenarios, as well as assumptions regarding percent congested (which is important for determining reliability impacts).

If the number of annual trips in the no-build is different from the build, the tool will generate a pop-up that prompts you "Some trips are unbalanced, please review and make adjustments if necessary. For a reliability analysis, the tool needs to know whether additional trips are diverted from another mode within the model (in which case they experience a cost savings due to mode switch), are diverted from another mode or region outside the model (in which case they realize half the total cost savings), or are induced (in which case they do not experience a cost savings relative to the build scenario because the trips were not taking place under the no-build).

MBCA provides a number of useful result reports including Summary Report, Benefit-Cost Analysis (results by mode, by year, for environmental factors, or all), Financial Analysis (Public/Private Cost & Revenue Sharing), and Grant Application. In addition, the Tracing/Validation reports, project cost summary and travel cost savings by cost type, allow users to troubleshoot results and identify the source of unexpected results.

For SRPEDD's analysis, the two most useful report categories are Benefit Cost Analysis and Grant Application. The Benefit Cost Analysis tab provides two reports: Benefit Cost Results by Mode and Benefit Cost Results by Year. For each report, the user can choose results from a regional perspective or national perspective. The national perspective is typically required when reporting results to federal agencies, as the Federal government does not consider a transfer of benefits from one region to another a net gain. The regional perspective often shows greater benefits because it counts benefits which would be considered a transfer from the national perspective. The regional perspective may be of interest to local and regional audiences, as a transfer of benefits into the region is experienced as a net gain to the local economy. Curiously, this report does not calculate the benefit-cost ratio, but provides total benefits and total costs that allow the user to calculate the ratio.

The Grant Application report was designed to be used for TIGER grant applications, and calculates the benefit-cost ratio under two different discount rate assumptions (3% and 7% are the default rates, reflecting the likely range of real inflation, but the user can adjust them. These rates over-ride whatever rate was input under the Timing menu and used for the separate Benefit Cost Analysis reports)

These reports categorize benefits as follows:

(A) Traveler money benefit (vehicle operating cost, business time, and reliability cost)
(B) Value of traveler non-money benefit (personal time and reliability value, safety value, consumer surplus)
(C) Logistics productivity
(D) Market access/other productivity
(E) Social and environmental value

Categories A and B capture a combination of standard travel benefits and wider economic benefits of reliability. Unfortunately, this makes it difficult to directly compare the results of MBCA with W.E.B. Reliability Tool outputs, though the aggregate outputs, excluding social and environmental value, should be comparable.

Costs are reported for capital costs, maintenance costs, and the residual value, as well as the total cost.

All dollar amounts are reported in constant dollars (the constant dollar year is clearly noted in the report), and reports that show benefit and cost streams by year report component benefits and costs as undiscounted, with totals reported as undiscounted and discounted.

Using MBCA to Analyze the Middleborough Rotary and New Bedford/Fairhaven Bridge Projects

This section describes how we applied the MBCA tool to the two subject projects, including additional data collection, development of inputs and assumptions, and an attempt to compare results with the W.E.B. Reliability tool outputs.

Analysis of Middleborough Rotary with MBCA

Inputs

To set up the Middleborough Rotary project in MBCA, we completed the following initial tasks (by menu tab):

- Project: Named the project
- Analysis Type: Selected "single project"
- Modes: Selected modes by trip purpose
    - "Car – passenger car", no split (all trip purposes)
    - "Truck – All", freight

- Timing:

Field	Input	Source
Construction Start Year	2020	Middleborough Rotary Fact Sheet (MassDOT for 2014 public meeting)
Construction End Year	2022	Middleborough Rotary Fact Sheet
Operations Start Year	2020	Assumption based on conclusion of construction
Operations End Year	2040	To reflect 20 year analysis period
Analysis Year	2040	Last year possible. Also represents year for which travel characteristics are input.

Constant Dollar Year	2015	It is traditional to use the current year, or the most recent year for which the real inflation rate is available.
Discount Rate (%)	3%, 5%, and 7% scenarios	3-5% is typical. TIGER Grants require analysis at 3% and 7%.
Travel Growth Rate (% of Trips)	0.28%	Calculated from AM/PM pea trips provided by FST
Name Analysis Periods	Annual	(defaults to Annual)

- Alternatives: Changed the build scenario name to "Middleborough Rotary Realignment"

- Costs (in millions):

Alternative	Cost Type	Road	Source
Base	Total Construction Costs	0.59	SRPEDD Planning Docs
Base	Annual Oper & Maint Costs	0.02	MassDOT
Middleborough Rotary Realignment	Total Construction Costs	51.60	SRPEDD Planning Docs
Middleborough Rotary Realignment	Annual Oper & Maint Costs	0.02	MassDOT

- Travel Characteristics:
  - We developed annual AM/PM peak trips from daily AM/PM peak trips, AM/PM peak VMT using trips and travel distance, and AM/PM peak VHT using trips and average travel time. These numbers are for 2040 (the analysis year), based on the implied average annual growth rate between 2014-2034, applied to 2014 AADT. The tool automatically populates assumptions for buffer time, crew members, average vehicle occupancy, and freight tons per truck.

Alternative	Mode	Purpose	Period Veh-Trips	Period VMT	Period VHT	Fraction Congested	Buffer Time (hrs/trip)	Av. Crew member per vehicle	Avg Veh Occupancy	Freight US Tons per Veh
No Build	All Trucks	Freight	149,512	109,218	15,747	0.8	0.0626	1.10	0	24.05
No Build	Passenger Car	All	2,840,723	2,075,148	299,193	0.8	0.0626	0	1.5	0
Rotary Realignment	All Trucks	Freight	149,512	109,218	1,884	0.25	0.0009	1.10	0	24.05
Rotary Realignment	Passenger Car	All	2,840,723	2,075,148	35,797	0.25	0.0009	0	1.5	0

  - Trip balancing was not necessary as the number of trips is the same for the build and no build scenario.

Results

Table 16 shows benefit cost results by year and mode, with key outputs labeled in red, A-F, as follows: (A) total undiscounted benefits, (B) total discounted benefits , (C) present value of the cost stream undiscounted, (D) present value of the cost stream discounted, (E) Net benefits, and (F) benefit-cost ratio of 2.1. Values shown below are discounted at 3%. The screen shots below reflect results with a 3% discount rate. Table 17 presents a summary of total benefits, total costs, net benefits, and benefit-cost ratio, undiscounted and at the 3%, 5%, and 7% discount rates.

Table 16. MBCA Benefit Cost Results by Year and Mode for the Middleborough Rotary Realignment Project

BENEFIT-COST RESULTS - BY YEAR (NATIONAL PERSPECTIVE) (5b)

Analysis Year: 2040   Project: FINAL Middleborough Rotary AMPM Peak 3
Constant $ Year: 2015   Region: National
Base Alternative: No Build   Period: All Periods
Project Alternative: Rotary Realignment   Perspective: National Perspective
Annual CO2 Cost Increase: 3%

Project's Impact on Travel Characteristics (Project - Base)

Project Year	Calendar Year	Vehicles			Passengers			Freight US Tons		
		Vehicle Trips	Vehicle Miles (VMT)	Vehicle Hours (VHT)	Passenger Trips	Passenger Miles	Passenger Hours	Freight US Tons Trips	Freight US Ton Miles	Freight US Ton Hours
1	2020	0	0	-87,393.25	0	0	-124,535.36	0	0	-105,090.76
2	2021	0	0	-175,275.9	0	0	-249,768.11	0	0	-210,770.03
3	2022	0	0	-263,650.01	0	0	-375,701.2	0	0	-317,040.27
4	2023	0	0	-264,388.23	0	0	-376,753.16	0	0	-317,927.99
5	2024	0	0	-265,128.52	0	0	-377,808.07	0	0	-318,818.19
6	2025	0	0	-265,870.88	0	0	-378,865.93	0	0	-319,710.88
7	2026	0	0	-266,615.32	0	0	-379,926.76	0	0	-320,606.07
8	2027	0	0	-267,361.84	0	0	-380,990.55	0	0	-321,503.76
9	2028	0	0	-268,110.45	0	0	-382,057.33	0	0	-322,403.97
10	2029	0	0	-268,861.16	0	0	-383,127.09	0	0	-323,306.71
11	2030	0	0	-269,613.98	0	0	-384,199.84	0	0	-324,211.96
12	2031	0	0	-270,368.89	0	0	-385,275.6	0	0	-325,119.76
13	2032	0	0	-271,125.93	0	0	-386,354.37	0	0	-326,030.09
14	2033	0	0	-271,885.08	0	0	-387,436.17	0	0	-326,942.98
15	2034	0	0	-272,646.36	0	0	-388,520.99	0	0	-327,858.42
16	2035	0	0	-273,409.77	0	0	-389,608.85	0	0	-328,776.42
17	2036	0	0	-274,175.32	0	0	-390,699.75	0	0	-329,697
18	2037	0	0	-274,943.01	0	0	-391,793.71	0	0	-330,620.15
19	2038	0	0	-275,712.85	0	0	-392,890.73	0	0	-331,545.88
20	2039	0	0	-276,484.84	0	0	-393,990.83	0	0	-332,474.21
21	2040	0	0	-277,259	0	0	-395,094	0	0	-333,405.14

Value of Benefit Stream ($m 2015 Const Dollars) – Undiscounted and Discounted

Project Year	Calendar Year	(A) Traveler Benefits ($)		(B) Traveler Benefits (non-$)			(C) Shipper/ Logistics Cost ($)	(D) Business Productivity ($)	(E) Social/ Environ. (non-$)	Total Benefits (Undiscounted)	Total Benefits (3% Discount)
		Vehicle Operating Costs	Business Time & Reliability Costs	Value of Personal Time & Reliability	Safety Cost	Additional Consumer Surplus					
1	2020	0.05	1.22	1.23	0	0	0.14	0	0.01	2.64	2.28
2	2021	0.1	2.44	2.46	0	0	0.28	0	0.02	5.3	4.44
3	2022	0.14	3.67	3.7	0	0	0.43	0	0.04	7.97	6.48
4	2023	0.14	3.68	3.71	0	0	0.43	0	0.04	8	6.31
5	2024	0.15	3.69	3.72	0	0	0.43	0	0.04	8.02	6.15
6	2025	0.15	3.7	3.73	0	0	0.43	0	0.04	8.04	5.98
7	2026	0.15	3.71	3.74	0	0	0.43	0	0.04	8.06	5.83
8	2027	0.15	3.72	3.75	0	0	0.43	0	0.04	8.09	5.67
9	2028	0.15	3.73	3.76	0	0	0.43	0	0.04	8.11	5.52
10	2029	0.15	3.74	3.77	0	0	0.44	0	0.04	8.13	5.38
11	2030	0.15	3.75	3.78	0	0	0.44	0	0.04	8.16	5.24
12	2031	0.15	3.76	3.79	0	0	0.44	0	0.04	8.18	5.1
13	2032	0.15	3.77	3.8	0	0	0.44	0	0.04	8.21	4.96
14	2033	0.15	3.78	3.81	0	0	0.44	0	0.04	8.23	4.83
15	2034	0.15	3.79	3.82	0	0	0.44	0	0.05	8.25	4.71
16	2035	0.15	3.8	3.83	0	0	0.44	0	0.05	8.28	4.58
17	2036	0.15	3.82	3.84	0	0	0.44	0	0.05	8.3	4.46
18	2037	0.15	3.83	3.85	0	0	0.45	0	0.05	8.33	4.35
19	2038	0.15	3.84	3.87	0	0	0.45	0	0.05	8.35	4.23
20	2039	0.15	3.85	3.88	0	0	0.45	0	0.05	8.37	4.12
21	2040	0.15	3.86	3.89	0	0	0.45	0	0.05	8.4	4.01
Totals		2.96	75.15	75.71	0	0	8.76	0	0.85	163.42 (A)	104.63 (B)

Project's Net Benefits ($m 2015 Const Dollars)

Project Year	Calendar Year	Project Costs					Project Benefits (from above)		Project Net Benefits	
		Startup Costs	O&M Costs	Residual Value	Total Costs (Undiscounted)	Total Costs (3% Discount)	Total Benefits (Undiscounted)	Total Benefits (3% Discount)	Net Total Benefits (Undiscounted)	Net Total Benefits (3% Discount)
1	2020	17	0	0	17	14.67	2.64	2.28	-14.36	-12.39
2	2021	17	0	0	17	14.24	5.3	4.44	-11.7	-9.8
3	2022	17	0	0	17	13.83	7.97	6.48	-9.03	-7.34
4	2023	0	0	0	0	0	8	6.31	8	6.31
5	2024	0	0	0	0	0	8.02	6.15	8.02	6.15
6	2025	0	0	0	0	0	8.04	5.98	8.04	5.98
7	2026	0	0	0	0	0	8.06	5.83	8.06	5.83
8	2027	0	0	0	0	0	8.09	5.67	8.09	5.67
9	2028	0	0	0	0	0	8.11	5.52	8.11	5.52
10	2029	0	0	0	0	0	8.13	5.38	8.13	5.38
11	2030	0	0	0	0	0	8.16	5.24	8.16	5.24
12	2031	0	0	0	0	0	8.18	5.1	8.18	5.1
13	2032	0	0	0	0	0	8.21	4.96	8.21	4.96
14	2033	0	0	0	0	0	8.23	4.83	8.23	4.83
15	2034	0	0	0	0	0	8.25	4.71	8.25	4.71
16	2035	0	0	0	0	0	8.28	4.58	8.28	4.58
17	2036	0	0	0	0	0	8.3	4.46	8.3	4.46
18	2037	0	0	0	0	0	8.33	4.35	8.33	4.35
19	2038	0	0	0	0	0	8.35	4.23	8.35	4.23
20	2039	0	0	0	0	0	8.37	4.12	8.37	4.12
21	2040	0	0	-5.1	-5.1	-2.44	8.4	4.01	13.5	6.45
Totals		51.01	0	-5.1	45.91 (C)	40.3 (D)	163.42	104.63	117.51	64.34 (E)

(continued next page)

BENEFIT-COST RESULTS - BY MODE (NATIONAL PERSPECTIVE) (5a)

Analysis Year: 2040
Constant $ Year: 2015
Base Alternative: No Build
Project Alternative: Rotary Realignment
Annual CO2 Cost Increase: 3%

Project: FINAL Middleborough Rotary AMPM Peak 3
Region: National
Period: All Periods
Perspective: National Perspective

Present Value of Benefit Stream ($m 2015 Const Dollars)

Mode	(A) Traveler Money Benefit		(B) Value of Traveler Non-Money Benefit			(C) Logistics Productivity ($)	(D) Mkt Access / Other Prod. ($)	(E) Social & Environ Value
	(A1) Vehicle Operating Costs	(A2) Business Time + Rel Cost	(B1) Personal Time + Rel Value	(B2) Safety Value	(B3) Consumer Surplus Value			
All Trucks - Freight	0.33	12.29	0	0	0	5.61	--	0.2
Passenger Car - All	1.57	35.83	48.48	0	0	0	--	0.33
Totals	1.9	48.12	48.48	0	0	5.61	0	0.53

Present Value of Cost Stream ($m 2015 Const Dollars)

Facility Type	Startup Costs	Annual O&M Costs	Residual Value	Net Total Costs
Road	42.73	0	2.44	40.3
Rail	0	0	0	0
Air	0	0	0	0
Marine	0	0	0	0
Total for All Facilities	42.73	0	2.44	40.3

Efficiency Measures

Benefit Measure	Benefit Definition	Present Value of Benefit Stream	Present Value of Cost Stream	Net Present Value (Benefits - Costs)	Benefit-Cost Ratio
Traveler Benefit	A+B	98.49	40.3	58.2	2.44
Full User Benefit	A+B+C	104.1	40.3	63.8	2.58
Total Societal Benefit	A+B+C+D+E	104.63	40.3	64.34	2.6 [F]

Wider Measures

Impact Measure	Impact Definition	Present Value of Impact Stream	Present Value of Cost Stream	Net Present Value (Impacts - Costs)	Impact/Cost Ratio
Add'l Gross Regional Product	GRP	0	40.3	-40.3	0
GRP plus Traveler non-$ Benefit	GRP+B	48.48	40.3	8.18	1.2
GRP plus Total non-$ Benefit	GRP+B+E	49.01	40.3	8.71	1.22

Table 17. Summary of MBCA Benefit-Cost Outputs at 3%, 5%, and 7% Discount Rates

	Undiscounted	3%	5%	7%
Total Benefits (millions 2015 $)	163.4	104.6	79.51	61.45
Total Costs (millions 2015 $)	45.9	40.3	36.59	33.1
Net Benefits (millions 2015 $)	117.5	64.3	42.93	28.35
Benefit-Cost Ratio		2.6	2.17	1.86

Source: MBCA.

Analysis of New Bedford/Fairhaven Bridge with MBCA

Though the W.E.B. Reliability tool was unable to capture the wider economic benefits of the New Bedford/Fairhaven Bridge project, we wanted to try to capture them with the MBCA tool for two reasons: (1) The MBCA tool is able to capture reliability benefits of all modes, including the marine component of the project, and (2) We wanted to investigate whether the different approach of MBCA would allow it to capture the benefits of the surface ITS component of the project that the W.E.B. Reliability tool was unable to capture.

As noted above, there are two build alternatives under consideration, both with the same transportation impacts (and therefore the same transportation benefits) and very similar cost profiles, Alternative 3D with a maximum estimated project cost of $125 million and Alternative 1T with a maximum estimated cost of $130 million. We began by running the tool using $125 million. Had the resulting benefit cost ratio been >1.0, we would have run it under the higher cost to see if it would still be positive under the slightly higher cost of Alternative 1T.

Inputs

To set up the New Bedford/Fairhaven bridge project in MBCA, we completed the following initial tasks (by menu tab):

- Project: Named the project
- Analysis Type: Selected "single project"
- Modes: Selected modes by trip purpose
    - "Car – passenger car", no split (all trip purposes)
    - "Ship-Marine Freight", freight
- Timing:

Field	Input	Source
Construction Start Year	2020	Assumption
Construction End Year	2022	Assumption
Operations Start Year	2022	Assumption based on conclusion of construction
Operations End Year	2042	Last year possible
Analysis Year	2042	Last year possible
Constant Dollar Year	2015	It is traditional to use the current year, or the most recent year for which the real inflation rate is available.
Discount Rate (%)	3%	3-5% is typical. TIGER Grants require analysis at 3% and 7%.
Travel Growth Rate (% of Trips)	0.0%	Based on travel data/projections from HDR
Name Analysis Periods	Annual	(defaults to Annual)

- Costs (millions)

MBCA allows costs to be entered by program element, however, only aggregate figures are available for this project at this stage in the planning. They are entered under marine since that is the primary cost element. This does not affect the results.

Alternative	Cost Type	Road	Marine
No build	Construction Costs	0	45
No build	Annual Ops & Maint Cost	0	0.4
Alt. 1T/3D	Construction Costs	0	125
Alt. 1T/3D	Annual Ops & Maint Cost	0	0.49

Source: New Bedford-Fairhaven Bridge Corridor Report (2015).

- Travel Characteristics
  We developed marine and surface trip, VMT, and VHT inputs based on transportation data from HDR's New Bedford-Fairhaven Bridge Corridor Study

Alternative	Facility	Mode	Purpose	Trips	VMT	VHT	Fraction Congested	Buffer Time	Crew per Vehicle	Av. Veh Occupancy	Freight Tons per Vehicle
No Build	Road	All Trucks	Freight	11,828	48,960	4,750	0.30	0.04	1.10	0	24.05
No Build	Water	Marine Freight	Freight	12	6	78	0.25	24	3	0	14,000.
No Build	Road	Passenger Car	All	382,374	1,583,028	153,587	0.30	0.038	0	1.5	0
Alt 1T or 3D	Road	All Trucks	Freight	11,828	111,342	3,009	0.30	0.02	1.10	0	24.05
Alt 1T or 3D	Water	Marine Freight	Freight	30	15	9	0.30	0.20	3	0	14,000.
Alt 1T or 3D	Road	Passenger Car	All	382,374	3,600,051	97,293	0.30	0.02	0	1.5	0

Source: HDR with SRPEDD calculations.

Trip origin/destination assumptions were developed using data from SRPEDD's travel model.

Alternative	Facility	Mode	Purpose	Fraction of trips: Internal	Fraction of trips: Incoming	Fraction of trips: Outgoing	Fraction of trips: Through
No Build	Road	All Trucks	Freight	0.2	0.4	0.4	0.0
No Build	Water	Marine Freight	Freight	0.0	0.5	0.5	0.0
No Build	Road	Passenger Car	All	0.2	0.4	0.4	0.0
Alt 1T or 3D	Road	All Trucks	Freight	0.2	0.4	0.4	0.0
Alt 1T or 3D	Water	Marine Freight	Freight	0.0	0.5	0.5	0.0
Alt 1T or 3D	Road	Passenger Car	All	0.2	0.4	0.4	0.0

Source: Estimated based on data from SRPEDD travel model.

- Trip Balancing. With the widened channel under either build scenario, an additional 12 container ships per year are expected to pass under the bridge to reach the New Bedford Harbor's North terminal. All of these ships are assumed to be diverted from other competing ports (i.e. from outside the region and outside the model), rather than diverted from another mode within the model or induced (i.e. trips that would not occur at all without the new facility). The actual cost savings that these "new" ships realize in choosing the North Terminal over another facility is unknown, but under economic consumer surplus theory, is assumed to be half of total benefits that accrue to existing users.[10]

Some trips are unbalanced, please review and make adjustments if needed

No Build vs Alt 1 Vertical-Lift Bridge

Summary of Travel Change Patterns

Trip Purpose	Passenger Trips				Freight US Ton-Trips			
	Total Base Scenario Pass-Trips	Total Project Scenario Pass-Trips	Difference (Proj-Base)	Share Of Project Scenario Trips	Total Base Scenario US Ton-Trips	Total Project Scenario US Ton-Trips	Difference (Proj-Base)	Share Of Project Scenario Trips
No Split	573,561	573,561	0	0.0%	0	0	0	0.0%
On-the-Clock	0	0	0	0.0%	0	0	0	0.0%
Commute	0	0	0	0.0%	0	0	0	0.0%
Personal/Rec	0	0	0	0.0%	0	0	0	0.0%
Freight	0	0	0	0.0%	452,463	704,463	252,000	35.8%

Please consider altering the number of trips or vehicle occupancy factors in either scenario, such that the number of person or freight trips match between scenarios. In the case of modelling true Induced demand/trips, make sure to specify the percentage of project trips which is due to induced demand. Please note, the sum of the In-Model, Out-of-Model and Induced percentages must be equal to one.

Region	Period	Facility	Mode	Purpose	Change in Passenger-Trips	Change in Freight US Ton-Trips	Fraction diverted from mode in model	Fraction diverted from mode or region outside model	Fraction induced (latent demand)
Default Region	Annual	Road	All Trucks	Freight	0	0	1	0	0
Default Region	Annual	Water	Marine Freight	Freight	0	252000	0	1	0
Default Region	Annual	Road	Passenger Car	All	0	0	1	0	0

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Results

As the Grant Application summary shows (Table 18), the project has negative total benefits, meaning that instead of cost savings, it represents increased costs. The Benefit-Cost by Mode report (Table 19) shows the source of these increased costs, which are largely due to the increased mileage associated with the long diversion. The table shows zero cost savings for the marine component, however we know empirically that there are cost savings of approximately $40,000 for each ship that experiences the 24-hour delay[11]. Furthermore, the Validation/Tracing report does show cost savings of

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[10] See http://bca.transportationeconomics.org/benefits/induced-travel/evaluating (the yellow triangle under the demand curve represents the benefits accruing to new users).
[11] New Bedford-Fairhaven Bridge Corridor Study, 2015 (HDR).

over $384,000 in the analysis year of 2042 for the marine mode. It is unclear why these costs are not being captured in the results table.

Table 18. MBCA Grant Application Report for the New Bedford-Fairhaven Bridge (Alternatives 1t or 3D)

Table 1: BCA Summary

Benefits	Compare 'Alt 1T or 3D' vs. 'No Build'	
	3% discount rate ($ mil.)	7% discount rate ($ mil.)
Vehicle operating costs	-12.59	-7.04
Reduced travel time	7.24	4.05
Value of personal time	8.49	4.75
Safety	-3.85	-2.15
Logistics/freight costs	0.73	0.41
Productivity from access/connectivity	0	0
Environmental factors	-1.19	-0.65
Consumer surplus and other social welfare	0	0
Total Benefits	-1.17	-0.64
Costs		
Capital Costs	67.02	53.39
Maintenance costs	1.16	0.65
Residual value	10.2	3.65
Total Costs	78.39	57.69
Benefit/Cost Ratio	-0.01492	-0.01104

Table 19. MBCA Benefit Cost by Mode Report: Present Value of Benefit Stream (Full Analysis)

BENEFIT/COST RESULTS - BY MODE (NATIONAL PERSPECTIVE) (5a)

Analysis Year: 2042
Constant $ Year: 2015
Base Alternative: No Build
Project Alternative: Alt 1T or 3D
Annual CO2 Cost Increase: 3%

Project: Bridge Alt 1T or 3D
Region: National
Period: All Periods
Perspective: National Perspective

Present Value of Benefit Stream ($m 2015 Const Dollars)

Mode	(A) Traveler Money Benefit		(B) Value of Traveler Non-Money Benefit			(C) Logistics Productivity ($)	(D) Mkt Access / Other Prod. ($)	(E) Social & Environ Value
	(A1) Vehicle Operating Costs	(A2) Business Time + Rel Cost	(B1) Personal Time + Rel Value	(B2) Safety Value	(B3) Consumer Surplus Value			
All Trucks - Freight	-0.77	0.97	0	-0.01	0	0.73	--	-0.2
Marine Freight - Freight	0	0	0	0	0	0	--	-0.08
Passenger Car - All	-11.82	6.28	8.49	-3.84	0	0	--	-0.91
Totals	-12.59	7.24	8.49	-3.85	0	0.73	0	-1.19

A separate tool run using only the marine mode produces different results (Table 20), with very small, positive cost savings for (A1) Vehicle Operating Cost and (A2) Business Time + Reliability Cost, which perhaps were too small to show up in the multi-modal run. However, it is not clear why $4.73 million would be reported for (C) Logistics Productivity under the marine only run and not under the multi-modal run. This inconsistency will need to be resolved before this tool can be fully evaluated and compared to the W.E.B. Reliability tool.

Table 20. MBCA Benefit Cost Results for Marine Mode Only

BENEFIT/COST RESULTS - BY MODE (NATIONAL PERSPECTIVE) (5a)

Analysis Year: 2042	Project: Bridge Marine-Only
Constant $ Year: 2015	Region: National
Base Alternative: No Build	Period: All Periods
Project Alternative: Alt 1T or 3D	Perspective: National Perspective
Annual CO2 Cost Increase: 3%	

Present Value of Benefit Stream ($m 2015 Const Dollars)

Mode	(A) Traveler Money Benefit		(B) Value of Traveler Non-Money Benefit			(C) Logistics Productivity ($)	(D) Mkt Access / Other Prod. ($)	(E) Social & Environ Value
	(A1) Vehicle Operating Costs	(A2) Business Time + Rel Cost	(B1) Personal Time + Rel Value	(B2) Safety Value	(B3) Consumer Surplus Value			
Marine Freight - Freight	0.23	0.08	0	0	0	4.73	--	-0.08
Totals	0.23	0.08	0	0	0	4.73	0	-0.08

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Comparing MBCA Outputs with W.E.B. Reliability Tool Outputs

Table 21 presents a comparison of benefit-cost results based on W.E.B. tool outputs (Reliability Tool + Accounting Matrix) and MBCA outputs. Because the W.E.B. Reliability tool was unable to capture wider economic benefits for the New Bedford-Fairhaven Bridge project, this comparison is only for the Middleborough Rotary project.

The MBCA tool used a more detailed accounting of benefits and costs than SRPEDD's side calculations. MBCA phased in benefits during the three-year construction period. Because near-term benefits are worth more than future benefits, this resulted in a significant difference in total project benefits. Similarly, MBCA spread the $51.0 million construction cost over the three-year construction period, which results in less than $51.0 million when adjusted for inflation, and also subtracted the inflation adjusted residual value[12] from total cost before discounting. These are minor methodological differences that could be refined if SRPEDD chooses to utilize W.E.B. analysis tools in the future. The resulting benefit-cost ratios ranging from 2.7 to 1.6 from the W.E.B Reliability tool and accounting matrix are remarkably close to the 2.6 to 1.9 benefit-cost ratios calculated by MBCA.

Table 21. Comparison of W.E.B. Analysis Tools and MBCA Outputs

	W.E.B. Reliability Tool + Accounting Matrix	MBCA	% Difference
Total Benefits - Undiscounted (2015 millions)	$212.8	$163.4	-23%
Discounted @ 3%	$158.9	$104.6	-24%
Discounted @ 5%	$134.2	$79.5	-25%
Discounted @ 7%	$115.3	$61.5	-26%
Costs - Undiscounted (2015 millions)	$51.0	$45.9	-10%
Discounted @ 3%	n/a	$40.3	n/a
Discounted @ 5%	n/a	$36.6	n/a
Discounted @ 7%	n/a	$33.1	n/a
Net Benefits	$161.8	$117.5	-27%
Discounted @ 3%	$107.9	$64.3	-26%
Discounted @ 5%	$83.2	$42.9	-23%

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[12] A transportation infrastructure asset is not typically fully depreciated over a 20-year analysis period, and the residual value represents the value that remains.

Discounted @ 7%	$64.3	$28.4	-12%
Benefit Cost Ratio			
Discounted @ 3%	3.1	2.6	-4%
Discounted @ 5%	2.6	2.2	4%
Discounted @ 7%	2.3	1.9	14%

Source: SRPEDD with W.E.B. Reliability Tool and Accounting Matrix, and MBCA.

OPPORTUNITIES FOR INTEGRATING SHRP1 C11 TOOL USE INTO SRPEDD'S DECISION-MAKING PROCESS

The previous sections of this report focused on the feasibility of SRPEDD using SHRP2 C11 Tools to capture the wider economic benefits of proposed transportation projects as part of a benefit-cost analysis. Those sections addressed such issues as data availability, ability to develop the technical knowledge to apply the tools and interpret results, and demands on staff time and institutional resources.

As the report indicates, SRPEDD was able to develop the necessary technical knowledge to collect the relevant data, apply the tools, interpret results and integrate them into a benefit-cost analysis. Though this first attempt was relatively time consuming and required specialized staff, a significant part of the effort was dedicated to developing the institutional capacity necessary to streamline data collection and run the tool and interpret results without specialized staff. Now that it has been determined that routine W.E.B. analysis tool use is feasible, it is important to determine whether its utility to the organization justifies ongoing commitment of resources.

This section addresses this issue by examining the following issues:

1. At what steps in the decision-making process would it be useful to have benefit-cost results that include wider economic benefits?

2. What role do potential economic benefits play in the decision-making process? What weight are they given relative to other issues such as safety and the environment?

3. How many planned/proposed projects in SRPEDD's jurisdiction have wider economic benefits? How often do new projects with wider economic benefits come under consideration? How frequently would W.E.B. tools be used to analyze, update, and refine results as projects progress through the decision-making process?

All significant transportation projects in SRPEDD's jurisdiction are funded primarily through a combination of state and federal funds. To be eligible for these funds, a project must be added to SRPEDD's Transportation Improvement Program (TIP). To be added to the TIP, SRPEDD and MassDOT staff thoroughly evaluate them on a wide range of factors including condition/performance of the existing facility (if applicable), safety, environmental, community and social justice, and economic development. That is, wider economic benefits, which are a subset of economic benefits, are just one of many factors by which projects are evaluated. Figure 3 provides an overview of the process by

which projects are added to SRPEDD's TIP, which is divided into three basic phases: Project inception; project initiation; and environmental, design, and right of way. There is a role for a benefit-cost analysis in each phase.

Project Inception Phase

During the project inception phase, a problem or needs are identified and possible solutions are developed. A public outreach process is initiated that should continue throughout project inception all the way to project construction (or project dismissal). At this point, project sponsors conduct an informal review with SRPEDD and MassDOT District staff, and with SRPEDD and MassDOT assistance where necessary, sponsors complete a Project Need Form (PNF).

The PNF contains the following elements relevant to identifying the presence of productivity benefits:

- Part III: Identification of Problem, Need, or Opportunity
  B. Mobility – Problem, Need, or Opportunity
    1. Please describe any existing or prospective highway congestion issues. Identify the nature and extent of congestion, including when it occurs and whether there is queuing. Include any traffic analysis including LOS (level of service) data, if available.
    2. Please describe any need or opportunity for greater connectivity or improved access along the corridor or to particular points along the facility. Identify any missing connection or constraint in access that could be improved for greater mobility.

Item III-B-1 could capture a response that indicates a role for the Reliability tool while the response to item III-B-2 may indicate a role for the W.E.B. Market Access or Intermodal Connectivity tools. The PNF also contains the following elements where it would be appropriate to include the results of the W.E.B. analysis tools as part of the response:

  D. Economic Development – Problem, Need, Or Opportunity
    1. Please describe any current, planned, or potential economic development opportunities within the project limits that would be supported by improvements to the facility.
    2. Identify any need or opportunity to improve access to services, promote industry clusters, facilitate affordable housing or job creation within the area.

The PNF, described above, is submitted to MassDOT for evaluation along with a completed Transportation Evaluation Criteria (TEC) form. The TEC contains questions in the areas of community impact and support; maintenance and infrastructure; safety and

security; mobility/congestion; livability/sustainable development; and environmental climate change. Each question is awarded a maximum points score, and projects can have a negative score on questions for which it has a negative impact. Questions that could include the results of a benefit-cost analysis with the results of W.E.B analysis tools appear in two sections: Mobility & Congestion and Livability/Sustainable Development Effects, as follows :

- Mobility & Congestion (18 total points possible):
    - Question 1 – Does the project address an existing or projected congestion problem/bottlenecks? (score range -6 to 6 points).
    - Question 2 – Does the project improve mobility, connectivity, or access for multi-modes of travel (score range -6 to 6 points).
    - Question 3 – Is the project on an existing freight route AND does it address issues identified by a State or SMMPO documented Freight Plan? (score range -3 to 3).
- Congestion and Livability/Sustainable Development Effects (12 total points possible)
    - Question 3 – Does the project provide or improve multimodal access to/from within Economic Target Areas, Economic Opportunity Areas, Priority Development Areas, 43D sites, Transit Oriented Developments (TOD's) or Environmental Justice areas (score range -3 to 3 points).

Taken together, Mobility & Congestion questions that could incorporate the results of W.E.B. analysis tools are worth a total of 15 points, out of the total of 18 for the category. It is not clear how heavily the results of W.E.B. analysis tools would weigh among other factors to be addresses in responding to each question. The scoring guide that accompanies Mobility & Congestion questions 1 and 2 appears to focus primarily on commuter travel (including transit) as well as non-vehicle traffic (pedestrian, bicycle), with little specific mention of business travelers, therefore it is unclear how demonstrated wider economic benefits would be scored for those items. Scoring guidelines for question 3 focus on how well the project addresses issues in an existing freight plan, so the results of a W.E.B. tool would be most useful in demonstrating the benefits of projects that address issues in an existing freight plan.

Congestion and Livability/Sustainable Development question 3 could imply a role for the W.E.B. Intermodal Connectivity tool for projects that improve highway access to rail, air, and marine intermodal terminals within one of the target areas listed. The W.E.B. Reliability or Market Access tools could also provide supporting data for projects that affect more than one mode - such as a project that addresses highway congestion reduction and commuter rail service – however the W.E.B. results themselves would cover only impacts resulting from the highway component of the projects. Note also that while the Congestion and Livability/Sustainable Development Effects category is worth up to 12 points, question 3 is worth only a maximum of 3 points, thus the

contribution of W.E.B. analysis tools from this category to the project's overall score would be minor.

SRPEDD updated the TEC and accompanying scoring guidelines in 2014, and revisits them periodically to ensure consistency with regional transportation planning goals and objectives. Perhaps if SRPEDD more formally adopts the use of W.E.B. tools as part of the project evaluation process, specific economic development criteria could be developed and integrated into the TEC that would more directly be supported by W.E.B. tool outputs.

Project Initiation Phase

If the project advances to the Initiation Phase, project sponsors will then be required to prepare a Project Initiation Form (PIF). The PIF requires some information similar to that on the PNF, however the form calls for a greater level of detail for items such as cost estimates and anticipated funding sources, and also requires an initial delegation of project responsibilities between MassDOT, the community, and other parties.

There are three items on the PIF that could be supported by the results of W.E.B. analysis tools. Part I – General information asks applicants to "Describe any regional benefits that would be realized should the Project Need be met". Part III – Project Description item D. Economic Development – Problem, Need, or Opportunity asks applicants to "1. Describe any improvements that improve a business district, business related elements or support proposed economic development opportunities", and "2. Identify improved access to services, industry clusters, or job creation in the project area. Include the number of jobs to be created, if available"[13].

Furthermore, the TEC, initially produced for submission with the PNF form during the Project Inception Phase, is revised and updated for submission with the PIF.

Environmental, Design and ROW Phase

Projects that advance from the initiation phase are programmed into a TIP year and become eligible for funding, and then proceed through the Environmental, Design, and Right of Way (ROW) phase. During this phase, they must satisfy NEPA/MEPA environmental regulations. Though MEPA/NEPA are focused on the physical environment, and oriented towards mitigating negative impacts rather than showcasing benefits, there is a limited role for demonstrating economic development benefits. Results of a benefit-cost analysis that incorporates wider economic benefits through use of W.E.B. analysis tools could be included as part of the NEPA EIS/MEPA ENF process.

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[13] Economic impacts, including impacts from wider economic benefits, can be expressed in terms of jobs supported by applying economic multipliers (IMPLAN, RIMSII, REMI) to dollar outputs.

Under NEPA, it could be included either as part of a benefit cost analysis completed under Section 1502.23[14] or as part of a cumulative impacts analysis. NEPA cumulative impacts guidelines state,

> "EPA comments should identify significant cumulative impacts that may affect resources of concern and suggest mitigation measures that will avoid or minimize adverse effects to the environment. While this guidance emphasizes the effects of projects on ecological resources, other resources and areas that should be considered include socioeconomic resources, human health, recreation, quality of life issues, and cultural and historical resources."

And

> "Cumulative impacts can affect a broad array of resources and ecosystem components. In addition to considering the biological resources that are the staple of NEPA analysis, examples of other resources that should be considered include historic and archaeological sites, socioeconomic services and issues, and community structure and character."[15]

All Phases: Public Outreach

The SRPEDD TIP funding guide indicates that public outreach should begin with project inception and continue throughout each phase to project completion. Including the results of a benefit cost analysis incorporating the results of W.E.B. tools could be of interest to some audiences, in particular, to local planning and economic development agency staff as well as stakeholders who are supportive of the project. The business community, for example, if generally supportive of a project, may see the inclusion of wider economic benefits as an indication that their business needs and interests are playing an important role in project evaluation.

However, stakeholders and citizens who are against the project understandably tend to be skeptical of analysis that supports a project. The highly technical nature and novelty of wider economic benefits analysis and W.E.B. analysis tools may exacerbate such skepticism and further antagonize those who oppose the project. As a result, it may be prudent to highlight wider economic benefits only to supportive audiences. To wider audiences representing a range of support, benefit-cost analysis results may be

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[14] NEPA implementation guidelines (CEQ) Section 1502.23 states, "If a cost-benefit analysis relevant to the choice among environmentally different alternatives is being considered for the proposed action, it shall be incorporated by reference or appended to the statement as an aid in evaluating the environmental consequences."

15 Consideration Of Cumulative Impacts In EPA Review of NEPA Documents, U.S. Environmental Protection Agency, Office of Federal Activities (2252A), EPA 315-R-99-002/May 1999.

presented more generally, still containing the results of W.E.B. analysis but without calling specific attention to them as a selling point of the project.

Screening the Existing TIP for Wider Economic Benefits

As the previous section indicates, there are various places throughout the TIP project evaluation process where benefit-cost analysis with wider economic benefits could support decision-making. The final step is to understand how often SRPEDD would be likely to perform such an analysis. To shed some light on this question, we applied the productivity screens described in the Methodology section to screen each project on the current TIP for productivity benefits. Out of 31 projects screened, four were found likely to have productivity benefits, and an additional three may have productivity benefits subject to further examination of project goals and characteristics.

Figure 3. Overview of TIP Decision-Making Process

Project Inception	Project Initiation	Environmental, Design and ROW
Project Identification • needs and solutions developed **Public Outreach** • garner support **Informal Review** • with SRPEDD • with MassDOT District staff **Prepare Project Need Form (PNF) -** • include Transportation Evaluation Criteria (TEC) • include accurate cost estimates • submit to MassDOT for evaluation	**Prepare Project Initiation Form (PIF)** • include Transportation Evaluation Criteria (TEC) and Project Need Form • include accurate cost estimates **Formal Review** • to the Project Review Committee • the SMMPO staff **Public Outreach** • actively seek input from interested parties	**25% Design Plans and Review** • environmental documentation & permitting • MEPA & NEPA determination • identification of applicable permits • right of way process • develop preliminary cost estimates • functional design report **25% Design Public Hearing / Outreach** • maintain support • seek meaningful input
← **Possible Results** →	← **Possible Results** →	← **Possible Results** →
• Determination to Advance Project • Determination to Dismiss Project	• Determination to Advance / Dismiss Project • Programming in a TIP year and a TEC score • Eligibilty for funding • Assigned a project ID# by MassDOT	• Proceed into Final Design - 75% design, 100% design, and PS&E • Construction

Source: SRPEDD's Transportation Improvement Funding Guide (2014).

APPENDIX: SCREENING TABLES FROM NCHRP 02-24

Table 22. NCHRP 02-24 Project Classification Form

Project Name _____ (fill in for your own use)

Project Facility Type (check one or more, as applicable) Corridor or Line Type:

☐Highway / Road ☐Dedicated Busway ☐Rail Line Intermodal Terminal Type:

☐Airport ☐Marine Port ☐Rail Freight ☐Passenger (Bus or Rail) ☐Maintenance Facility

Use Orientation :
☐Passenger ☐Freight ☐Both passenger and freight

Dominant Project Objective(s) (check one or more)
☐Congestion/Reliability ☐Capacity /Future Growth ☐Travel Time (distance, speed)
☐Service Frequency ☐Closure/Detour Reduction☐Intermodal Connectivity
☐Metro Market Access ☐Business Site Access ☐Access to Isolated Rural Community
☐Safety ☐Preservation or Rehabilitation ☐Quality of Life

Primary Project Impact Area (check one or more)
☐Urban / Metro Area ☐Rural Area☐Inter-City Connection ☐State/Region
☐National / International Gateway

Trip Purposes Served (Above Average): (check one or more)
☐Freight ☐Commuting ☐Business Travel ☐Recreation/Tourism ☐Mix (no trip type is above avg.)

Source: NCHRP 02-24: Assessing Productivity Impacts of Transportation Investments (page 34).

A. Projects that typically have little or no productivity effects

Projects that Address Social/Environmental/Safety issues and Personal Recreation Travel*
· Redesign to enhance safety – improve existing routes by changes in guard rails, shoulders, geometrics, visual obstructions, surface traction, lighting, signs; · Enhancement to address environmental factors (noise, air, visual impacts) – sound barrier walls, berms, vegetation in buffer zones or relocation of facilities to reduce adverse effects; · Redesign to address social cohesion factors – underpasses or decking of right of way trenches to enable access paths from neighborhoods to schools, parks, community facilities; · Redesign to reduce detours or closures due to natural occurrences – road or rail corridor drainage, elevation and barrier projects to minimize effects of landslides and floods; · Special purpose road and rail routes – new or enhanced routes to better access tourism and recreational destinations.

B. Projects with productivity benefits driven by traditionally measured user benefits

Projects that can reduce Time Cost for Business-Related Travel*
· Speed Improvement on links – upgrade roads or rail tracks to enable faster vehicle speeds; · Bypass links – add special lanes, tracks, or modal route separation (including busways), to enable long-distance and pass-through vehicles to avoid local bottlenecks; · Connector links – add special truck access routes for industrial parks, border crossings, intermodal rail, air freight or marine terminals; · Higher Capacity Vehicles – upgrade roadway, rail line, airport runway or structure (road or rail bridge, over-pass or tunnel) to increase allowable vehicle size and weight ; · Higher Frequency Operations – implement positive train control, enhanced air traffic control or other technologies that reduce minimum vehicle spacing. · Dwell Time Reduction at Nodes – convert road intersection to limited access interchange; add turning lanes; optimize signal timing; implement in-road tolling; upgrade processing speed at bus terminal, rail terminal, airport or marine port;

(continued)

C. Projects with wider business benefits not all captured by traditional benefit assessment

C1. Projects that can Enhance Reliability (and Reduce Time Cost) for Business-Related Travel*

· Reduction in peak period congestion bottlenecks – add highway lanes; add rail tracks; add airport gates; expand truck or rail loading facilities; expand dock capacity at seaports

· Reduction in incidence of interfering activities – construct road or rail overpass or underpass to reduce grade crossings; replace drawbridge with high clearance bridge; construct alternative routes for route affected by activity at sports/entertainment venues;

· Reduction in incidence of collisions – implement design improvements to enhance safety for freight movements via roads, rail lines, or ship channels;

C2. Projects that Enhance Regional Accessibility (and Reduce Time Cost) for Business Travel*

· New (or substantially upgraded) access routes between communities in a region – add a new highway route, busway route, rail transit route or ferry route that enlarges the market for travel to/from endpoints served (and hence induces more travel between those points);

· Enhanced service frequency between communities in a region – implement high speed and reduced stop (express) services for scheduled bus, rail or ferry services;

C3. Projects that Enhance Intermodal Connectivity (and Reduce Time Cost) for Business Travel*

· Enhanced ground access to intermodal terminal – implement new or improved highway route or rail transit service for ground access airport, train station or ferry terminal;

· Expanded connecting services at intermodal terminal – add number of destinations served, or frequency/quality of scheduled services -- for inter-city air/rail/ferry transportation services available at airport, train station or ferry terminal;

* Business travel includes freight deliveries and worker travel to deliver services or attend business meetings) – the cost of which is typically paid by businesses. Commuting travel may be included in productivity measurement when the affected trips are predominantly to/from an employment cluster or center where businesses are paying a wage premium to workers in compensation for the longer travel time, greater delay or higher expense associated with working there. That applies most typically for travel to large urban centers with congested access and high parking cost, or to locations at the fringe of a labor market area -- as discussed in Appendix A.2. Source: NCHRP 02-24: Assessing Productivity Impacts of Transportation Investments (page 22).

Table 24. NCHRP 02-24 Screening Decision Tool

Response from Step 1 Project Classification Form	(A) Productivity Analysis is Not Warranted	(B) Productivity Analysis Using Available Tools	(C) Custom Productivity Analysis
Q2 Project Facility Type			
A. Administration or Maintenance Facility	X		
B. Highway / Road (Passenger or Freight)		X	
C. Local Transit (Bus or Rail)		X	
D. Airport, Marine Port, Freight or Passenger Rail Terminal (intercity)			X
Q3 Dominant Project Objective			
A. Preservation or Rehabilitation, Safety or Quality of Life Enhancement	X		
B. Congestion/Reliability, Capacity, Travel Time, Metro Market Access, Access to Business Site Location, Intermodal Access		X	
C. Closure/Detour Reduction, Access for Isolated Rural Community, or Service Frequency Improvements			X
Q4 Dominant Project Impact Area			
A. Urban/Metro Area or Rural Area		X	
B. Inter-City or Gateway Connection			X
Q5 Trip Purpose Served (Above Average)			
A. Personal Travel (social, recreation)	X		
B. Commuting, Business Travel, Freight		X	
C. Visitor Access			X

Source: NCHRP 02-24: Assessing Productivity Impacts of Transportation Investments (page 37).

Table 25. NCHRP 02-24 Analysis Tool Selection Table

(A) Q3 Project Objective	(B) Mode	(C) Threshold Factor	(D) Analysis Tool **
Travel Time Reduction (due to speed, distance change)	Road (Car, Truck)	Annual reduction in VHT > 80,000 hrs	STB Analysis (Standard Travel Benefit)
	Public Transit (Bus, Rail)	Annual reduction in PTT > 80,000 hrs	
Enhance Capacity, Reduce Congestion	Road (Car, Truck)	LOS = D	Reliability Analysis Tool + STB Analysis
	Public Transit (Bus, Rail)	Avg. Volume/Capacity > 0.85	
Travel Time Reliability (delay incidence due to congestion)	Road (Car, Bus, Truck)	Travel Time Index (TTI) > 1.3	Reliability Analysis Tool + STB Analysis
Metro Area Access (between housing & employment)	Road (Car, Bus, Truck)	Population > 50,000 and density > 1,800/sq.mi.	Market Access Tool + STB Analysis
Metro or Regional Business Delivery Access	Road (Freight)	trucks > 12% of vehicles	Market Access Tool + STB Analysis
Connectivity to Intermodal Terminal	Road (Freight)	trucks > 12% of vehicles	Intermodal Connectivity Tool + STB Analysis
	Road (Passenger)	none	

Source: NCHRP 02-24: Assessing Productivity Impacts of Transportation Investments (page 39).