Building a Balanced Transportation System Using Reliability Performance Measures

Reference Guide

draft report

prepared for

Strategic Highway Research Program

prepared by

Cambridge Systematics, Inc.
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# Table of Contents

Executive Summary.................................................................................................................................. a

1.0 Introduction...................................................................................................................................... 1
  1.1 Background – Reliability is an Important Aspect of Traveler Experience ...................... 1
  1.2 Framework – Performance-Based, Collaborative Planning ............................................. 3
  1.3 How To Use This Reference Guide.................................................................................... 10

2.0 Incorporating Reliability in Policy Statements....................................................................... 13
  2.1 Key Questions ....................................................................................................................... 13
  2.2 Approaches to Answering the Key Questions ................................................................. 13
  2.3 Technical Preparation .......................................................................................................... 14
  2.4 How To .................................................................................................................................. 14

3.0 Measuring and Tracking Reliability ......................................................................................... 19
  3.1 Key Questions ....................................................................................................................... 19
  3.2 Approaches to Answer the Key Questions ....................................................................... 19
  3.3 Technical Preparation .......................................................................................................... 22
  3.4 How To .................................................................................................................................. 24

4.0 Evaluating Reliability Needs and Deficiencies....................................................................... 29
  4.1 Key Questions ....................................................................................................................... 29
  4.2 Approaches to Answering the Key Questions ................................................................. 29
  4.3 Technical Preparation .......................................................................................................... 30
  4.4 How To .................................................................................................................................. 31

5.0 Setting the Right Size of Operations and Management Programs ...................................... 41
  5.1 Key Questions ....................................................................................................................... 42
  5.2 Approaches to Answering the Key Questions ................................................................. 42
  5.3 Technical Preparation .......................................................................................................... 43
  5.4 How To .................................................................................................................................. 45

6.0 Prioritizing Projects Using Reliability ...................................................................................... 49
  6.1 Key Questions ....................................................................................................................... 49
  6.2 Approaches to Answering the Key Questions .................................................................... 50
  6.3 How To .................................................................................................................................. 54
List of Tables

Table 1.1  Institutional Arrangements That Support Planning and Programming for Reliability ................................................................. 5
Table 1.2  Elements of Performance Management ....................................................................................................................... 6
Table 2.1  Key Choices for Drafting a Reliability Policy Statement .......... 16
Table 4.1  Sample Operations Costs, Benefits, and Cost-Effectiveness .......... 36
List of Figures

Figure 1.1  Description of Reliability ................................................................. 2
Figure 1.2  The Causes of Travel Delay ............................................................... 3
Figure 1.3  Stylized Graph Showing Costs and Benefits over Time of a Generic Project ................................................................. 8
Figure 1.4  Capacity versus Operations Project Impacts ...................................... 9
Figure 2.1  Reliability Objective Tree ................................................................. 17
Figure 3.1  The Travel-Time Distribution is the Basis for Defining Reliability Metrics ................................................................. 20
Figure 3.2  Resources Required to Apply Different Tools and Methods to Evaluate Reliability Performance ............................................. 23
Figure 3.3  Examples of Communicating Travel-Time Reliability .................... 26
Figure 4.1  Strategies to Improve Reliability ....................................................... 30
Figure 4.2  Travel-Time Index Variation by Area Size ...................................... 32
Figure 4.3  Atlanta Area Example of Communicating Travel-Time Reliability ................................................................................ 34
Figure 4.4  Reliability Performance Curve ......................................................... 37
Figure 5.1  Program Tradeoff Approach to Investment Planning and Project Prioritization ................................................................. 43
Figure 6.1  Models of Performance-Based Planning and Programming ............ 49
Figure 6.2  Example Performance Measure Weighting Scheme ....................... 55
Figure 6.3  Example of a Hybrid Prioritization Scheme Comparing Cost-Effectiveness and Project Score ................................................................. 60
Executive Summary

Building a Balanced Transportation System Using Reliability Performance Measures provides a high-level reference for incorporating reliability into transportation planning and programming. The reference guide enables planning, programming, and operations managers to apply the concept of travel-time reliability to balance program funding project priorities.

The new Moving Ahead for Progress in the 21st Century Act (MAP-21) transportation bill calls for performance-based planning and programming and requires that states and MPOs track and improve reliability performance because reliable travel is one of the major components of the traveling public’s user experience. Agencies typically do not explicitly address reliability in their planning and programming process, largely because it is an emerging topic just now becoming established in the transportation community. Excluding reliability performance leads to an inefficient distribution of funds among programs and projects, tending to favor larger, longer term, and capital intensive capacity projects over smaller, shorter term, and less expensive operations and management projects. This reference guide exists to help agencies incorporate reliability into performance-based planning and programming. It will support them in:

1. Balancing limited transportation funding. Limited funding requires agencies to make the most efficient and effective investments.

2. Considering all project types on a level playing field. Agencies must consider more than capacity projects to meet their goals efficiently and effectively. Operations and management strategies are targeted at improving the reliability of the system and must be included.

3. Measuring reliability across projects and programs. Capturing the benefits of operations and management strategies requires examining reliability.

What do we mean by reliability?

Reliability means getting there on-time, nearly every time. It means leaving for the airport and knowing that you will catch your flight. It means not paying another late fee at daycare. It means leaving for work in the morning at 7:15 a.m., like usual, and getting into the office at 8:00 a.m., not somewhere between 8:00 a.m. and 8:30 a.m., depending on the traffic. It means avoiding the stress and planning time it takes to overcome not knowing when you really will arrive. It means less wasted time. In the end, it really means trusting that you will arrive to your destination when you expect to.

By following the five steps in Building a Balanced Transportation System Using Reliability Performance Measures, agencies can incorporate reliability into the planning and programming process. These steps are repeated throughout many components of plans in the planning and programming process, including long-range plans, congestion management processes, corridor plans, and operations plans. The five steps are built around the foundation of key decision points (KDP) from the SHRP 2 Capacity Program that identified a comprehensive approach to
Innovative planning. More information on this effort can be found at: http://www.transportationforcommunities.com. The steps are listed below.

- **Incorporating Reliability in Policy Statements.** To incorporate reliability, agencies must establish that reliability is among the core strategic goals or objectives the agency strives to achieve.

- **Developing and Tracking a Reliability Performance Measure.** Well-defined reliability measures based on quality supporting data are critical for understanding and communicating how the transportation system is performing.

- **Evaluating Reliability Needs and Deficiencies.** Like any goal area, one first valuable step is to understand the extent of reliability deficiencies and needs. Where are travel times least predictable? What would it cost to address the deficiencies that exist? The outputs of this process (maps, charts, and figures) will provide background when developing policies, setting the size of the reliability program, and prioritizing projects.

- **Setting the Size of the Operations Program.** A basic question that agencies naturally will ask is, “How big should my operations and management program be?” Answering that question with performance measures requires assessing the relationship between investment and performance.

- **Project Prioritization.** Like many other measures, reliability performance measures can be a factor used in screening and prioritizing projects. Without reliability, it is more likely that an agency will fund capacity projects to improve reliability when they should be considering operations and management projects first.

The reference guide is accompanied by an in depth *Technical Reference*. The *Technical Reference* provides detailed background and instruction describing how to collect travel-time data, select and evaluate reliability performance measures using the full range of available analytical tools and methods.
1.0 Introduction

Building a Balanced Transportation System Using Reliability Performance Measures describes, with as much flexibility as possible, how to incorporate reliability into transportation planning and programming. The reference guide enables planning, programming, and operations managers to balance program funding project priorities.

This reference guide is designed for planning, programming, and operations managers who will be leading planning efforts and making decisions about how the plans will be completed.

The introduction presents three key pieces of information to help users orient themselves to the information presented in the reference guide.

1. **Reliability is an Important Aspect of Traveler Experience.** Background on reliability and the strategies to address reliability.

2. **Performance-Based, Collaborative Planning.** A framework for incorporating reliability into the planning and programming process based around collaborative decision making and a performance-based approach.

3. **How to Use this Reference Guide.** A description of how the guide is organized.

1.1 **BACKGROUND – RELIABILITY IS AN IMPORTANT ASPECT OF TRAVELER EXPERIENCE**

Travel-time reliability, or simply reliability, is a measure of how consistent or predictable travel times are over time. Technically, reliability is the variation in travel time over time measured statistically using histograms, probability density functions, or cumulative distribution functions. Figure 1.1 describes what reliability is, its causes, and the ways that it can be reported. For the user, reliability means getting to daycare on-time for an evening pickup avoiding expensive late fees, arriving at an appointment on-time, and arriving at work on-time, nearly every time. Reliable travel means that weather, crashes, and construction work zones do not cause lengthy, unpredictable, and frustrating delays.

To improve reliability, we must be able to measure it. This reference guide describes how to measure reliability and how to update agency-wide planning and programming processes to ensure that projects to address it are planned for and adequately funded.

Specific technical guidance related to the definition of travel-time reliability can be found in Section 2.1 of the Technical Reference.
Use the Right Tools to Improve Reliability

The traditional planning and programming process is structured to plan for large capacity improvement projects, not to address smaller, “quick turnaround” operations and management investments that could provide significant and immediate relief to congestion and reliability. Over 50 percent of congestion is directly attributable to large fluctuations in demand (due to special events, e.g.), poor signal timing, traffic incidents, inclement weather, and work zones, rather than capacity related bottlenecks (Figure 1.2). These circumstances are less predictable and are the root cause of unreliable travel. Improving travel conditions during these circumstances will improve reliability. While capacity projects can improve reliability by improving the ability of the system to absorb unpredictable circumstances, they should not necessarily be an agency’s first or only choice. One should consider capital projects to improve reliability only after exhausting available operations and maintenance investments. Implementing a capacity project to improve incident delay is akin to using a hammer on a screw - typically, it is the wrong tool for the job. On the other hand, operations and
management projects specifically are intended to address reliability. Operations and management projects include coordinating signal timing, Intelligent Transportation Systems (ITS), incident response, and other similar efforts. This reference guide describes how to plan and program projects targeted at improving reliability.

More technical guidance on the topic of measuring travel-time reliability is in Section 2 of the Technical Reference.

**Figure 1.2  The Causes of Travel Delay**


### 1.2 **FRAMEWORK – PERFORMANCE-BASED, COLLABORATIVE PLANNING**

Before turning to the guidance provided here, this section identifies the two foundational efforts on which the reference guide is built. The first of these - the SHRP 2 Capacity Program - has identified a comprehensive approach to collaborative planning built around a set of key decision points. This guide provides guidance on how to incorporate reliability into the most critical of these key decision points.
The second foundational effort for developing this reference guide is the **national trend towards performance-based planning and programming**. Over the last decade or so, an increasing number of agencies have been managing their systems and organizations using performance measures. After strong support for performance management and performance-based planning, Moving Ahead for Progress in the 21st Century Act (MAP-21) has codified an approach that requires tracking and reporting performance in seven national goal areas, including safety, infrastructure condition, congestion reduction, **system reliability**, freight movement and economic vitality, environmental sustainability, and reduced project delivery delays. MAP-21 solidifies reliability as one of the critical national transportation performance measures.

**Collaborative Planning – Institutional Arrangements and Stakeholder Engagement**

Ensuring that reliability is addressed following a collaborative approach to planning requires developing sound institutional arrangements. The resources in Table 1.1 are intended to help transportation agencies improve reliability. The table is structured to explain what sort of institutional arrangements are important, why they are important, and how to make the necessary arrangements.

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**For Further Reading**

The Strategic Highway Research Program (SHRP) 2 provides a comprehensive approach to collaborative transportation planning. More information on this effort can be found at: http://www.transportationforcommunities.com.
## Table 1.1 Institutional Arrangements That Support Planning and Programming for Reliability

<table>
<thead>
<tr>
<th>What Arrangements Should Be Made?</th>
<th>Why Should It Be Done?</th>
<th>Resource Explaining How to Make Necessary Arrangements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define specific reliability goals, document current business processes and recommended changes, implement a process, measure outcomes against reliability goals, and institutionalize the process.</td>
<td>Organizing and institutionalizing the internal business process to account for reliability will set the stage for success in improving reliability.</td>
<td>Guide to Integrating Business Processes to Improve Travel-Time Reliability (SHRP) – The guide details steps for agencies to improve collecting and analyzing data; integrating travel-time reliability considerations into planning, programming, and project delivery; adopting innovative operational strategies and technologies; and modifying their institutional structures and business practices surrounding traffic operations.</td>
</tr>
<tr>
<td>Develop a collaborative and coordinated effort among many transportation organizations and within key units of a transportation organization.</td>
<td>Properly incorporating reliability into the planning process by figuring out who has the right data, how to get it from them, how to continue getting it from them, and how to analyze and report it will ensure that reliability performance measures can be developed and tracked.</td>
<td>Institutional Architectures to Improve Systems Operations and Management: Strategies to Improve Travel-Time Reliability often Focus on Highway Operations (SHRP) – The report identifies strategies by which transportation agencies can adjust their institutional architecture – including culture, organization and staffing, resource allocation, and partnerships – to support more effective systems operations and management (SO&amp;M).</td>
</tr>
<tr>
<td>Develop a rapport with first responders (fire, police, ambulance, etc.). These stakeholders are among those with the largest influence on reliability through incident management.</td>
<td>Knowing how to reach out to the first responders can help when building an early understanding of reliability deficiencies, begin to conceptualize how to improve them, and developing effective strategies for improving reliability.</td>
<td>Training of Traffic Incident Responders (SHRP) – A strong interdisciplinary traffic incident management program can significantly decrease incident duration and, when combined with traveler information, can increase peak-period freeway speeds, reduce crash rates, and improve trip-time reliability.</td>
</tr>
<tr>
<td>Collaborate with other agencies to achieve respective goals and objectives.</td>
<td>Collaborating among agencies regarding data, funding, communication, procedures, information, resources, and delivery of services will ensure that the most up-to-date and relevant information on reliability performance is obtained.</td>
<td>The Collaborative Advantage: Realizing the Tangible Benefits of Regional Transportation Operations Collaboration (FHWA) – Agencies can realize a range of tangible benefits from participating in multi-agency collaborative efforts for regional transportation operations, including access to funding and other resources, improvements in agency operations and productivity, and outcomes that help agencies achieve their mobility and safety goals. Statewide Opportunities for Integrating Operations, Safety and Multimodal Planning: A Reference Manual (FHWA) – The document provides a “how to” guide for transportation professionals to integrate operations into safety and multimodal planning. They highlight the important role of multidisciplinary teams; data collection, sharing, and analysis; and the broad use of performance measures.</td>
</tr>
<tr>
<td>Address differences in perspective, institutions, and funding between operators and planners.</td>
<td>Working together with operators and planners will help to effectively balance funding among needs to support a reliability policy.</td>
<td>Incorporating ITS Into the Transportation Planning Process: An Integrated Planning Framework (ITS, M&amp;O, Infrastructure) Executive Guidebook (FHWA) – The report defines and develops an integrated decision process that embraces ITS and addresses gaps in perspective, institutions, and funding between those that operate and maintain our transportation system of today (e.g., traffic and transit operations, maintenance) and those that plan, design, and construct our transportation facilities and infrastructure (the focus of conventional planning) for the future. The integrated process is one where ITS, system management, and operations strategies are considered on an equal basis with traditional elements of the transportation system.</td>
</tr>
</tbody>
</table>
Incorporating Reliability into the Technical Process – Performance-Based Planning and Programming

One of the cornerstones of MAP-21’s highway program transformation is a requirement that state DOTs and metropolitan planning organizations (MPO) develop performance-based transportation plans and programs. This reference guide builds on work completed by the Federal Highway Administration (FHWA) and Federal Transit Administration (FTA) to develop a framework for performance-based planning and programming. Table 1.2 presents this framework, and identifies how the sections of this reference guide relate to the framework.

Table 1.2 Elements of Performance Management

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goals and Objectives</td>
<td>Goals and objectives that capture an agency’s strategic direction.</td>
<td>Incorporating Reliability into Policy Statements (see 2.0)</td>
</tr>
<tr>
<td>Performance Measures</td>
<td>Agreed on measures for goals and objectives.</td>
<td>Developing and Tracking a Reliability Performance Measure (see 3.0)</td>
</tr>
<tr>
<td>Identify Strategies</td>
<td>Strategies, policies, and investments that address transportation system needs within the identified goal areas.</td>
<td>Evaluating Reliability Needs and Deficiencies (see 4.0)</td>
</tr>
<tr>
<td>Strategy Evaluation</td>
<td>Evaluate strategies and define program-level system performance expectations.</td>
<td>Evaluating Reliability Needs and Deficiencies (see 4.0)</td>
</tr>
<tr>
<td>Targets/Trends</td>
<td>Established targets/trends for each goal/measure based on an understanding of a desirable future for each goal area and measure.</td>
<td>Sizing an Operations and Maintenance Program (see 5.0)</td>
</tr>
<tr>
<td>Resource Allocation</td>
<td>Identify the amount and mix of funding needed to achieve targets set to address performance goals within individual program areas.</td>
<td>Sizing an Operations and Maintenance Program (see 5.0) and Project Prioritization (see 6.0)</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Identify improvements in analytics, process, etc. to improve the planning process.</td>
<td>Not addressed</td>
</tr>
<tr>
<td>Reporting and Monitoring</td>
<td>Reporting and monitoring progress on goals relative to targets and resource allocation efforts.</td>
<td>Developing and Tracking a Reliability Performance Measure (see 3.0)</td>
</tr>
</tbody>
</table>

For Further Reading

The Federal Highway Administration (FHWA) has developed a white paper that describes the elements of performance-based planning. Read this document for background information on what is likely to be expected from performance-based plans and programs.

http://www.fhwa.dot.gov/planning/performance_based_planning/resources/white_paper/wp00.cfm
Addressing Reliability Within the Planning Process Requires Leveling the Playing Field for All Projects

To effectively incorporate reliability into a performance-based planning and programming process, it is important to consider the full life-cycle costs and benefits of operations and management, capacity, and other types of investments. The equations and the graphics (Figures 1.3 and 1.4) below depict the life-cycle costs and benefits of a generic project. Agency costs are depicted in Figure 1.3 as beige, user reliability benefits are depicted as blue, and user reliability disbenefits are depicted as light blue. Costs and benefits are presented for three time periods, including project-planning (site acquisition, planning and engineering), construction, and postconstruction. The size of the box indicates the size of the cost or benefit. Typically, capacity projects cost a great deal more to plan and build but compared to their cost to construct, they have relatively low maintenance costs. Reliability projects, on the other hand, typically have much lower planning and construction costs but compared to their cost to construct, have substantial maintenance and operations costs.

\[
\text{Agency Cost} = \text{Planning Cost} + \text{Construction Cost} + \text{Operations and Maintenance Cost}
\]

\[
\text{Reliability Benefit} = \text{Construction Reliability Disbenefit} + \text{Reliability Benefit}
\]

The graphic, while simply an illustration, demonstrates the point that operations and management projects typically are quick to build and begin improving reliability earlier than a capital project. In addition, typical operations and management projects do not cause the additional reliability disbenefit of a capital project.
Figure 1.3  Stylized Graph Showing Costs and Benefits over Time of a Generic Project

- **User Reliability Benefit**
  - Reliability Projects
    - Smaller scale operations and management projects (ramp meters, variable message signs), require time to plan as a system, but are not always implemented as part of a broader plan.
  - Capacity Projects
    - Typical large-scale capacity projects can require significant planning and engineering time before construction.

- **Agency Cost**

- **User Reliability Disbenefit**
  - Reliability Projects
    - Reliability benefits are typically smaller than those for large capacity projects but they begin accruing in less time. (Reliability Project)
  - Capacity Projects
    - Reliability benefits are typically larger than those for reliability projects but they take far longer to begin accruing. (Capacity Projects)
Performance-Based Planning and the Color of Money

All agencies have to address fundamental constraints set by Congress, state legislatures, and other sources on the uses of funds for various types of projects. Because operations and management projects are important strategies to address reliability, these restrictions can limit an agency’s flexibility in identifying and funding the appropriate set of strategies. Because of the range of circumstances within which agencies operate, and given the desire to focus this reference guide on a performance-based approach, these issues are side aside following a key finding identified by FHWA and Federal Transit Administration (FTA):

“Fundamental to a performance-based approach is the recognition that agencies should first identify projects that are consistent with their goals and performance targets, and then determine the appropriate funding source for those projects. Unlike a traditional programming and budgeting process that identifies funding sources first, this approach first identifies the set of projects that best help the agency meet its goals or targets.”

By first considering the performance implications of investment and resource allocation decisions, agencies can look for creative approaches to fund projects that are most needed to improve performance and can develop information to help shape how operations and management investments are funded in the future.

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1 Performance-Based Planning and Programming – White Paper. FHWA and FTA. 2012.
1.3  **How To Use This Reference Guide**

*Building a Balanced Transportation System Using Reliability Performance Measures* is written for planning, programming, and operations managers and focuses on the choices and options that need to be made to integrate reliability into the planning and programming process. This section describes the overall organization of the reference guide and the key issues addressed within each section.

**Organization of the Reference Guide**

The guide is organized into the most important, most repeated steps in the planning and programming process:

- **Chapter 2 – Incorporating Reliability in Policy Statements.** Use reliability performance measures and concepts to draft policy statements (vision, mission, goals, and objectives), define the long-term direction of the agency, and make the right choices when setting program funding levels and prioritizing projects.

- **Chapter 3 – Developing and Tracking a Reliability Performance Measure.** Create well-defined reliability measures based on quality supporting data. Well-defined reliability performance measures define an important, but often overlooked, aspect of customer needs. The measures help to support the development of policy language and are critical to making reasoned choices.

- **Chapter 4 – Evaluating Reliability Needs and Deficiencies.** Use reliability to estimate/predict transportation needs and deficiencies and to develop lists of projects to address reliability. Estimating reliability deficiencies using well-defined measures will help to define the size and source of the reliability problem and to inform policy. The outputs of this process (maps, charts, and figures) will provide background when developing policies, setting the size of the reliability program, and prioritizing projects.

- **Chapter 5 – Setting the Size of the Operations Program.** Use reliability performance to set reliability program funding levels and targets. Also, use reliability performance to set the right funding levels for other programs. Without considering reliability, it is more likely that capacity projects will be funded over operations and management projects.

- **Chapter 6 - Project Prioritization.** Use reliability performance to prioritize projects.

**Organization of the Sections**

The chapters describing the steps (Chapter 2 through 6) each refer directly to more detailed guidance in the companion *Technical Reference* and to examples gathered from current industry practice as well as from case studies that were conducted as part of this study. Each chapter of the reference guide is organized as follows:

- **Technical Preparation.** This section identifies the work that should be accomplished before beginning the “how to” section of the chapter. Typically, this section includes methods for analyzing reliability performance, descriptions of data to be collected, and details of other work to be reviewed. See the *Technical Reference* for a detailed description of each of the
analytical tools and for details on economic-based decision-making. Throughout the reference guide, bold and italicized text indicates a reference to the Technical Reference.

- **Key Questions.** This section details issues to consider and choices to be made when beginning work on a particular chapter.

- **Approaches to answering key questions.** Planning is flexible and every agency plans differently. This section outlines the options for answering the key questions.

- **How-To.** Instructive, prescriptive guidance for incorporating reliability into the key steps in the planning process. This section also includes a discussion of the impact on different types of plans (such as long-range plans, corridor plans, etc.).
2.0 Incorporating Reliability in Policy Statements

Transportation agencies draft policy statements (mission, value, goals, and objectives) to indicate the priorities of the organization. Typically, the first and most critical set of policies is drafted in the State long-range transportation plan (LRTP). Ensuring that reliability is addressed in these policies is the critical first step toward incorporating reliability into planning and programming. Addressing reliability as a policy issue can require technical analysis (i.e., what is the extent of unreliable travel conditions in a corridor or region?) and public and stakeholder coordination (i.e., to what extent do various users of the transportation system identify reliability as an issue?). Institutional coordination is critical in this stage; a failure to work with a wide range of stakeholders can limit the coverage of an agency’s goals.

Once a policy statement includes reliability, it can initiate a cascade of changes, starting with reliability performance measures for monitoring and project selection, inclusion in regional transportation plans (RTP) and other statewide and regional plans including congestion management plans (CMP), corridor plans, subarea plans, and modal plans (i.e., freight, aeronautics, rail, transit, pedestrian, and bicycle).

2.1 Key Questions

- How does one tailor the goals and objectives in the plan to include reliability in a way that matters to the state or region?
- What are the chief causes of poor reliability in a state or region?

2.2 Approaches to Answering the Key Questions

Develop an understanding of the location and causes of reliability issues. Use several points-of-view to help identify and solidify understanding.

- Focus analysis on the reliability of different roadway types (i.e., by functional class, vehicle-miles traveled, statewide classification, or other classification).
- Focus analysis on the reliability of state, metro-area, or subarea.
- Focus analysis on the reliability of key corridors connecting population and economic centers, modal hubs such as airports, and other major traffic generators.
- Focus analysis on the reliability of key freight routes.
Building a Balanced Transportation System Using Reliability Performance Measures

- Focus analysis on the reliability of key commuter routes.
- Focus analysis on the reliability of sections of highway heavily impacted by weather, special events, or incidents.
- Focus analysis on the reliability of the major causes of unreliable travel, including incidents, special events, inclement weather, and poorly timed signals, and focus on those reliability projects that address most significant contributing causes in the state or region.

2.3 TECHNICAL PREPARATION

This section details the technical material needed to incorporate reliability into policy statements. At this stage readily available reliability data should be used, including trends if available, to support policy development. Alternatively, use the guidance in Chapter 3 of this guide to select and track reliability performance to develop trends and support the policy development.

Collect existing reliability data. Look for reliability performance analysis in CMPs, operations plans (Regional ITS architecture, or RTPs). If available, use these results to draft the policy statements. These data may include estimates of reliability performance for individual corridors or the overall system.

Develop reliability trends by assessing reliability performance using guidance in Chapter 3 (Optional). Reliability trends show how reliability has changed over time and will help the agency, partners and stakeholders to develop an understanding of reliability issues in the area. Collect as much real travel-time data for the analysis as possible, but given that real-time travel-time data are relatively new, it is unlikely that the agency has a historical dataset long enough to show meaningful trends. To supplement observed travel-time data, consider collecting historic travel demand model output and estimate historical reliability trends using sketch planning models. Complement historical trend data with modeled future trend data to help support assertions about what the status quo will bring to bear the future. Develop future trends for certain types of visioning efforts, including scenario development, to understand how reliable the system will be in future under different logical capacity and demand scenarios.

For Further Reading.

Establishing Monitoring Programs for Travel Time Reliability, a product of SHRP 2 project L02, presents methods by which travel time reliability can be monitored, assessed, and communicated to end users of the transportation system. This resource was not available in published form at the time of writing.

2.4 HOW TO

This section describes how to incorporate reliability into policy statements using the work prepared above.
Combine trend data into charts, tables, maps, and narratives. These products will help explain how reliability has been changing and is anticipated to change over time. For example, develop maps showing ranges of reliability and identify the types of roadways where the users are experiencing reliability problems.

**Washington DOT Congestion Report Describes Reliability Trends**

In their 2011 Congestion Report, Washington DOT reports that 17 of the 36 high-demand commutes in Puget Sound saw modest changes (less than or equal to 2 minutes) in 95 percent reliable travel time between 2008 and 2010. Fourteen commutes saw reliable travel times worsen between 3 and 10 minutes, while reliable travel times improved on five commutes ranging from 3 minutes to 11 minutes.


**Georgia Regional Transportation Authority Uses Maps to Communicate Reliability**

In their 2010 Transportation MAP Report, the Georgia Regional Transportation Authority (GRTA) designed a series of maps to communicate reliability problems in their region. Showing maps like this over time is an effective way to communicate reliability problems.

http://www.grta.org/tran_map/2010_Transportation

Develop a list of the primary locations experiencing reliability issues. Look for reliability issues through different lenses, including:

- **Roadway types or key corridors** (by functional class, key commuter or freight routes, or other important roadway designation);
- **Geographies** (urban, rural, or key subareas);
• **Impacted stakeholders** (commuters, freight trucks, transit, etc.); and

• **Cause of unreliable travel** (incidents, inclement weather, etc.).

Engage stakeholders. Use existing and new engagement techniques to reach out to stakeholders who care about reliability using visual displays to communicate how reliability-focused projects will help their customer experience. Record their opinions to help shape the policy statements.

Develop policy statements. Use judgment to develop policy statements tailored to reflect, stakeholder and partner feedback. Policy statements may include goals, objectives, and strategies to improve those goals. Table 2.1 presents a selection of choices to consider when drafting policy statements related to reliability. The table works from left to right, helping build a policy statement based on the real issues identified when looking through the different lenses. For example, if travel on the interstates in the urban areas is becoming increasingly unreliable for freight trucks due to wintry conditions and businesses are threatening to relocate out of the area, focus on measuring reliability of the key freight corridors in urban areas.

**Table 2.1 Key Choices for Drafting a Reliability Policy Statement**

<table>
<thead>
<tr>
<th>Improve Reliability...</th>
<th>On...</th>
<th>In...</th>
<th>For...</th>
<th>By...</th>
</tr>
</thead>
<tbody>
<tr>
<td>...Interstates...</td>
<td>Urban Areas...</td>
<td>Freight...</td>
<td>...Improving Incident Management.</td>
<td></td>
</tr>
<tr>
<td>...Arterials...</td>
<td>Rural Areas...</td>
<td>Transit...</td>
<td>...Improving Storm Management.</td>
<td></td>
</tr>
<tr>
<td>...National Highway System...</td>
<td>Key Subareas...</td>
<td>Commuters...</td>
<td>...Improving Safety.</td>
<td></td>
</tr>
<tr>
<td>...Key Corridors...</td>
<td>Visitors...</td>
<td>...Improving Work Zone Management.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>...Key Commuter Routes...</td>
<td></td>
<td>...Managing Demand.</td>
<td></td>
<td></td>
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<tr>
<td>...Key Freight Corridors...</td>
<td></td>
<td>...Improving Special Event Management.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>...Improving Traffic Operations</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2.1 below shows a reliability objective tree that describes the relationship among goals, objectives, and strategies - three components of a policy statement. The goal at the top is the broadest and most important policy statement. If users are experiencing significant reliability issues, this can be something like “Improve System Reliability,” but users are experiencing a specific brand of reliability issues, this may be more specific. The next level describes objectives, which are one level more detailed than the goal. The third level describes strategies, which define specific items that are planned to be accomplished to improve reliability.

2 If you have a list of operations and management projects, use that material when communicating about reliability and be as specific as possible. Including real projects that people can relate to will enhance their understanding of the issue. If you do not have a well-defined list of projects, use generic reliability projects to have this discussion - you will have an opportunity to develop a targeted reliability project list in Chapter 4 of this guide.
Examples of Reliability in Goals and Objectives

Many agencies have begun to incorporate the notion of reliability into their policy statements. Examples includes:

- **Massachusetts DOT** (MassDOT) Mission: The MassDOT mission is “Deliver excellent customer service to people who travel in the Commonwealth, and to provide our nation’s safest and most reliable transportation system in a way that strengthens our economy and quality of life.” The mission sits above the goal level and sets the direction for the entire agency.

- **Madison Area Transportation Planning Board** (TPB) Goal: The Madison Area TPB’s 2030 Plan set a goal to achieve a transportation system that is “Reliable – minimizes and alerts persons to unexpected travel delays.”

- **Florida DOT** (FDOT) Objective: Based on stakeholder feedback, the Florida 2060 FTP includes the objective “Increase the efficiency and reliability of travel for people and freight” under the goal “Improve mobility and connectivity for people and freight.”

- **Washington DOT**’s vision for transportation investment, developed as part of Moving Washington, “combines three essential transportation strategies to achieve and align our objectives and those of our partners:” Operate efficiently, manage demand, and add capacity strategically.

Figure 2.1  Reliability Objective Tree

The discussion above focuses on developing reliability policy statements at the system or organizational level. In general a strategic plan, long-range transportation plan, or other similar document will provide a high-level policy direction for the agency and the system for which it has responsibility. Other planning efforts will likely reference the primary document, especially for long-range goals, but in many cases agencies may develop specific objectives and strategies for a given corridor, area, or mode of transportation.

The reliability policy direction for the state and region has been set. The rest of the guide will show how to select performance measures, estimate needs and deficiencies, set program funding levels, and prioritize projects.

For Further Reading

FHWA describes how to Integrate operations into the metropolitan transportation planning process to maximize the performance of the existing and planned system. They describe an approach to developing a regional transportation plan that contains specific, measurable operations objectives, performance measures, and management and operations strategies that directly influence the projects selected for the transportation improvement program (TIP).


FHWA also offers practitioners a menu of options for incorporating operations into their plans using sample operations objectives and performance measures. They include excerpts from a model regional transportation plan to illustrate the results of an objectives-driven, performance-based approach to planning for operations.


Florida DOT District 4 TSM&O Defines Reliability Objectives

The TSM&O task team is developing a TSM&O program and includes reliability among its objectives, “Achieve peak period travel time reliability on critical arterial segments in the TSM&O network.” The objective is structured similarly to that found in any other sort of plan, but is targeted to measure performance on their TSM&O network.

3.0 Measuring and Tracking Reliability

Performance measures provide the technical basis for monitoring performance, setting program funding levels and prioritizing projects. Performance measures can support goal setting by demonstrating the significance of a given need and can be used to help set program funding levels or prioritize projects - the key steps of a performance-based process. Performance measures provide an opportunity to “level the field” or allow comparison of unlike programs or benefits (e.g., comparing capacity addition to operational or other programs) for the purposes of finding the right package of strategies to address transportation needs.

3.1 Key Questions

- What measure should be selected?
- How should the measures be tailored to reflect the reliability needs of the system?
- What is the best way to communicate performance measures to various audiences?

3.2 Approaches to Answer the Key Questions

It is critical to select a performance measure that can help users see how reliability impacts them on an intuitive level and to help planners and operators throughout the agency understand why reliability is important. There are many different ways of measuring reliability performance but the key is to select a measure that reflects the need of users most accurately. The items below show the different ways to measure reliability:

- **Review potential performance measures.** A host of reliability performance measures can be chosen from that will help tell a story. While there are other reliability performance measures in use (skew statistic, buffer index, misery index, etc.), the Planning Time Index (PTI) is becoming the preferred reliability performance measure throughout the industry because it gives intuitive and consistent results.\(^3\) These measures can be calculated with varying degrees of technical rigor. While the PTI is likely to be the primary measure, it also is useful to estimate other measures because these measures each give a different

\(^3\) Agencies also have used the Buffer Index to measure reliability, but research has raised questions about its consistency and intuitiveness. For more details, see SHRP 2 L03 for a detailed discussion of performance measures.
perspective on reliability. As secondary measures, consider selecting failure measures (percent of ‘late’ trips) and different versions of the Travel Time Index (TTI).\(^4\) In the end, all measures of reliability are drawn from the distribution of travel time. Figure 3.1 shows a typical travel-time distribution and indicates how the most popular measures relate to the distribution and to one another.

**Figure 3.1 The Travel-Time Distribution is the Basis for Defining Reliability Metrics**

![Travel-Time Distribution Diagram]

C**Calculating the Planning-Time Index**

The planning time index is the 95\(^{th}\) percentile travel time divided by the free-flow travel time. The 95\(^{th}\) percentile of travel time is the travel time at which 95 percent of all travel requires less time. Similar measures can be established for other percentiles (i.e., where 80 or 99 or another percent of travel requires less time.

\[
\text{Planning-Time Index} = \frac{95^{th} \text{ Percentile Travel Time}}{\text{Free-Flow Travel Time}}
\]

- **Measure for different time periods.** Typical time periods include AM peak hour or period and PM peak hour or period. Select the measure to help address the reliability issues of the user’s experience. For example, a reliability analysis focused on special events may select various evening and/or weekend midday periods to capture when the issues are anticipated.

\(^4\) You can estimate a different version of the TTI for any percentile. This can be useful when tailoring your performance measure to match the critical reliability issues in your state or region.
• **Measure for different travel patterns.** Reliability performance can be considered for trips or for segments and the selection can impact the choice of measure.
  
  - For trips, in addition to PTI and TTI, on-time arrival can be measured, similar to transit and air travel, in a way that is not logical to do for segments. Travel-time data vendors are beginning to release data on individual trip-based travel times. These data can help identify key commuter patterns and their reliability traits.
  
  - For segments, measure travel-time reliability using more traditional travel-time data and models by dividing the highway network into segments and considering reliability for all travelers on those segments.

• **Measure for different roadway types.** Reliability performance for different roadway types (i.e., functional class, different levels of vehicle-miles-traveled, statewide roadway designations, etc.) should be considered. Identify a higher percentile TTI for more critical corridors. For example, measure 99\textsuperscript{th} percentile TTI for the most critical corridor in the state while measuring the PTI for other roadways.

• **Measure for different users.** Consider reliability performance for different users. Anecdotal data suggest that different users perceive reliability differently given their circumstances. Incorporate these perceptions into the reliability measure by selecting different TTIs for different users. The list below offers some theoretical examples to illustrate the point:
  
  - **The Freight Carrier.** A freight carrier balancing the need to make pickups (to make money) and the need to arrive on-time to avoid a penalty for being late will perceive travel time to be reliable if he is on-time 95 to 99 times out of 100. To him, the PTI or the 99\textsuperscript{th} percentile TTI is important. For specific, freight-heavy segments (e.g., the roadway from the Miami Airport to the flower distribution center to its west), travel may be unreliable if the carrier is late once out of 1,000 times. To them, the 99.9\textsuperscript{th} percentile TTI is important.
  
  - **The Visitor.** A visitor making a one-time pass through an area without time constraints will perceive travel time to be reliable if they are on time 6 times out of 10. To the visitor the 60\textsuperscript{th} percentile TTI is important.
  
  - **The Commuter.** A commuter will perceive travel time to be reliable if they are on time 95 times out of 100 (e.g., late to work no more than once per month). To them, the PTI is important.

• **Measure for different geographies.** Consider reliability performance for different geographies. Roll the measures, add a multimodal focus, or weight the measures by vehicle-miles-traveled (VMT).

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5 In much of the reliability literature, segments are referred to as ‘facilities.’
- **State- or Region-Wide.** Roll-up segment measures by identifying the percent of all segments with reliability worse than a certain threshold. Alternatively, estimate a VMT-weighted measure.

- **Corridor-Wide.** Roll-up segment measures in a manner similar to state- and region-wide measures. In addition, estimate mode-specific reliability measures to discern performance among different modal options in the corridor.

### 3.3 Technical Preparation

In order to select the appropriate tools, first determine what is available. The list of tools will vary depending on the plan. For long-range plans and programs, consider sketch planning and travel demand model postprocessors. For corridor studies, CMPs, and operations plans, consider sketch planning, model postprocessors, simulation, and multiresolution models. These methods are described below. The *Technical Reference Section 5.0* provides more details and examples of each of these analysis methods.

- **Modeled Reliability:**
  - **Sketch Planning Methods.** Sketch planning methods provide a quick assessment of reliability using readily available data (travel times, volumes, etc.) as inputs. They are the least resource intensive of the analysis methods and produce order-of-magnitude results. It is typical to use a spreadsheet to build a sketch planning model.
  
  - **Model Postprocessing Methods.** These methods focus on applying customized analysis routines to more robust network supply and demand condition data from travel demand models to generate more specific estimates of travel-time reliability.
  
  - **Simulation.** These methods make use of advanced analytical models to assess driver behavior and their reactions to unpredictable circumstances. Simulation models can give modeled travel-time distributions from which reliability performance measures can be built.
  
  - **Multiresolution methods.** These methods combine several other analysis methods to assess reliability through different lenses. Multiresolution methods take advantage of the integration of several standard analysis tools, (e.g., microsimulation and travel demand models) combining different tools’ ability to assess shorter- and longer-range impacts of various congestion mitigation strategies.

- **Monitored reliability.** These tools/methods provide analysis of realtime and archived traffic data. They differ from the aforementioned methods in that they assess past conditions rather than forecasting future conditions.

- **Consider available resources.** Set the budget and schedule for the planning effort. This will help to determine the appropriate tool. Table 3.1 describes the resources required to

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6 Chapter 5 of this guide has a discussion about setting thresholds for reliability.
use each of the methods. Sketch planning methods require the fewest resources while simulation, multiresolution, and monitoring methods require the most.

**Figure 3.2 Resources Required to Apply Different Tools and Methods to Evaluate Reliability Performance**

- **Collect data.** Collect information on available historical travel-time data or travel demand model output. Use these data to help draft policies (Guide: Chapter 2).
  - **Historical travel-time data.** Collect observed travel-time data from the current travel-time monitoring system, other ITS sensors (bluetooth, cameras, induction loops, etc.), or third-party data vendors (e.g., Inrix and Navteq are third-party vendors who provide continuous travel-time data to support system operations that also can be useful for planning). Comprehensive travel-time data allows for the analysis of the best, most accurate estimates of reliability. With these data, an estimate can be made for any of the myriad reliability measures by developing a travel-time distribution. The *Technical Reference Section 5.1* contains a detailed description of different travel-time data resources, how to set up a travel-time monitoring system, and how to estimate reliability using various sketch-planning methods.
  - **Collect existing travel-time data.** Check with State or MPO operations, systems planning, planning and policy, and performance management offices to determine if they have purchased historical third-party travel-time data. Additionally, these offices or regional traffic management centers (TMC) may have collected and archived travel-time data using ITS devices (bluetooth, toll tag readers, cameras, etc.).
  - **Determine what travel-time data can be purchased.** If detailed travel-time data is needed, data may be purchased from a third party.
  - **Consider installing a travel-time monitoring system** using existing or new ITS sensors to allow for travel-time data collection in the future.
• **Travel Demand Model Data.** Collect statewide or regional travel demand model output data in combination with sketch planning or model postprocessing methods to estimate travel-time reliability. Typically, travel demand model data will be used for LRPs, RTPs, and CMPs.

• **Simulation Model Data.** Collect data necessary to develop and run a simulation model. Use the travel-time outputs from several runs of the simulation model to develop reliability performance measures. Typically, simulation models will be used for subareas (e.g., core downtown area, small system of interconnected highways or transit lines, or corridor).

• **Root causes of unreliable travel data.** Collect incident, weather, and data describing other circumstances that lead to unreliable conditions. These data can help measure the impact of circumstances on reliability.

### 3.4 How To

This section describes how to estimate reliability performance using the work prepared above.

**Select a reliability performance measure.** Select a reliability measure that the leadership, staff, and stakeholders understand and that yields consistent results. If reliability has not previously been measured, begin with the PTI.

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**Examples of Reliability Performance Measures in Use at Transportation Agencies**

- **Florida DOT.** Florida DOT uses a combination of a model post-processor called FITSEval and real travel time data to evaluate the TTI for all users on all segments of their Strategic Intermodal System (SIS).

- **Knoxville Regional Transportation Planning Organization (TPO) CMP.** In their CMP, the Knoxville TPO measures the PTI for all users on freeways and major arterials in the region and plans to narrow the time period to a ‘specific time period of the day.’ In addition, the TPO has developed an incident management specific measure to support the overall reliability statistic: clearance time of traffic incidents on freeways and major arterials in the region.

- **Madison MPO CMP.** The Madison MPO developed guidelines for the reliability measures that they will include in their CMP. They will include both peak and off-peak measures because while congestion often focuses on peak period commutes, off-peak measures can identify different system problems, including those that can be important to freight movement efficiency. They also will include measures for the region and key sub-areas and corridors that reflect primary modal travel patterns.

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**Estimate reliability performance.** Estimate the PTI or another measure for the relevant period (e.g., AM peak), travel pattern (e.g., segment), roadway type (e.g., functional class), user (e.g., commuter), and geography (e.g., urban area) that addresses the needs. For example, determine if origin-destination (OD) or segment-level analysis is being performed, then define the measure as “planning-time index for freight trucks in the AM peak hour;” “planning-time index of all traffic in the PM peak hour;” “planning-time index on key tourist routes in summer midday;” “planning-time index during a weather event on the interstate system” or something else that
meets the specific needs of the state, region, corridor, or project area. See the Technical Reference Section 5.0 for detailed examples of how to apply various tools to estimate reliability.

Convert reliability performance into good/fair/poor categories. Converting the measure in this way will allow communication of results more easily. This style of presentation is common for infrastructure performance (i.e., percent of bridge deck in ‘good’ condition) and provides a clearer means to communicate performance. To do so, identify thresholds that are appropriate for the region or state, based on the chosen performance measure. Chapter 4 of this guide has a thorough explanation for how to tailor thresholds for the agency, but potential examples include:

- **Good** – “Good” performance is when the PTI is less than 1.3 (PTI < 1.3);
- **Fair** – “Fair” performance is when the PTI is between 1.3 and 2 (1.3 < PTI < 2); and
- **Poor** – “Poor” performance is when the PTI is greater than 2 (2 < PTI).

Track reliability performance. Use reliability monitoring systems to track reliability over time. Once the measure and the monitoring systems are in place, continue to track reliability to determine what impact the policies are having on the reliability of the system over time. Continuous travel-time data can be purchased or use sketch-planning or model postprocessing methods to estimate reliability periodically. See the Technical Reference Section 4.0 for detailed examples of how to apply each of the tools to assess reliability performance.
For Further Reading

Establishing Monitoring Programs for Travel Time Reliability, a product of SHRP 2 project L02, presents methods by which travel time reliability can be monitored, assessed, and communicated to end users of the transportation system. This resource was not available in published form at the time of writing.

Report reliability performance. Use concise, illustrative graphics and plain language to report reliability for management and stakeholders alike. Figure 3.2 provides examples of maps to communicate reliability performance. The left map, from the Georgia Regional Transportation Authority, illustrates the segments that experience the worst reliability using the PTI. Red and purple segments have “poor” reliability, yellow segments have “fair” reliability, and green segments have “good” reliability. The right map, from the Capital District Transportation Committee (CDTC) in Albany, NY, presents the PTI. In this example, the width of the line represents free-flow (base) travel time and the dark line represents the 95th percentile travel time.

Figure 3.3 Examples of Communicating Travel-Time Reliability

Develop different reliability performance measures for different plans that are tailored to the purposes of several different plans and mutually supportive of one another. For example, the State of Florida set a statewide reliability performance measure, the Hillsborough MPO developed a supportive measure for their CMP, and Broward County developed a supporting measure for their TSM&O plan:

- **State Long-Range Plan.** Long-range plans will typically use a broad measure at the corridor or system level to support a specific policy statement. In their LRP, FDOT identified performance as Reliability of travel and delivery (such as on-time arrival or variability of travel times). The measure is high-level and meant to set the overall direction for the State.

- **CMP.** CMPs typically provide more detailed focused evaluations of reliability. For example, the Hillsborough MPO includes the following measure: “Do commuters need to factor in less “buffer” time to ensure on-time arrivals?” The measure (Buffer Index) is tailored to commuters and is more specific than that identified in the LRP. This measure also satisfies statewide measure.

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Operations Plan. Operations plans also typically provide more detailed focused evaluations of reliability. For example, the Broward county TSM&O committee measure the Travel-Time Index specifically for their TSM&O network. This measure also satisfies the statewide measure.  

Reliability performance measures have been chosen. The rest of the guide will show how to estimate needs and deficiencies, set program funding levels, and prioritize projects.

4.0 Evaluating Reliability Needs and Deficiencies

Agencies define needs and deficiencies to describe the significance of their reliability challenges. An agency can define needs by comparing reliability performance to thresholds or simply by describing areas of poor performance to identify challenges. Three key terms are important to define for analyzing needs and deficiencies.

- **Reliability thresholds.** The point at which a segment or network is considered to have good, fair, or poor reliability. The thresholds developed in Chapter 3 of this guide should be used to identify needs and deficiencies.

- **Reliability deficiency.** A segment or trip that is unreliable. Unreliable travel is identified by comparing reliability performance to a threshold. When the performance is worse than the threshold, the segment is considered unreliable.

- **Reliability need.** The project necessary to ensure that a segment or trip is reliable. In financial terms, the need can be defined as the total cost to improve deficiencies to an acceptable level. The total need can help to support budget requests or identify the gap between fundable and unfundable needs.

4.1 **Key Questions**

- How are reliability thresholds set?
- How should reliability deficiencies be translated into needs?

4.2 **Approaches to Answering the Key Questions**

- Set a threshold for different combinations of time periods, travel patterns, roadway types, users, or geography.
- Define needs based with or without revenue restrictions.
4.3 **Technical Preparation**

- **Reliability Performance.** Use Chapter 3 of this guide to select and assess reliability performance measures.

- **Develop a List of Reliability Project Alternatives.** Define projects that are anticipated to improve the reliability of the transportation system. They can include capacity projects but typically include operations and travel demand management (TDM) projects targeted to improve transit, highway, or freight operations. It is important to keep in mind that while capital investment projects improve the reliability of the system, the main goal of these types of projects is to reduce recurring delay, while operations and management projects are designed to address non-recurring delay.\(^\text{11}\) Figure 4.1 identifies the range of strategies that can improve reliability.

---

**Figure 4.1 Strategies to Improve Reliability**

- **Highway**
  - Additional Capacity
  - Truck only lanes
  - Rail improvements
  - New freeways/arterials
  - Widen freeways/arterials
  - Street connectivity
  - New toll roads/toll lanes
  - Grade separations
  - HOV/managed lanes
  - Multimodal corridors

- **Transit**
  - New rail lines
  - New bus routes
  - New busways/BRT
  - Additional service on existing lines
  - Neighborhood/activity center circulators
  - Park/ride lots
  - TMC Operations
  - Incident management
  - Event management
  - Ramp metering
  - Lane controls
  - Managed lanes
  - Real-time traveler information
  - Electronic toll collection
  - Work zone management
  - Road weather information systems
  - Variable speed limits
  - Ramp closures
  - Bottleneck removal
  - HOV ramp bypass
  - Signal retiming/optimization
  - Changeable lane assignments
  - Real-time traveler information
  - Parking restrictions

- **Freight**
  - Truck only lanes
  - Rail improvements
  - New rail lines
  - New bus routes
  - New busways/BRT
  - Additional service on existing lines
  - Neighborhood/activity center circulators
  - Park/ride lots
  - TMC Operations
  - Incident management
  - Event management
  - Real-time traveler information
  - Parking restrictions

- **Arterial**
  - TMC Operations
  - Incident management
  - Event management
  - Ramp metering
  - Lane controls
  - Managed lanes
  - Real-time traveler information
  - Electronic toll collection
  - Work zone management
  - Road weather information systems
  - Variable speed limits
  - Ramp closures
  - Bottleneck removal
  - HOV ramp bypass
  - Signal retiming/optimization
  - Changeable lane assignments

- **Freeway**
  - TMC Operations
  - Incident management
  - Event management
  - Ramp metering
  - Lane controls
  - Managed lanes
  - Real-time traveler information
  - Electronic toll collection
  - Work zone management
  - Road weather information systems
  - Variable speed limits
  - Ramp closures
  - Bottleneck removal
  - HOV ramp bypass
  - Signal retiming/optimization

- **Operational Improvements**
  - TMC Operations
  - Incident management
  - Event management
  - Ramp metering
  - Lane controls
  - Managed lanes
  - Real-time traveler information
  - Electronic toll collection
  - Work zone management
  - Road weather information systems
  - Variable speed limits
  - Ramp closures
  - Bottleneck removal

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\(^{11}\) Recurring delay is predictable delay caused by demand exceeding capacity. Recurring delay is expected delay.
4.4 How To

Set Reliability Thresholds

Measuring performance can tell how the system is performing, but it cannot identify reliability issues. To do that, a threshold must be developed. Any segment or trip with reliability performance worse than this threshold may be considered to have a deficiency. Because reliability is a function of the perception of system users and varies significantly across locations, seasons, times of day and days of the week, there is no standard threshold that indicates when reliability is considered unacceptable. For example, Figure 4.2 illustrates how travel times (and reliability) vary by urban area size, using data from the Texas Transportation Institute’s Urban Mobility Report.
Defining thresholds requires understanding user perceptions of reliable travel. It is recommended that an iterative approach is used to: set preliminary thresholds, make maps of reliability performance (Described in Chapter 2), identify deficiencies, present the materials, discuss whether these materials match agency and stakeholder understanding of reliability deficiencies, and adjust the threshold up or down as needed. If good/fair/poor categories have been identified for the reliability performance measure, use those as the starting point and feed any new thresholds back into the categories if changes are made.

Consider the following when developing thresholds:

- **Users.** Develop different thresholds for different users of the system. Depending on the specific issues, consider reliability for commuters, freight carriers, tourists, and other user groups.

- **Time Period.** Develop thresholds for travel at various time periods to reflect specific user expectations such as AM and PM peak periods, weekday midday, weekend midday.

- **Roadway Types.** Develop thresholds for different roadway types to reflect specific conditions on those roadways, such as interstates, expressways, National highway system (NHS) roads, major arterials, or principal transit, freight, or other modal corridors (e.g., those connecting critical economic centers).
**Madison, WI MPO Reliability Threshold**

In their CMP, the Madison, WI MPO defined a reliability threshold as follows: “The travel time index for the morning peak period should not exceed 175% of free flow travel time in the East Washington corridor.” They defined the threshold for their chosen measure, in a specific time period and along a specific corridor. Any travel time index above this will be considered deficient.

- **Geography.** For all general geographies, including statewide, regional, corridor, and subarea, set thresholds that apply to all users who overall have a low to moderate tolerance for unreliable travel, such as different tolerances for urban and rural travelers.

**Assess Deficiencies**

Compare each trip or segment to the threshold and highlight those that segments that are worse than the threshold; these are deficient. If the thresholds do not tell a story that stakeholders and internal agency staff can understand intuitively (e.g., the segments or trips identified that do not feel deficient to them), then adjust them until they can. Use the maps developed in Chapter 3 to show the deficiencies. Recall how GRTA used a map to illustrate which segments experience the worst reliability using the PTI. In this case, the agency set an illustrative threshold for the entire region, indicating that red and purple segments to have ‘poor’ reliability, yellow segments to have ‘fair’ reliability, and green segments to have ‘good’ reliability.

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Define Needs

Needs are the projects and costs or program-funding necessary to eliminate the reliability deficiency. Both unfunded/funded needs and overall needs can be defined. Overall needs include all needs without any financial restrictions, funded needs are those needs that can be met with projected funding levels, and unfunded needs are those needs remaining once funding is exhausted. There are three ways to develop overall needs.

- **Judgment.** Develop needs using judgment by selecting a list of projects that will improve reliability.

- **Program-Level Needs.** Develop program-level needs by developing performance curves that show how performance will change with different funding levels. To construct a curve for the agency, develop a list of potential reliability-specific projects (regardless of whether funding is available to build them); develop approximate costs and benefits for each project, rank-order them, and build a cumulative curve of cost (x-axis) charted against benefit (y-axis).
• **Project-Level Needs.** Develop project-level needs in the same way that Bridge and Pavement Management Systems do - select the projects using Incremental Benefit-Cost Analysis (IBC).

*Option 2 – Estimate Needs at the Program Level*

• **Assess Total Project Costs.** For each reliability project, populate the total project-specific capital costs using the roster of costs for reliability projects.

• **Assess Project Benefits.** For each project, populate the project-specific benefits using the most rigorous available tool and approach. Either populate using the roster of reliability benefits or estimate reliability benefits using a sketch planning method, model postprocessor, or simulation model. For example, if the MOE is planning-time index on urban freeway and principal arterial in the AM peak hour, then collect or assess existing reliability conditions on these segments during this time and use sketch planning methods to estimate how the planning-time index will improve with the proposed project.

• **Rank-Order The Projects.** Aim to generate a realistic priority project list.
  
  - *Based on project prioritization from existing operations and management plans or professional judgment.* If there are published operations and management plans that prioritize projects and have gained political support, then use this as the priority list. The results will be different from another mathematically ranked project list but are likely to hold more political influence because the list has been through due process already.

  - *From most cost-effective to least cost-effective.* If there are no publications, rank-order the projects by cost-effectiveness where cost-effectiveness is measured by project cost/reliability benefit.

  - *Applying a method described in Chapter 6.* Chapter 6 of this guide describes how to rank-order and prioritize projects using several different approaches, including a project score approach and a benefit/cost approach.

Table 4.1 presents project costs (based on professional judgment), benefits, and cost-effectiveness for operations and management projects in the Knoxville Transportation Planning Organization (TPO) region. See the *Technical Reference Section 5.0* for a detailed how-to for estimating reliability using these methods and tools.
<table>
<thead>
<tr>
<th>Project</th>
<th>Planning-Time Index improvement</th>
<th>Capital Cost$</th>
<th>Cost-Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cities of Maryville and Alcoa CCTV Camera Deployment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Segment 1 – U.S. 129 from Pellissippi Parkway to Hunt Road</td>
<td>0.13</td>
<td>$100,000</td>
<td>$7,876</td>
</tr>
<tr>
<td>Cities of Maryville and Alcoa CCTV Camera Deployment</td>
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<td></td>
</tr>
<tr>
<td>Segment 2 – U.S. 129 from Hunt Road to U.S. 411</td>
<td>0.12</td>
<td>$100,000</td>
<td>$8,312</td>
</tr>
<tr>
<td>City of Oak Ridge Traffic Signal System Upgrades</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Segment 2 – Illinois Ave from Tulane Ave to Lafayette Dr</td>
<td>0.19</td>
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<tr>
<td>Segment 1 – Illinois Ave from Robertsville Road to Tulane Ave</td>
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<tr>
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<td>Segment 1 - Kingston Parkway from Northshore Drive to Pellissippi Parkway</td>
<td>0.03</td>
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<td>$139,483</td>
</tr>
</tbody>
</table>

*Does not include operations and maintenance costs. Costs are based on professional judgment.*
Graph The Relationship Between Reliability Funding And Performance. Develop a curve based on the reliability benefits and costs that shows how funding levels impact reliability performance. Build a curve that shows how benefits and costs will accumulate incrementally as more and more of the reliability projects on the list are built. Plot the benefits on the y-axis and the costs on the x-axis. Figure 4.4 presents an example curve that compares the cumulative benefits and costs of investments in different programs.

**Figure 4.4  Reliability Performance Curve**

Estimate needs. Identify the point on the curve where it begins to flatten. This is the point where diminishing returns on the investments will be seen. This is the performance that should be achieved and the funding that is necessary to achieve it. In the example of the Knoxville TPO, the curve starts to flatten at around $10 million. At this point, the benefits become more costly. With their first $10 million, they would be able to purchase about a change in PTI of five. For an additional $10 million, they only would be able to purchase a change in PTI of about two. Based on this, the Knoxville needs would be somewhere between $10 and $15 million.
Detroit MPO Analysis of the Relationship of Operations Strategies on Reliability Performance

The Detroit MPO, the South East Michigan Council of Governments (SEMCOG), recently assessed the effectiveness of investment strategies on regional transportation benefits. Previously, this analysis examined hours of delay per VMT, in addition to measures in other goal areas. More recently, SEMCOG included freeway reliability within its assessment to better evaluate operational and reliability mitigation measures within the analysis. The analysis examined several representative corridors within the region, estimated expected incident related delay using a model post processor, and estimated the travel time index using sketch planning techniques.

They evaluated several reliability mitigations strategies along a study corridor, including freeway management (surveillance, monitoring, ramp metering), incident management including freeway service patrols, and traffic signal coordination. To estimate regional benefits, they extrapolated the benefits of the study corridor to representative corridors and then to the region as a whole. This allowed them to develop an improved performance curve compared funding levels to reliability performance in conjunction with average travel time performance. In contrast to measuring the change in PTI as was done in the Knoxville example above, SEMCOG opted to add the unreliable travel time to the average travel time.

The comparison of the benefits estimated both with and without considering reliability show that investments in the operations strategies yield a much greater impact on total hours of delay, particularly at the lower investment levels. Small investments in these strategies result in a steep curve of reducing delay levels. Similar to the curve not considering reliability, there is a declining utility to higher investment levels and increased investment brings about lower incremental improvement for each dollar spent.

Option 3 – Estimate Needs at the Project Level

- **Screen out Inappropriate Projects.** Screen out projects for which the benefit/cost ratio is worse than a specified B/C threshold value, or where the alternative is strictly worse than some other alternative for the same segment (e.g., has less benefit than a cheaper project or a lower benefit/cost ratio than a more expensive project).
• **Rank-Order the Projects from Highest Cost to Lowest Cost.** The IBC will be assessed from the least-expensive to the most-expensive projects.

• **Calculate the Incremental Benefit and Cost.** Calculate the IBC for a project by comparing it to the next cheapest alternative, which may be to do nothing.

• **Build a Curve.** Rank-order the projects by IBC ratio, a measure of the difference in cost divided by the difference in reliability benefit between two projects.

• **Select Projects.** Select all projects until the IBC ratio begins to level off; this is the point of diminishing returns. Alternatively, select all projects above a certain IBC ratio.

• **Estimate needs.** Sum the costs of all selected projects. These are the needs.

<table>
<thead>
<tr>
<th>Calculating the Incremental Benefit-Cost Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculate the Incremental Benefit cost ratio as:</td>
</tr>
</tbody>
</table>
| \[
| \frac{(Benefit \text{ Project 1} - Benefit \text{ Project 2})}{(Cost \text{ Project 1} - Cost \text{ Project 2})}
| \]
| Project 1 is the more expensive of the two. Use Chapter 6 of this guide to estimate benefits and costs for reliability projects. |

• **An Alternative Approach to Develop a Project List.** A set package of alternatives to improve a corridor using judgment or IBC could be built. To do so, for each corridor in the system, package reliability projects together with all other projects into a good, better, best option for the corridor. Use IBC to select the appropriate package of projects for each corridor. Finally, use the project prioritization methods described in Chapter 6 to prioritize the packages of projects among corridors.


Identifying needs and deficiencies and setting targets are all critical steps in producing a performance-based long-range plan, program, corridor plan, CMP, or operations plan. However, for each of these plans, the level of technical rigor varies.

The remainder of the guide will describe how to set program funding levels and prioritize projects.
5.0 Setting the Right Size of Operations and Management Programs

Setting the appropriate size of operations and management program funding will enable agencies to address reliability needs and consider how much emphasis to give to these programs relative to preservation, safety, capacity expansion, and other programs.

There are no widely used methods to set the size of program funding levels. Many agencies distribute funding to programs based on federal and state funding requirements and historical practice. Use performance measures to set program funding levels to answer the question, “How do I find the right level of funding for all of programs so that I can best meet the various needs of users?” Note that this process often takes place separately from the development of a specific plan or program, but can happen as part of a LRP or strategic plan and has a clear influence on STIPs and TIPs.

Within the framework for performance-based planning and programming developed by FHWA and FTA, this is a critical analytic step in the planning process. It is the place where agencies consider the relationship between overall investment levels and performance and can be used to provide information to decision makers.

In this step, set funding levels for the transportation programs (e.g., setting operations and management funding levels in context with preservation, safety, capacity funding levels) so that the agency can focus its investments on the goals and objectives set for the state or region. In many areas of the country, reliability needs remain unmet because there are no dedicated funding sources and no dedicated programmatic investments.

Consider This
Because there often are no dedicated funding sources for operations and management projects, it can be difficult to achieve performance targets you set for reliability. Your agency can be far along with performance planning, prioritizing projects based on performance and linking performance measures to policy statements, but if it cannot find a way to fund a reliability program, then you will not be able to build these projects. In many states, finding a dedicated funding source is a matter of legislative action. Use your reliability performance measures, targets, and trends to convince legislators that cost-effective reliability projects are important for the customers of their roadway system. Use the measures to describe how these projects can be affordable and help tackle some of the major congestion issues facing urban and rural areas alike.
5.1 KEY QUESTIONS

- How does one estimate the benefits of a reliability program given different funding levels?
- How should reliability be included when estimating the benefits of other programs (capacity, safety)?
- How should funding programs be related to project prioritization?

5.2 APPROACHES TO ANSWERING THE KEY QUESTIONS

There are three potential models for setting program-level funding allocations. The first model is to simply follow historic practice and the constraints on individual funds. The second option pools all funds into one funding bucket and prioritizes all projects regardless of project type. The third allocates funding to broad programs (preservation, safety, operations, etc.), then prioritizes projects within programs (Figure 5.1). This requires estimating the impact of changing program budgets on the performance of each goal area/funding bucket. This chapter describes the process for setting program-level funding buckets for operations and management programs using information about reliability performance.

1. Measure the reliability benefits of a reliability program compared to all other programs, develop an understanding of the system performance tradeoffs, and set funding levels using professional judgment.
2. Measure the total combined benefits of a reliability program compared to all other programs, develop an understanding of the system performance tradeoffs, and set funding levels using professional judgment.

Florida DOT Prioritization Process Only Addresses Capacity Projects

Florida DOT has a system for prioritizing projects of statewide significance but this system only can prioritize projects that build capacity - it is a legislative requirement that only capital expansion projects be included. While there have been some cases where reliability projects have been recast as capacity projects, this is not typical. The state may need to make a case to the legislature that reliability projects address the needs of system users to give these projects an opportunity for funding from the pool of funds currently available to capacity projects.
5.3 TECHNICAL PREPARATION

- **Identify and exclude projects that currently are obligated to complete.** This can include earmarked projects, legislative requirements, or projects that already are programmed in the TIP or STIP.

- **Organize programs.** Decide whether to combine programs for funding purposes. A common set of programs may include preservation, safety, capacity expansion/mobility, and operations and management. The operations and management program and the capacity program can be combined to allow the projects to compete directly. Typically, other programs will include capacity, preservation, safety, economic development, environment, and livability and sustainability but might also include other programs unique to the agency (e.g., interchanges).

- **Define what type of projects fit into each program.** Develop a clear breakdown of projects among different programs.

- **Collect or create performance curves.** If the agency developed a reliability performance curve for the needs assessment described in Chapter 4 of this guide, use it in this chapter to help set program funding levels. If the agency defined needs based on judgment, create performance curves using the guidance in Chapter 4.

- **Select a measure of effectiveness (MOE).** The MOE is a single measure of performance attributed to reliability projects. Having one measure for reliability will serve to simplify a complex process. There are two approaches to consider. In the first, select one reliability performance measure that was identified for tracking performance in Chapter 2 of this guide (e.g., planning-time index, travel-time index, or misery index). In the second,
combine several performance measures (i.e., measures for safety and preservation), by monetizing them or by creating a combined project score. Chapter 6 of this guide details ways to combine different measures into a single MOE. Similarly, reliability can be included into MOEs for other program areas by monetizing and combining them.

- **Build a generic operations and management project cost and benefit roster.** Collect performance benefits and cost (unit costs for construction as well as annual operations and maintenance costs\(^\text{13}\)), data for reliability projects. Use those from other similar projects within the agency, from similar agencies, or from the ITS project cost and benefits database.\(^\text{14}\) Ensure that the benefits are in the same units as the MOE (i.e., planning-time index). Either use this generic roster or estimate project-specific reliability benefits using other methods.

### FHWA Tool for Operations Benefit/Cost

FHWA released a sketch-planning tool for estimating the benefit-cost ratio of operations projects called the Tool for Operations Benefit/Cost (TOPS-BC). The tool maintains a lookup database of likely impacts of various strategies on various MOEs, including reliability. For each strategy and MOE, the tool displays a typical range of benefits. Most of the costs and benefits were derived from the ITS project cost and benefits database.

See: [Http://www.itscosts.its.dot.gov/its/benecost.nsf/AdjustedUnitCosts](http://www.itscosts.its.dot.gov/its/benecost.nsf/AdjustedUnitCosts).

- **Program funding levels.** Identify program funding levels for all existing programs. This is the available pot of money for the programs. These funding levels will be used to design scenarios and to set performance targets.

- **Performance versus cost curves for all other programs.** When applicable, use available tools to estimate program level performance versus spending for the other funding programs. For example, there are well-developed tools for bridge (e.g., the Pontis Bridge Management System and the National Bridge Investment Analysis System (NBIAS)) and for pavement and general capacity adding projects (e.g., the Highway Economic Requirements System (HERS)) that can be used to develop these curves. If these tools are not available, follow a similar process to that described in this chapter to develop performance versus cost curves for other programs.

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\(^{13}\)For the purposes of this analysis, capitalize the operations and maintenance costs by estimating their net present value. Apply the discount rate approved by the Office of Management and Budget in their Circular A-94 (most recently, this was 7 percent) and, absent better information, assume the project will have a useful life of 20 years. This process equates the operations and maintenance costs to capital costs. [Http://www.whitehouse.gov/omb/circulars_a094](http://www.whitehouse.gov/omb/circulars_a094).

\(^{14}\)Http://www.itscosts.its.dot.gov/its/benecost.nsf/AdjustedUnitCosts.
5.4 How To

Now that the curve has been developed, apply this curve to set funding levels for the programs, in concert with the other performance versus cost curves for the other programs. The steps below detail how to do this.

Develop Scenarios. The scenarios should directly relate to the agency’s overall policy statements and should help make the challenging decision to support each policy with the right amount of funding. For example, the Florida DOT case study revealed that they think they might want to use some preservation funds on operations projects. Some example scenarios include:

- **Preservation First.** This scenario will dedicate a large percent of the annual revenue into preservation, leaving relatively less for capacity, safety, and reliability programs.
- **Safety First.** This scenario will dedicate a large percent of the annual revenue into preservation.
- **Reliability First.** This scenario will dedicate a large percent of annual revenue into reliability.
- **People’s Choice.** This scenario will dedicate funding based on stakeholder feedback.
- **Equal Spending.** This scenario will balance funding among the different programs equally.

Analyze Funding Scenarios. There are an infinite number of ways to structure an analysis around the funding scenarios. There are two levels of decisions: among-program and in-program funding distributions. In the first, describe how the total available funding will be distributed among programs or groups of programs. In the second, describe how the program-level funding will be distributed among types of projects within the program.

Make the In-Program Funding Distribution. The curve developed above does not have sufficient detail to analyze different in-program funding distributions. When a roster is used of potential projects, it effectively sets the distribution of projects a priori (e.g., the projects included in the curve could be split among incident management (20 percent), special event management (30 percent), traffic operations (30 percent), and a TMC (20 percent)), and this becomes the standard distribution.

For Advanced Users

If you want to analyze a different split of projects in your reliability program, develop a new curve with the split of projects that you would like. If you do move forward with this approach, then you will need to test different program funding levels. You are not making program funding decisions at this point, but you do want to get a feel for how reliability performance will change under different program funding levels and different splits of project types. With that information in-hand, make a decision about the proper split among project types within the program. This split will inform how you make among-program decisions.
**Make Program Allocation Decisions.** Collect all of the performance versus cost curves for all of the programs and distribute funding based on the scenarios and review the performance. If the balance of system performance is not satisfactory among all programs, change the funding levels to different programs until it is satisfactory.

**Set Targets.** The target can be aspirational or be restricted by funding projections. If possible, base targets on realistic funding projections because this will give the decision making process a strong grounding in reality. If funding projections are being used, use the results of the “make among-program decisions” section above to support the target setting exercise. From that exercise, a set of program-specific performance curves and will have identified the preferred programmatic split among programs. Typically, targets take the form of having a certain percent of the network achieving a certain level of performance by a certain year. For example, a reliability target might read “90 percent of urban arterials will have a “good” planning-time index by 2030.”

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**Knoxville TPO Reliability Target**

“By 2020, reduce the variability in travel time on freeways and major arterials in the region such that 95% of trips along a roadway segment have travel times no more than 1.5 times the average travel time on that segment for a specific time period of the day.” Targets were set for specific roadway types during specific time periods and plain English was used to describe the reliability performance measure (i.e., “95% of trips have travel times no more than 1.5 times the average travel time.”)

Source: Developed as part of the SHRP 2 L05 Case Study with the Knoxville TPO.

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**For Further Reading**

NCHRP Report 666 Target-Setting Methods and Data Management to Support performance-based Resource Allocation by Transportation Agencies, Volume II: Guide for Target-Setting and Data Management. NCHRP Report 666 describes methods that managers of state departments of transportation (DOTs) and other agencies can use for setting performance targets to achieve multiple objectives and interact with multiple decision-makers and stakeholder groups, and how data management systems within a DOT can support performance-based decision-making.

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Make Decisions. Present the results of the analysis to decision makers in a format that enables them to review the program funding levels and the performance, with the goal of reaching consensus on long-range funding and performance targets for the region. It is possible to arrive at these conclusions through open discourse, but it will be useful to quantify the consequences of the program decisions.

Arizona DOT Used Open Discourse to Set Funding Levels

In their LRP, the Arizona DOT distributed funding to programs using stakeholder feedback through committee meetings. The figure below shows how their final determination of programmatic split, spending 10 percent on non-highway, 27 percent on highway expansion, 34 percent on highway preservation, and 29 percent on highway modernization.


The long-range plan is the appropriate place for setting the funding strategy, including setting and meeting targets. Setting targets at this level will set the stage for decision making in all other plans.

Program funding levels have now been set. The last chapter of the guide will show how to prioritize projects.
6.0 Prioritizing Projects Using Reliability

This section of the reference guide identifies how to use reliability as a measure to support project prioritization - the process of identifying a preferred, constrained list of projects to be implemented, usually in the form of a TIP or a STIP. This section asks the question – “assuming no constraints on funding within individual programs, what are my ideal investments?” It is not constrained by the color of money, though one will need to consider those constraints later when matching funding programs to individual projects.

There are two performance-based planning and programming models. Applying the first model, all transportation funds are pooled into one bucket and all project types prioritized together on one level playing field. Applying the second model, program funding levels are set using Chapter 5 of this reference guide, then projects are prioritized within the different funding programs. In this model, one can define which projects are allowed to compete with one another. Figure 6.1 shows a visual concept of the first model (left) and the second model (right).

Figure 6.1 Models of Performance-Based Planning and Programming

6.1 Key Questions

- How are the benefits of different operations and capacity projects estimated?
- How are the myriad benefits of the projects balanced to choose the project that best supports an agency’s policies and priorities?
6.2 **Approaches to Answering the Key Questions**

**When all benefits and costs can be monetized.** Monetize the benefits and costs, use classic benefit/cost analysis, and rank-order projects from the highest to the lowest benefit/cost ratio. In some cases, each of the performance measures can be monetized. In this case, projects can be prioritized based on their life-cycle costs and benefits. Monetizing the benefits and costs allows for classic benefit/cost analysis (B/C) to be performed. When done correctly, this analysis will allow one to value the different life-cycle costs of very different project types and to prioritize those that are most economically efficient (highest B/C ratio). In the application of these approaches, double counting must be avoided by carefully and properly accounting for the benefits and costs. Due to the level of detail required, agencies typically only will perform rigorous B/C analysis on corridor level studies or to compare the largest of projects. This can include benefit/cost analysis, marginal analysis, and/or cost-effectiveness analysis. These techniques require more fiscal and technical resources to complete but can give a clearer picture of priorities. For example, rank-order projects from the highest benefit/cost ratio to the lowest or select all projects with a benefit/cost ratio of one or higher.

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**Florida DOT B/C Analysis Tool**

Florida is building a B/C analysis tool that will compare the benefits and costs of projects costing more than $50 million. At times, agencies perform basic sketch level B/C analysis on large numbers of projects, but typically this is done with a more limited number of costs and benefits and with estimated using sketch planning tools.

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**For Further Reading**

The FHWA Operations benefit-cost desk reference describes in detail the process for estimating the benefits and costs for operations projects. In addition, the project developed a spreadsheet tool that can be used to estimate B/C ratio of many operations projects.


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**When not all benefits and costs can be monetized:**

- Use judgment to select the priority projects.
- Use a qualitative project scoring scheme to assess benefits based on judgment (i.e., how much does a project improve reliability? No improvement (0 points), Somewhat improves reliability (1 point), Substantially improves reliability (2 points)).
- Estimate the cost-effectiveness ($/unit of benefit) and rank-order the projects from the highest to the lowest cost-effectiveness. In some cases, one will want to compare projects on an economic basis but will not be able to monetize all of the measures. In this case, use cost-effectiveness analysis to prioritize projects. Cost-effectiveness analysis allows one to compare the cost to purchase a performance benefit. Cost-effectiveness can be calculated by dividing performance savings or a project score by the cost. This would tell how much
reliability can be “bought” if the project is built. On the other hand, if the reliability measure is combined into an overall project score this will tell how much overall performance is bought if the project is built.

- Leave the measures in their native benefit units (e.g., planning-time index), combine all measures into a project score, and rank-order the projects with the highest project score to the lowest. When prioritizing projects with benefits that are not easily monetized (e.g., how much does a reliability project improve community livability?), projects can be prioritized based on their performance relative to the universe of projects. In this method, also called “marginal analysis” weights also can apply to the measures to indicate how much each supports overall policy statements. Similar to qualitative scores, this approach develops a weighted numerical value for each project. The steps of this process include estimating performance measures for each project, normalizing scores across projects, and weighting measures to reflect their significance. In contrast with the qualitative score, the performance score is based on the numeric value of the reliability performance measure. For example, rank-order projects from the highest performance score to the lowest.

**Hybrid.** Combine any of the above prioritization techniques. For example, combine cost/benefit ratio or cost-effectiveness with the project score to support decision-making from both the economic and performance-based perspectives. When prioritizing projects, it can be useful to combine economic efficiency analysis or cost-effectiveness with weighted project scores to develop a sense of how well a project performs and how efficient it is. In practice, most agencies will use a hybrid method that combines two or more of the above methods. For example, an agency may combine weighted performance scores with benefit/cost analysis to identify project priorities through two lenses: performance and economic efficiency. For example, organize projects into tiers based on both dimensions:

- Tier 1: High benefit/cost ratio, high performance;
- Tier 2: High benefit/cost ratio, mediocre performance OR high performance and mediocre benefit/cost ratio; and
- Tier 3: Mediocre performance and mediocre benefit/cost ratio.

**Technical Preparation**

- **Develop a Project List.** A list of real potential projects is needed to prioritize. This may have been done in performing the needs analysis and may have provided a list of real projects to build performance curves. If so, use that list here. Otherwise, develop a list from other plans, including projects identified in regional and statewide LRPs, CMPs, corridor plans, and operations plans. It is likely that many relevant strategies to improve reliability in the CMP will be found. While all MPOs develop project-level investment plans, states have more discretion and can develop policy plans (these states only develop policy statements), program-level investment plans (these states develop policy statements and determine program funding distributions), or project-level investment plans (these states develop plans with a rank-ordered list of priority projects).
Other Things to Think About When Developing a Project List

Identify other project characteristics such as whether the project is shovel-ready, whether it has political support, or whether it should be packaged with another project or groups of projects. These additional considerations will help you refine your priority list, find mutually supportive projects, and build your TIP or STIP.

MnDOT Packages of Reliability Strategies

MnDOT develops packages of mutually supportive solutions to address urban peak period recurring and nonrecurring delay-related reliability in the Twin Cities. A corridor strategy package may include a combination of a managed lane, active traffic management ITS technologies, electronic tolling to support congestion pricing, and express bus routing through the managed lane. Such a package’s strategies are complementary and include managed capacity expansion, ITS, operations, and transit solutions.

- **Identify performance measures.** Select a reliability measure using Chapter 4 of this guide. Assess the reliability benefits of each project in the project list. Also select additional measures related to other performance areas such as congestion or safety. The use of additional will enable understanding of the implications of potential projects beyond reliability. In addition, this step is required to compare reliability projects to projects in other programs. If help is needed to develop a comprehensive list of performance measures, see the SHRP 2 performance measures web tool.\(^\text{16}\)

Consider the Program Organization as You Identify Performance Measures

If you have a stand-alone reliability program (e.g. there are different capacity, preservation, and safety programs) within which you will need to prioritize operations projects (e.g. management projects fall under a different program), you might use only one measure of reliability to rank the projects effectively. That is, you can select the critical measures for the reliability program, specifically, likely focused on your reliability performance measure. Then preservation projects can compete based on how well they preserve the system, and safety projects can compete based on how well they improve the safety of your users. In contrast, if all of the projects compete with one another, then you will need to evaluate the full range of benefits for each. That is, you will need to assess the safety and preservation benefits of reliability projects in order to properly rank-order the projects.

• **Select a monetary value of reliability.** Based on the findings of the SHRP program, reliability can reasonably be valued at 0.8 times the value of average travel time.\(^{17}\) In other words, every minute of delay that a user experiences due to an incident, for example, is worth a little less than a minute of normal, everyday delay caused by normal congestion. Essentially, people are willing to pay a little less to avoid the possibility of being stuck in traffic due to a crash than they are to avoid being stuck in traffic due to normal everyday congestion.

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For Further Reading

The SHRP program produced a white paper on valuing reliability that provides a valuable and detailed description of the ways that researchers have monetized reliability benefits and current trends in the literature. Lately, the value of reliability has been trending downward, from being around twice as valuable as average travel time toward being about equal.

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• **Build a generic reliability project cost and benefit roster.** If benefits and costs for assessing needs or setting the size of the reliability program have been collected, use those here. If not, collect benefits and cost data for reliability projects. Use those from other similar projects within the agency, those from similar agencies, or those from the ITS project cost and benefits database.\(^{18}\) Ensure that the benefits are in the same units as the performance measures (i.e., planning-time index). Later, either use this generic roster or estimate project-specific reliability benefits using other methods.

• **Select an approach to estimate the impact of a project on reliability.** Benefits of reliability projects can be identified by collecting estimates of reliability benefits from existing plans. This may be preferred because it is possible that the authors of these plans will have performed a detailed and more rigorous analysis of the reliability benefits of a project. Benefits also can be identified within the project prioritization framework. In this case, identify and prepare a sketch planning method or model postprocessor tool to estimate benefits. See the *Technical Reference Sections 3, 4, and 5* for a detailed how-to for estimating reliability using these methods and tools.

  - **Sketch planning.** These analysis methods provide a quick assessment of reliability (and the impacts of projects affecting reliability) using readily available data as inputs to the analysis.
  
  - **Model postprocessing.** These analysis methods apply customized analysis routines to more robust network supply and demand data from regional or state travel demand models to generate specific estimates of travel-time reliability.
  
  - **Simulation.** These methods make use of an advanced traffic simulation model’s ability to test and assess likely driver reactions to non-recurring circumstances. Use simulation method if a corridor study, CMP, or operations plan is being developed.

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\(^{17}\)Reliability Valuation White Paper.

\(^{18}\)http://www.itscosts.its.dot.gov/its/benecost.nsf/AdjustedUnitCosts.
- **Multiresolution/multiscenario modeling.** These approaches integrate several standard analysis tools, (e.g., microsimulation and travel demand models) to combine different tools’ abilities to assess shorter- and longer-range impacts of various projects on reliability performance.

- **Collect the data required for the analysis approach.** For a sketch planning method or model postprocessor tool, the data can come from the travel demand model outputs. See the *Technical Reference Section 3.3* for a detailed how-to for using travel demand model outputs in combination with sketch methods and model postprocessor tools to estimate reliability.

## 6.3 How To

Prioritization of projects and incorporation of reliability can be accomplished in several ways. In this section, we describe those suited for performance-based planning, including prioritizing based on weighted project scores, economic efficiency, cost-effectiveness, and a hybrid approach. The results of the project prioritization analysis can feed into program funding setting and the needs analysis.

### How To Prioritize Using Weighted Project Scores

- **Assess project benefits.** For each reliability project, populate the project-specific benefits using the selected approach.
  - *Populate using the roster of reliability benefits.* Use this if a generic roster of reliability benefits has been developed. Typically, the more local the benefits, the more applicable they will be to the specific situation.
  - *Populate using estimates of reliability benefits from CMPs, corridor studies, or other subarea studies.* If a long-range plan is being developed, or a program, pull project benefits from other studies, especially if they applied a simulation or multiresolution model to estimate the benefits as these benefits are likely to be more refined and accurate than a sketch planning method that would be used here.
  - *Estimate reliability benefits using a sketch planning method, model postprocessor, or simulation model.* For example, if a long-range plan or program is being developed, use sketch planning methods. For example, the Knoxville TPO used the data-poor methods from SHRP 2 L03 to estimate the reliability benefits. See the *Technical Reference Section 5.0* for a detailed how-to for estimating reliability using these methods and tools.

- **Estimate project points.** For each project, estimate the total reliability project points. Project points identify how much a project improves reliability performance or ‘project effectiveness’ relative to all other projects in the universe of projects. The general formula for calculating a project points is:

\[
\text{Project Points} = \frac{\text{Project Effectiveness} - \text{Minimum Project Effectiveness}}{\text{Maximum Project Effectiveness} - \text{Minimum Project Effectiveness}}
\]
For example, if a project improves reliability by 20 planning-time index points and this 20-point improvement is 5 points more than the lowest performing investment (that investment improves reliability by 15 planning-time index points) and 30 points fewer than the highest performing investment (that investment improves reliability by 50 planning-time index points), then the project in question would receive 14 project points, calculated as $20 - 15/50 - 15$. Continue this process for each of the remaining measures and each of the remaining projects.

Develop weights for measures. Distribute 100 points among all measures. Distribute based on stakeholder feedback, professional judgment, simple pair wise comparisons, or the quantifiable pair wise method called the Analytical Hierarchy Process (AHP) based on structured stakeholder feedback. Figure 6.2 shows an example of this exercise, compiling reliability measures among all other project measures. In this fictitious example, the agency set weights based on policy statements aimed at supporting growth in the gross state product, reliability, and preservation above all others.

Figure 6.2 Example Performance Measure Weighting Scheme

<table>
<thead>
<tr>
<th>Measure</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction in crashes</td>
<td>10</td>
</tr>
<tr>
<td>Lane miles of pavement improved</td>
<td>12</td>
</tr>
<tr>
<td>Deck area of structurally deficient bridge improved</td>
<td>10</td>
</tr>
<tr>
<td>Reduction in person-hours of travel</td>
<td>10</td>
</tr>
<tr>
<td>Does the project include bicycle or pedestrian elements?</td>
<td>8</td>
</tr>
<tr>
<td>Reduction in planning time index</td>
<td>15</td>
</tr>
<tr>
<td>Increase in GSP</td>
<td>20</td>
</tr>
<tr>
<td>Reduction in GHG emissions</td>
<td>10</td>
</tr>
<tr>
<td>Reduction in NAAQS non-attainment air pollutants</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Cambridge Systematics.

Estimate the project score. Take the project points (based on a scale of 1-100 from Step 1 in this chapter) and multiply them by the weight. For example, if an investment scored 14 project points by improving reliability and reliability was given a weight of 15, then the investment would “earn” 2.1 points toward the final project score (14*15/100). Repeat this step for all other measures and sum the results to calculate the complete project score.

• **Prioritize projects.** Rank order projects from the projects scoring the highest to the project scoring the lowest in the combined weighted project score. If there is a financial constraint, select projects from the top until the budget is expended.

**Prioritize Projects Using Economic Efficiency**

This guide introduces the concept of including the benefits of reliable travel time to B/C analysis. Typically, standard costs in most B/C analyses include agency costs, avoidable accidents, travel time, and vehicle operating costs. Some agencies calculate the avoidable pollution cost and the cost of carbon as well. This section lays out the steps for estimating reliability for inclusion in the typical B/C analysis.

**For Further Reading**


• **Select a timeframe.** If the agency maintains its own procedures for conducting B/C analysis that specify a timeframe, use that. If not, the time horizon should begin when the first expenditures on the first project begin and extend until the end of the useful life of the longest-lived alternative in the project universe or at some future point in time when analysis no longer is meaningful (e.g., the costs and benefits are discounted until they are worth nearly no money in today’s dollars). The longest-lived project within the reliability program will be shorter if the program excludes capacity projects. The timeframe should be the same for benefits and costs. Typically, absent other guidance, use a timeframe of 20 years.

• **Select a discount rate.** Based on OMB circular A-94, the recommended discount rate for benefit-cost analysis is seven percent. This rate approximates the marginal pretax rate of return on an average investment in the private sector in recent years. However, given recent the recent economic downturn, the OMB states that future versions of the Circular will include significant changes in this rate.

• **Estimate the net present value (NPV) of project costs.** For each project in the reliability program, select project-specific costs using the roster of costs over the analysis timeframe. Planning and construction costs accrue in the early years. Note that in benefit-cost analysis, operations and maintenance costs typically are included as negative benefits.

• **Apply the discount rate and estimate the NPV.** Apply the discount rate for each year in the cost stream and sum the discounted costs to calculate the NPV of project costs.

\[
NPV \text{ Costs} = \sum_{i=0}^{n} \frac{\text{Costs in Year } i}{(1 + \text{Discount Rate})^{\text{Year } i}}
\]
• **Estimate the NPV of project benefits.** Define the types of benefits to include in the analysis. Every project impacts reliability when it is being constructed (disbenefit) and when it is open to the public (benefit). There are three distinct benefits to measure when considering reliability projects, listed below. See the *Technical Reference Section 6.0* for a step-by-step process for estimating reliability benefits and disbenefits.

  - **Construction disbenefits.** Construction work zones are one of the leading causes of unreliable travel, causing 10 percent of total delay. Estimate how work zones impact reliability. Appendix C.4 of the *Technical Reference* describes additional analysis methods for estimating the impacts of work zones.

  - **Operations and Maintenance.** Operations and maintenance costs typically are included as negative benefits in a benefit/cost analysis.

  - **Benefits.** Because of how researchers have valued reliability in the literature, structure the benefits analysis carefully to properly value reliability for the B/C analysis. Instead of tracking the index, which tells the degree of unreliability (great for tracking performance), measure the actual amount of unreliable travel time (necessary for valuing reliability). The current best-practice for estimating the amount of unreliable travel time for valuation purposes is to estimate the difference between the 80th percentile and 50th percentile travel time. Estimate these values in addition to the primary performance measure because it allows you to use the value of reliability found in the literature. To estimate these travel-time indices, use a sketch planning model or a simulation model.

• **Develop a benefit stream.** Estimate benefits for each project and each year in the timeframe. Construction reliability disbenefits accrue in the early years while reliability benefits begin accruing only after construction is complete.

• **Estimate the monetary value of reliability.** Current research shows that users are willing to pay about $1 cents to avoid unexpected delay for every $1 they would pay to avoid expected delay. However, this value has been trending downward in the research. Because of this, the SHRP program suggests using 0.8 as the ratio of the value of reliability (VOR) to the value of time (VOT). The U.S. DOT recommends using $18 per person-hour for average travel time for all purposes, in 2009 dollars. Based on this, reliability is valued at $14.40 per person-hour ($18 X 0.8 = $14.40). Recall that we recommend this value of reliability based on research and that it is based on the difference between the 80th percentile travel time and the 50th percentile travel time.

• **Monetize project benefits.** Multiply the value of reliability by the reliability benefits.

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Building a Balanced Transportation System Using Reliability Performance Measures

**Not All Users Value Time Equally**

Different values are placed on reliability compared to average travel time by different users at different times and for different trip purposes. The ratio of reliable travel time to average travel time is considered the Reliability Ratio. SHRP 2 Projects C04 and L04 derived an expansive set of values of reliability for combinations of trip type, income, and trip length. In general, the influence of these factors is:

- **Trip Type** – the Reliability Ratio for the trip to work is higher than the trip from work or non-work trips.
- **Income** – for the work trip, lower income groups have a higher Reliability Ratio (presumably because their work schedules are more rigidly fixed by employers).
- **Trip Length** – for the work trip, the Reliability Ratio decreases with trip distance.
- **Studies of How Freight Users Value Reliability Are Not as Plentiful as For Passenger Travel** – Some evidence exists that both the value of reliability and Reliability Ratio is higher than for passenger travel, but these values are highly dependent on the type and value of commodity.

- **Apply the discount rate and estimate the NPV.** Convert project benefits into dollars using the value of reliability. Sum the NPV of the total reliability benefits of the project over its full useful life. Note that operations and maintenance costs are considered negative benefits:

\[
NPV\text{ Benefits} = \sum_{i=0}^{n} \frac{Benefits \ in \ Year \ i}{(1 + Discount \ Rate)^{Year\ i}}
\]

- **Estimate project B/C ratio.** Divide total discounted benefits by total discounted costs.

\[
B/C = \frac{NPV\ Benefits}{NPV\ Costs}
\]

- **Prioritize projects.** Prioritize projects having the highest B/C ratio. Select projects with a B/C ratio above an acceptable threshold (e.g., select all projects with a B/C ratio of one or greater because these projects are economically efficient). If working with funding constraints, select projects starting with the highest B/C ratio and continue until funds are exhausted.

**How-To Prioritize Projects Using Cost-Effectiveness**

To compare projects with measures that cannot be monetized (for example, many community and livability measures are impractical to monetize), measuring its cost-effectiveness will help to determine how much performance is bought if investing in the project. This perspective will help to balance expensive projects with significant performance benefits against inexpensive
projects with smaller benefits. The OMB, in their circular A-94 that, “Typically, a project is cost-effective if, on the basis of life-cycle cost analysis of competing alternatives, it is determined to have the lowest costs expressed in present value terms for a given amount of benefits.”\textsuperscript{22} However, cost-effectiveness also can be simplified by comparing current year costs and current year benefits as a basis for comparison. That is, imagine a scenario in which the project is built and paid for this year. Using this simplified approach allows avoidance of the labor involved with estimating life-cycle project benefits for each measure.

- **Estimate project benefits.** Unlike in B/C analysis, reliability measure direction can be used in cost-effectiveness analysis. Do this for the reliability on its own if comparing projects within a reliability program, or combine all of the reliability measures into a project score using the instructions in the “How-to prioritize based on weighted project scores” section above.

- **Estimate project costs.** Identify costs for all projects using the roster of project costs.

- **Estimate cost-effectiveness.** Divide the current year costs by current year reliability measure or project score, depending on how the programs are organized. The equation below shows this formulaically.

\[
\text{Cost Effectiveness} = \frac{\text{Project Cost}}{\text{Change in Project Score}}
\]

- **Prioritize projects.** Rank-order the projects with those having the highest cost-effectiveness coming first. A cost-effectiveness threshold can be set and select all projects above that threshold. If working with funding constraints, select projects starting with the highest cost-effectiveness ratio and continue until funds are exhausted.

**Prioritize Based Using a Hybrid Approach**

To combine different approaches, build a two-dimensional chart that shows performance on one axis and cost-effectiveness or B/C ratio on the other. This will help compare projects in the performance and economic dimension at the same time.

- **Combine project score with cost-effectiveness analysis.** The ultimate goal is to have a cost-effective project that also scores high on weighted performance marks. That is, combining cost-effectiveness with performance scores indicates the ‘bang for the buck’ and the total performance improvement. Divide the graph into four quarters and identify each quarter as a tier. Projects that are a good value and improve the performance the most fall into the highest tier and should be the priority. Projects that improve the performance moderately but have a good bang for the buck or projects that improve the performance greatly but provide only moderate value due to high cost should be medium priority. Projects that do not provide value and provide little performance improvement should be low priority.

\textsuperscript{22}OMB circular A-94.
Combine project score with benefit/cost analysis. Put the project score on the X-axis and the benefit/cost ratio on the Y-axis. Projects that are economically efficient and improve the performance the most fall into the highest tier and should be the priority. Projects that improve the performance moderately but have good economic efficiency, or projects that improve the performance greatly but provide only economic efficiency should be medium priority. Projects that are not economically efficient and provide little performance improvement should be low priority.

Long-Range Plan, Corridor Plan, Congestion Management Process, Operations Plan

State long-range plans clearly call for a more sketch-level analysis which makes project score and cost-effectiveness measures more viable. RTPs require project prioritization of some sort. CMP, Corridor Plans, and Operations plans, on the other hand, call for a more rigorous analysis and can use project score, cost-effectiveness, or benefit/cost analysis.

Programming

Take the priority projects, match them with funding sources, and schedule them for construction. Here, look for synergies and potential overlaps among priority capacity and reliability projects.

Building a Balanced Transportation System Using Reliability Performance Measures provided guidance to define policy statements, select performance measures, estimate needs and deficiencies, set program funding levels, and prioritize projects using reliability. Additional detailed information and instruction to assist with incorporating reliability into planning and programming can be found in the Technical Reference.