



Incorporating Travel-Time Reliability into the Congestion Management Process: A Primer

February 2015



U.S. Department of Transportation
Federal Highway Administration



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16. Abstract This primer explains the value of incorporating travel-time reliability into the Congestion Management Process (CMP) and identifies the most current tools available to assist with this effort. It draws from applied research and best practices from regional agencies nationwide. It emphasizes the importance of expanding the scope of the CMP to include monitoring and addressing non-recurrent congestion utilizing Planning for Operations strategies. It is intended for use by state and metropolitan planning organization (MPO) planners as well as operations managers and analysts who are planning and programming transportation investments to better manage congestion in our urban areas.			
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Dear Colleague,

The Federal Highway Administration (FHWA) Office of Operations and the Office of Planning, Environment, and Realty are pleased to present this publication titled "Incorporating Travel-Time Reliability into the Congestion Management Process (CMP): A Primer". Support for this effort came from the second Strategic Highway Research Program (SHRP 2), managed by the Transportation Research Board (TRB). Realizing the growing need to address reliability in transportation planning, and the importance of the CMP in the metropolitan transportation planning process, the Technical Coordinating Committee of SHRP 2 recommended that work be done on incorporating reliability into the CMP, utilizing the SHRP 2 Reliability products.

Reliability is an important element of congestion that historically has not been considered as part of the CMP. Across the U.S., congestion due to non-recurring disruptions such as traffic incidents, weather, work zones, and special events accounts for an average of 55 percent of total delay. Because many of these events are not predictable, they affect the reliability of the system and have a significant impact on congestion. The primary objective of this primer is to provide direction and potential opportunities for incorporating reliability, specifically travel-time reliability, into the CMP and identify the most-current tools available to assist with this effort, including the SHRP 2 Reliability products. It is intended for use by State and metropolitan planning organization (MPO) planners who are involved in the development of the CMP as well as by operations managers and analysts who are also engaged in the development of the CMP. This primer explains the value of incorporating travel-time reliability into the CMP; how to get started, in a checklist format; and some examples, or models, of good practice for incorporating reliability into the CMP.

Our Offices will be supporting this primer through workshops and related technical assistance activities. If you have any comments on this material or need additional copies, please contact Jim Hunt at jim.hunt@dot.gov, 717-221-4422; Wayne Berman at Wayne.Berman@dot.gov, 202-366-4069, and/or Egan Smith at Egan.Smith@dot.gov, 202-366-6072.

Sincerely yours,

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in ²	square inches	645.2	square millimeters	mm ²
ft ²	square feet	0.093	square meters	m ²
yd ²	square yard	0.836	square meters	m ²
ac	acres	0.405	hectares	ha
mi ²	square miles	2.59	square kilometers	km ²
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft ³	cubic feet	0.028	cubic meters	m ³
yd ³	cubic yards	0.765	cubic meters	m ³
NOTE: volumes greater than 1000 L shall be shown in m ³				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m ²	cd/m ²
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in ²	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm ²	square millimeters	0.0016	square inches	in ²
m ²	square meters	10.764	square feet	ft ²
m ²	square meters	1.195	square yards	yd ²
ha	hectares	2.47	acres	ac
km ²	square kilometers	0.386	square miles	mi ²
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m ³	cubic meters	35.314	cubic feet	ft ³
m ³	cubic meters	1.307	cubic yards	yd ³
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact degrees)				
°C	Celsius	1.8C+32	Fahrenheit	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m ²	candela/m ²	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in ²

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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List of Acronyms and Symbols

CMP	Congestion Management Process (Federal guidelines) or Congestion Management Program (locally or regionally adopted)
DOT	Department of Transportation
FHWA	Federal Highway Administration
GPS	Global Positioning System
GIS	Geographic Information Systems
HCM	Highway Capacity Manual
HOT	High Occupancy Toll
HOV	High Occupancy Vehicle
ITS	Intelligent Transportation Systems
LOS	Level of Service
MAP-21	Moving Ahead for Progress in the 21st Century Act (Federal surface transportation reauthorization law from 2012 to the issuance of this report)
MPO	Metropolitan Planning Organization
MTP	Metropolitan Transportation Plan
NHS	National Highway System
NPMRDS	National Performance Management Research Data Set
PeMS	(California's) Performance Measurement System
PBPP	Performance-Based Planning and Programming
PTI	Planning Time Index
SAFETEA-LU	Safe Accountable Flexible Efficient Transportation Equity Act: A Legacy for Users (Federal surface transportation reauthorization law from 2005 to 2012)
SHRP 2	The second Strategic Highway Research Program
SOV	Single Occupant Vehicle
TIP	Transportation Improvement Program
TMA	Transportation Management Area
TMC	Transportation Management Center
TSM&O	Transportation System Management and Operations
TTI	Travel Time Index
V/C	Volume to Capacity Ratio
VHD	Vehicle Hours of Delay
VHT	Vehicle Hours Traveled
VMT	Vehicle Miles Traveled



Photograph courtesy of iStock (Todd Arena)

Overview

Travel-time reliability is an important element of congestion that historically has not been considered as part of the Congestion Management Process (CMP). Taken on average, and as a whole across the United States, non-recurring congestion accounts for more delay than recurring congestion. Non-recurring congestion is caused by disruptions, such as traffic incidents, weather, road construction and maintenance, poor signal timing, and/or special events.

Three major factors are driving the focus on travel-time reliability:

Roadway Expansion Constraints – Physical and other constraints make traditional capacity improvements increasingly difficult. Transportation system management and operations strategies (TSM&O), designed to address reliability are usually easier to implement and can be installed more quickly than traditional capacity improvements.

Customer Expectations – The value of travel-time reliability is being increasingly recognized as a key aspect of transportation performance to system users. For personal travel, travel to support commute trips, and most importantly travel that affects freight operations, research is showing that travel-time reliability is valued at a level comparable to, and in some cases more than, average travel time.

Federal Surface Transportation Reauthorization Law – Moving Ahead for Progress in the 21st Century Act (MAP-21) establishes a system reliability goal for the national transportation system with an emphasis on performance-based planning and programming (PBPP) to ensure achievement of that goal.

This primer identifies opportunities for incorporating travel-time reliability into the CMP. It is intended for use by state and metropolitan planning organization (MPO) planners as well as by operations managers and analysts who are planning and programming transportation investments to better manage congestion in urban areas. The primer illustrates how advances in probe data and system detection technologies, as well as new analysis tools developed under the second Strategic Highway Research Program (SHRP 2) [1] program, can enable reliability analysis to be incorporated into the CMP.

The primer is organized as follows:

Chapter 1

Introduction:

Defines travel-time reliability as well as the impetus for and value of incorporating it into the CMP.

Chapter 2

How to Incorporate Reliability into the Congestion Management Process:

Focuses on key points in the CMP where travel-time reliability could be added to create a more robust plan. This includes:

- Objectives and performance measures
- Diagnosing causes of reliability problems
- Generation of reliability strategies
- Evaluation of reliability strategies
- Monitoring of reliability outcomes

Many of the data sets and tools for evaluating reliability are described in this section, including the use products developed as part of SHRP 2.

Chapter 3

Getting Started:

Provides a checklist for agencies to use for getting started on incorporating reliability into their CMP.

Chapter 4

Model Congestion Management Plan:

Demonstrates specific sections of current CMPs in which reliability has been incorporated.

Chapter 5

Summary:

Recaps the motivation for the Federal Highway Administration (FHWA) to support the development of robust CMPs.

Chapter 6

References:

Details the source of materials used for this primer's development.

Appendix

Provides a brief overview of the CMP and reference to the *Congestion Management Process: A Guidebook* for those who are unfamiliar or need a refresher on the process.



Photograph courtesy of Kittelson & Associates, Inc.

Chapter 1 Introduction

This primer identifies opportunities for incorporating travel-time reliability into the Congestion Management Process (CMP). It is intended for use by state and Metropolitan Planning Organization (MPO) planners as well as by operations managers and analysts who are planning and programming transportation investments to better manage congestion in urban areas.

Travel-time reliability, which considers the effects that non-recurring events have on delay over time, is an important element of congestion that historically has not been considered as part of the CMP. Taken on average, and as a whole across the United States, non-recurring congestion accounts for more delay than recurring congestion. Non-recurring congestion is caused by disruptions, such as traffic incidents, weather, road construction and maintenance, and/or special events, as shown in **Figure 1**. This is particularly true in areas with smaller population sizes that do not experience much recurring congestion.

Recurring and Non-Recurring Congestion

Recurring congestion, or expected congestion, occurs when too many people routinely attempt to drive on a roadway or enter a transit vehicle at the same time. Recurring congestion typically happens during commute hours for most regions.

Non-recurring congestion happens when there are disruptions to the flow of traffic or transit. Disruptions include crashes, disabled vehicles, large special events (concerts, sports games, etc.), inclement weather, and construction work zones.

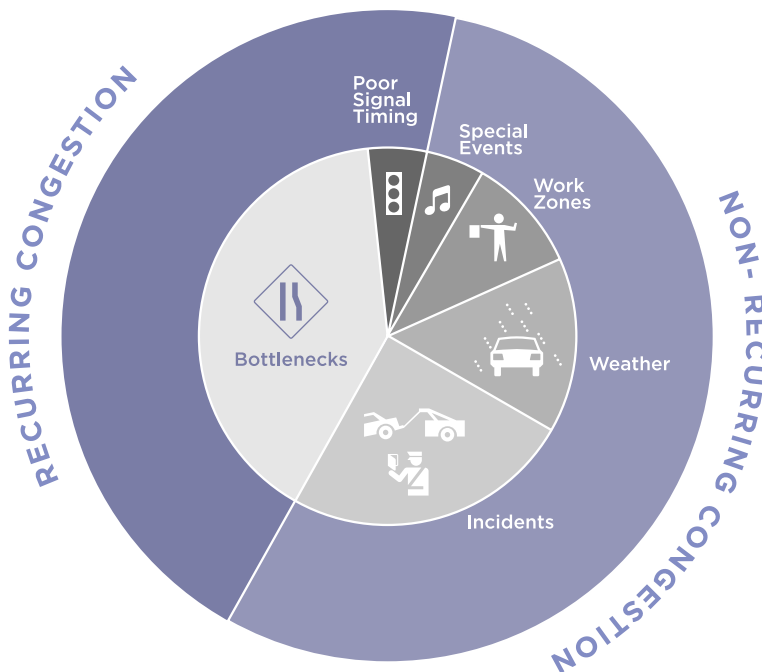


Figure 1. Chart. Causes of Congestion

Source: Adapted from Traffic Congestion and Reliability: Trends and Advanced Strategies for Congestion Mitigation, Figure ES.2, Federal Highway Administration, http://ops.fhwa.dot.gov/congestion_report/executive_summary.htm#what_is_congestion

To date, most CMPs assess congestion using traditional proxy measures such as level of service and volume-to-capacity ratios. Traffic counts are reduced to average annual daily traffic, leading to viewing the system on a “typical” day. This approach is attributed to the historical costs of continuous data collection and to the lack of analysis tools available for assessing travel-time reliability.

Advances in probe data and system detection technologies have significantly reduced data collection costs. Travel times can now be monitored continuously and cost effectively at the individual facility and network levels, enabling the calculation of reliability. Software programs have been developed to translate these data directly into performance measures.

Several research projects on reliability were conducted as part of the second Strategic Highway Research Program (SHRP 2) [1]. They developed relationships, methods, and analytical tools and techniques to define, measure, monitor, and improve the reliability of roadway networks.

Travel-time reliability is important to the traveling public and shippers, and they often factor in how predictable their trip time is when making decisions about route choice, departure times, or mode of travel. Given this importance, along with the advent of data sources and analytical tools that make measuring and assessing reliability viable, additional guidance is needed to enable MPOs to incorporate reliability into their planning processes.

1.1 What is Travel-Time Reliability?

Travel-time reliability is defined as consistent travel times for the same trip as measured day-to-day or across different times of the day. If trip times are inconsistent, the travel time is considered to be unreliable, because it is difficult to generate consistent and accurate estimates for it.

Travel-time reliability is a metric that is important to and innately understood by travelers and shippers. Variable or unpredictable travel times make it more difficult for travelers and shippers to plan their travel, often forcing them to add extra time to protect themselves against the uncertainty of arrival times. This uncertainty may lead to ineffective or even counterproductive travel decisions that waste time and money.

Frequent disruptions to normal flows lead to uncertainty for the traveling public and freight shippers. **Figure 2** provides an illustrative example of what travelers experience over a year's time and how they are most likely to recall the highest travel-time delays. As this figure shows, major delays due to non-recurring incidents may be infrequent, but their effects can be large when they happen. In addition, those exceptionally bad days are the ones best remembered by the traveling public.

Same Trip

A trip taken on a regular basis with identical characteristics, including its purpose, origin, destination, time-of-day, mode, and route.

The basic causes of unreliable travel times are (1) an imbalance between demand and capacity and (2) the congestion that can result from such an imbalance. Once congestion occurs, travel times become more variable (less reliable and thus less predictable). Moreover, congested facilities lack the resilience to accommodate unexpected travel interruptions, which leads to flow breakdowns and serious degradation of reliability. Travel times vary from one day to the next because conditions influencing traffic differ each day.

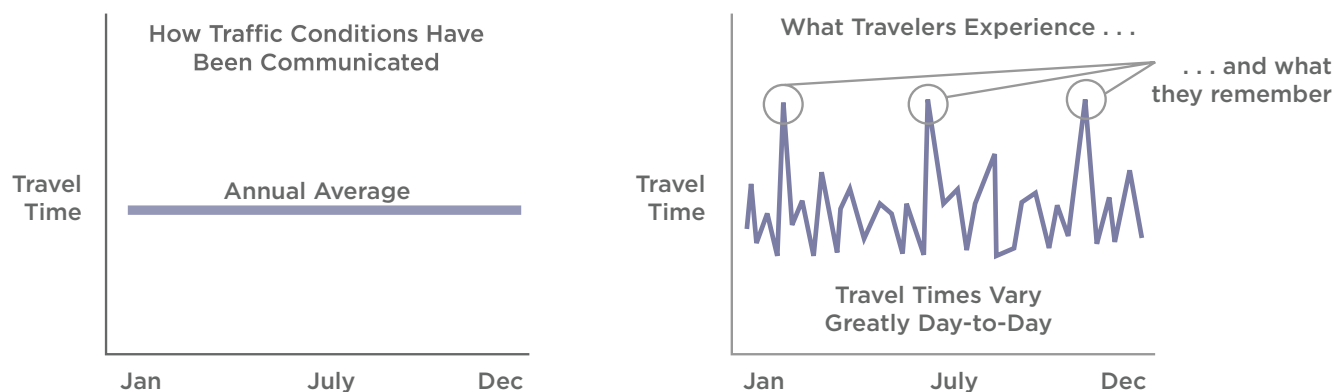


Figure 2. Graph. An Illustrative Example of Typical Travel Time Reporting versus What Travelers Experience

Source: Travel-Time Reliability: Making it There On Time, All The Time, Federal Highway Administration, FHWA-HOP-06-070, http://ops.fhwa.dot.gov/publications/tt_reliability/TTR_Report.htm

The SHRP 2 L02 Guidebook [2] identifies seven sources of congestion that influence travel-time reliability. They are: fluctuations in normal travel, inadequate base capacity, special events, traffic incidents, weather, traffic-control devices, and work zones. Actions responding to these factors fall into two broad categories. The first category of actions addresses the demand for travel, including the use of travel information and pricing and incentive-based strategies to influence when, where, how, and how much travel (both personal travel and freight movement) occurs. Emerging smart phone applications such as for dynamic ridesharing and real-time parking information can also be effective tools for managing real-time travel demand. The second category of actions includes actions to increase roadway capacity or otherwise maximize throughput, such as the following:

- Expansions of, or additions to, highway or transit facilities;
- Application of better operational and technical systems, such as active traffic management and intelligent transportation systems, to maximize the performance of existing infrastructure;
- Advances in technology and procedures that more-quickly restore capacity that has been lost as a result of disruptions (incidents, weather conditions, work zones); and
- Optimal use of existing transportation system capacity controlled by other transportation agencies, firms, or individuals. (This can be accomplished by providing incentives for mode shifts from single-occupant vehicles to multi-occupant vehicles and more-effective use of alternative rights-of-way).

The types of solutions that can address demand and capacity imbalances depend on whether congestion can be anticipated or whether congestion results from unexpected events.

When volume routinely approaches or exceeds capacity (recurring congestion), demand management and capacity increases are likely to be effective in improving reliability. In cases in which unexpected disruptions cause the bulk of congestion (non-recurring congestion), techniques that detect disruptions and facilitate rapid recovery from those events are more likely to be effective. Even for situations in which unexpected disruptions cause the majority of congestion, however, strategies for demand management and capacity increases will also warrant consideration. These strategies create a capacity margin that helps to ensure the system's resilience in effectively responding to unexpected events.

1.2 Why Does Reliability Matter Now?

Traffic congestion due to non-recurring events such as traffic incidents, weather, road work zones, and special events accounts for a majority of total traffic congestion-related delay in the United States. Up until recently, there were few options for cost-effectively collecting data for non-recurring events, particularly unplanned events such as crashes. MPOs and states that recognized the importance of travel-time reliability early on developed proxy objectives and performance measures, such as reducing collisions. Most agencies, however, have focused their CMPs on recurring congestion.

Why Focus on Reliability Now?

Constraints on expansion of the nation's transportation system, expectations of the traveling public, and Federal legislation are driving interest in travel-time reliability.

Improved monitoring technology and the availability of tools through the SHRP 2 program now make it feasible to evaluate reliability.

The focus on recurring congestion in CMPs has been easier to quantify from a monitoring standpoint, but has led to improvement strategies that focus on capacity expansion. Capacity expansion is increasingly difficult and expensive to implement. Expanding the scope of CMPs to address non-recurring congestion would mean more data collection and analysis. However, it would also lead to an expanded toolbox of improvement strategies that would incorporate transportation system management and operations (TSM&O). TSM&O strategies are generally easier and less expensive to implement.

With the growing field of inexpensive travel-time monitoring technologies and new prediction tools through the SHRP 2 program, it is now feasible to develop reliability performance measures. Analysis tools have been developed to identify current reliability problems and to predict reliability problems in the future.

Three major factors have also contributed to driving the focus on travel-time reliability by Federal, state, and metropolitan planning organizations: constraints on further expansion of the nation's transportation system, expectations by the traveling public, and recent Federal legislation.

Constraints on Expansion of the Transportation System



Photograph courtesy of Kittelson & Associates, Inc.

The era of new roadway construction has largely ended in most of the major metropolitan areas of the country. In addition, the practice of widening existing roadways is also falling out of favor due to high costs, the built out nature of many urbanized areas, and community desires for more multi-modal streets. While vehicle miles traveled (VMT) per-capita has been dropping steadily since 2004, population growth continues, particularly in urban areas, and this has led to more VMT overall. At the same time, transit ridership has increased to its highest level since 1956 [3]. There's growing momentum for making more-efficient use of the entire existing transportation system.

Growth in population, drivers, vehicles, and vehicle miles of travel overall has far outpaced roadway capacity expansion. As shown in **Figure 3**, the population of the United States increased 36 percent in the 30 years between 1980 and 2010, the number of auto drivers increased by 45 percent, the number of licensed vehicles increased by 50 percent, and the annual VMT increased by 94 percent. Meanwhile, new lane-miles of highways increased by only 8 percent during the same period.

As the physical capacity of our roadways is consumed by the growth in traffic, they become more vulnerable to disruptions caused by traffic incidents, inclement weather, special events, and work zones. These non-recurring events can occur at any time and place, and can cause congestion even in areas that don't usually experience recurring congestion. Variability in travel times is increasing on more roadways and for more times of the day, in part because non-recurring congestion has not typically been addressed in CMPs, or in the traditional transportation planning process. The highway transportation system has become more fragile and more susceptible to major disruptions due to traffic incidents.

Vehicle Miles Traveled (VMT) is a measurement of miles traveled by vehicles in an area over for a specified time frame. For example, the Federal Highway Administration summarizes monthly and yearly VMT for the nation and each state.

Highway Lane Miles is calculated by the number of lanes multiplied by the length in miles. It can be used to track capacity expansion for both existing and new roadways.

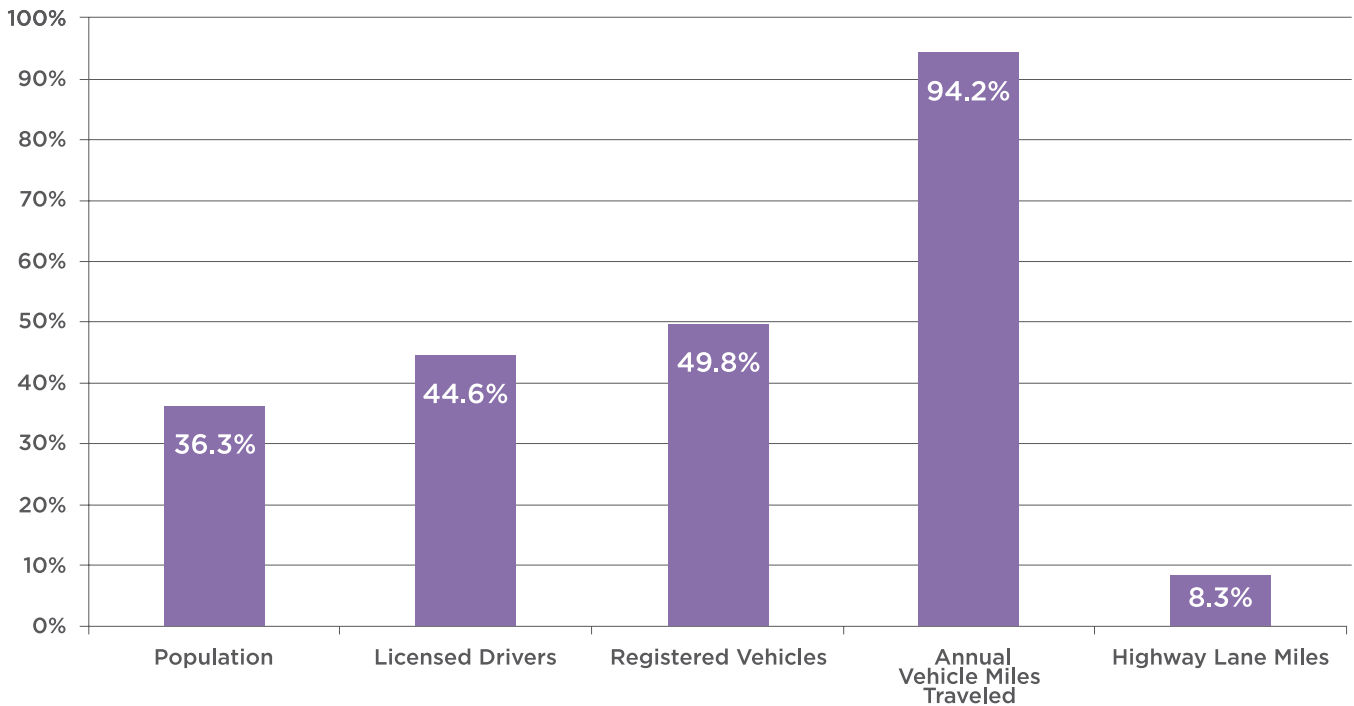


Figure 3. Chart. 30-Year Growth of Key Metrics in Relation to Highway Lane Miles

Created using data from the United States Census Bureau and the Federal Highway Administration's Office of Highway Policy Information, Highway Statistics Series

Expectations of the Traveling Public



Photograph courtesy of Kittelson & Associates, Inc.

Surveys of the traveling public and freight shippers repeatedly show that they value travel-time reliability more than speed. They are aware that technologies have been developed to extract data from mobile devices and to monitor real-time traffic conditions.

They expect that public agencies will use this data to provide real-time information and to alleviate the effects of disruptions on the roadway and transit network.

Federal Surface Transportation Reauthorization Law

On July 6, 2012, President Obama signed into law Moving Ahead for Progress in the 21st Century Act (MAP-21)[4]. It funds Federal surface transportation programs at an average of about \$41 billion per fiscal year and has been extended through May 31, 2015.

This was the first long-term highway authorization enacted since 2005. In addition to funding, MAP-21 establishes the policy and programmatic framework for investments to guide the growth and development of nation's transportation infrastructure.

MAP-21 established a new paradigm for states and MPOs called "performance-based planning and programming" (PBPP). This means that MPOs, state departments of transportation (DOT), and transit operators will be involved in performance measurement, target setting, and reporting on the outcomes of their transportation investments. MAP-21 began this process by setting seven national goals, and subsequently prescribing performance measures for each. One of the seven goals is:

"(4) System reliability - To improve the efficiency of the surface transportation system." MPOs that develop reliability goals and incorporate reliability into their CMPs provide a pathway to developing PBPP elements that aid this national goal by improving regional travel.¹

Since 1991, Federal transportation law has required that MPOs explicitly address congestion. The Safe Accountable Flexible Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) surface transportation reauthorization law stipulated the requirement for the use of the CMP in Transportation Management Areas (TMAs). This requirement was continued under MAP-21. The CMP consists of actions employing a variety of performance measures and analytic tools to define and identify congestion across all modes, and to develop and select appropriate strategies to reduce congestion.

¹ As of the writing of this primer the notice of proposed rule-making (NPRM) had not been released, thus the specific requirements and where they will apply were not known.



Photograph courtesy of iStock (B. Esov)

These strategies may include capital projects in the metropolitan transportation plan (MTP) and transportation improvement program (TIP), or operations actions carried out by MPO member agencies. While the CMP establishes a set of prioritized projects and actions, it does not impose upon MPOs a requirement to program them. An individual MPO may, for example, assign a low priority to congestion mitigation in their planning goals and objectives.

Over time, MPOs will need to pay attention to outcomes of the Federal investments in their TIP by reporting on performance. Many have only rudimentary performance measurement and monitoring systems in place. While some of the national goals may be limited to the National Highway System (NHS), reliability is a system-wide issue for most agencies, incorporating freeway, arterial, and transit operations.

1.3 The CMP and the Value of Incorporating Reliability

MPOs, by their very nature, must be responsive to the needs of their constituents as they develop plans and investment programs for the future of their regions. These typically address a wide range of issues, including mobility, safety, accessibility for all users, and quality of life. Non-recurring congestion can have a negative impact on all of these factors. Some MPOs are learning to pay more attention to system reliability. It is a metric that has become important to their constituents and elected officials.

Incorporating travel-time reliability into the CMP creates a systematic method to address the issue. The benefits include a more-robust understanding of the regional transportation system and a toolbox of strategies that go beyond capacity expansion to include operations and demand management solutions. A CMP that does not incorporate reliability will be heavily weighted towards traditional capacity improvements, missing out on, or under valuing more cost-effective operations strategies.

The Value of Reliability

Travel-time reliability is a metric that is important to and is innately understood by travelers, freight shippers, and elected officials.

A CMP that adequately incorporates reliability will tend to include more (or place a greater weight on) operations strategies, such as signal retiming or traveler information. **Figure 4** demonstrates a variety of capacity-related and operations-related strategies that may be included in a robust CMP.

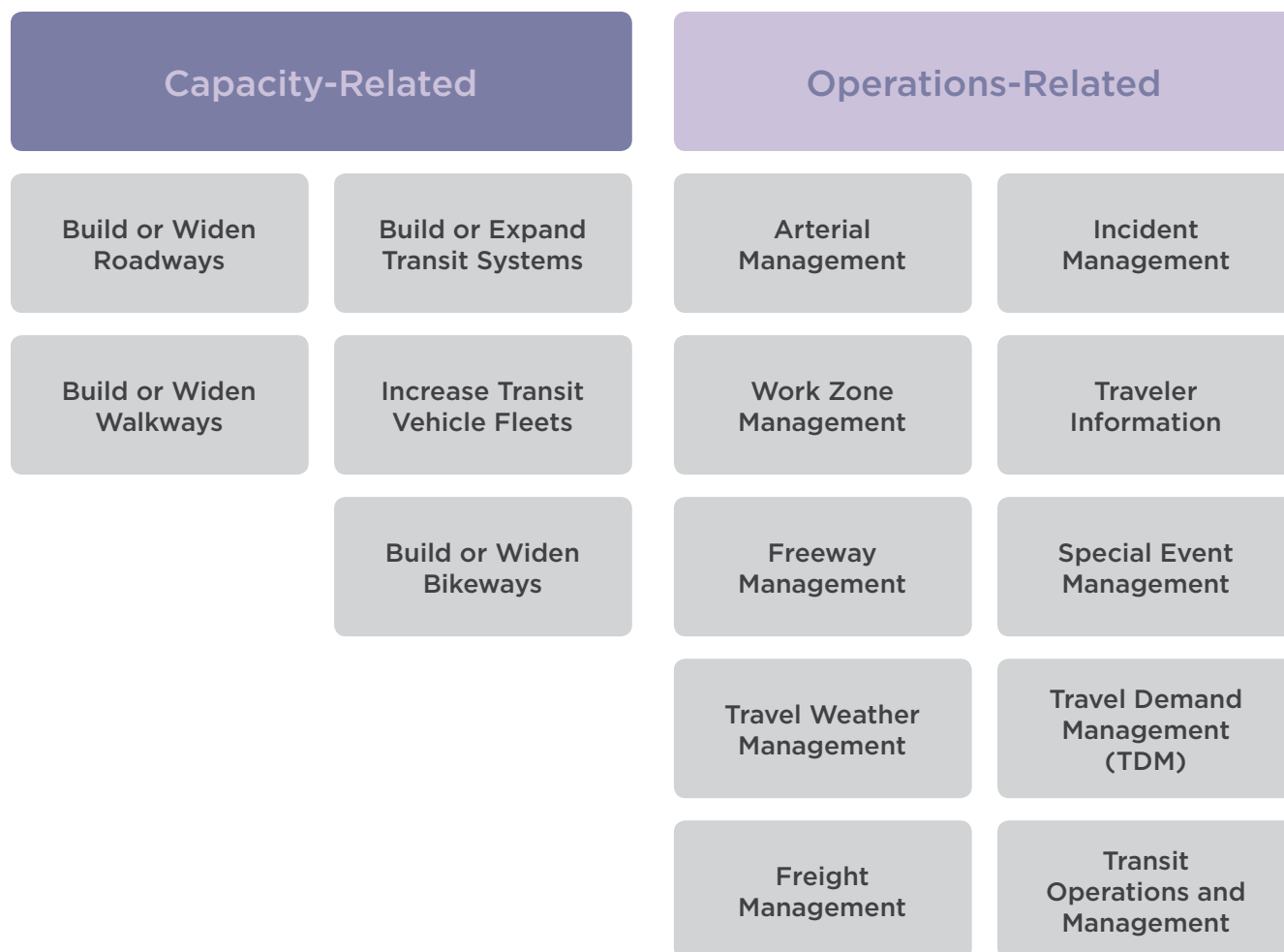
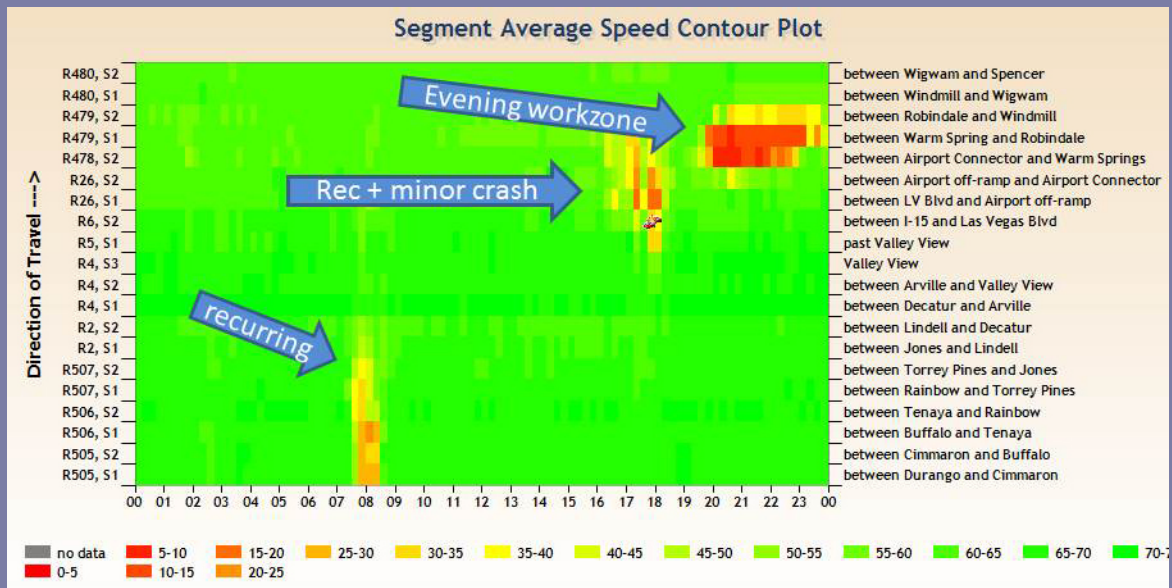


Figure 4. Chart. Typical Capacity and Operations Related Strategies

Incorporating Travel-Time Reliability Throughout a CMP: An Example from the Las Vegas Region

Regional Transportation Commission of Southern Nevada, the MPO for the Las Vegas region, has effectively incorporated travel-time reliability performance into its congestion management program. To this end, the MPO has developed objectives and performance measures, instrumented its network, and developed speed profile curves to assist with identifying sources of both recurring and non-recurring congestion. The data sets are arranged to be reported in user-defined temporal and spatial groups in order to identify reliability issues. Staff at the MPO actively monitors the transportation network and evaluates the effectiveness of incident management and ramp metering programs. More information can be found at: <http://www.rtcnv.com/planning-engineering/transportation-planning/2013-2035-regional-transportation-plan-update/>



Source: Regional Transportation Commission of Southern Nevada

Another advantage of incorporating reliability into the CMP is that many of the TSM&O strategies for addressing reliability problems can be deployed more quickly, at lower cost, and with a smaller environmental impact than traditional large-scale capacity improvements.

Focusing on system management and operations has been shown to have positive effects not only on reliability, but on safety and the environment as well. Many of the steps to create the CMP provide opportunities to incorporate travel-time reliability.

These include:

- Developing goals and objectives
- Identifying performance measures
- Monitoring
- Identification of problems
- Identification of strategies
- Monitoring effectiveness of implemented strategies

1.4 Purpose of the Primer

This primer is intended to provide advice to staff at MPOs on how to reevaluate their CMPs. It will show the value of integrating travel-time reliability into the CMP to address non-recurrent congestion. It will identify tools and data sources that are available to assist planners in monitoring and predicting travel-time reliability. Incorporating reliability in the CMP will result in a more-robust regional transportation system with objectives, performance measures, and strategies that align more closely with public and freight shippers' concerns.

In particular, this primer provides guidance and potential opportunities for using products developed through the SHRP 2 Reliability focus area. They have been developed, in part, to support and advance the CMP and Planning for Operations [5] as part of the metropolitan transportation planning process. SHRP 2 was authorized by Congress to address some of the most-pressing needs related to the nation's highway system, including congestion stemming both from inadequate physical capacity and from events that reduce the effective capacity of a highway facility. SHRP 2 reliability products focused on developing basic analytical techniques, design procedures, and institutional approaches to address the events—such as crashes, work zones, special events, and inclement weather—that often result in the unpredictable congestion that make travel times unreliable. This primer also includes guidance for using the National Performance Monitoring Research Data Set (NPMRDS) and other reliability tools.

1.5 Content of the Primer

The primer includes a “How-To” guide for incorporating travel-time reliability into an agency's next CMP (**Chapter 2**). It also contains a guide to getting started (**Chapter 3**) and a model CMP (**Chapter 4**) that use examples from CMPs that have incorporated travel-time reliability. The appendix contains a CMP refresher (**Appendix**).

Throughout the primer are examples from MPOs that have included travel-time reliability in their CMPs and Planning for Operations processes. The primer's content is sensitive to metropolitan regions of various sizes and addresses a range of issues from agencies that have very little system performance data to those with access to a large amount of data, recognizing that the field of transportation data collection is resource-intensive but also very dynamic and technology-enabled.

Urbanized areas with populations greater than 200,000 are designated as TMAs by the Federal Highway Administration and the Federal Transit Administration. MPOs located in long-standing TMAs often have many years of experience producing congestion management plans. By taking advantage of the contents of this primer, MPOs can now include non-recurring congestion and travel-time reliability in a CMP that provides more value to their constituents.



Photograph courtesy of iStock (Eugene Gurevich)

Chapter 2 How to Incorporate Reliability into the Congestion Management Process

This chapter identifies the key points and resources, tools, and methods for incorporating reliability into the Congestion Management Process (CMP) and for supporting Planning for Operations. Those who are not familiar with or need a refresher on the CMP are directed to the **Appendix** of this primer. There are many resources available to assist agencies with developing a CMP that incorporates travel-time reliability. In particular, this chapter shows how reliability can be incorporated into the following CMP Actions that are shown in **Figure 5**:

- Develop Regional Objectives
- Develop Multimodal Performance Measures
- Analyze Congestion Problems and Needs
- Identify and Assess Strategies
- Evaluate Strategy Effectiveness

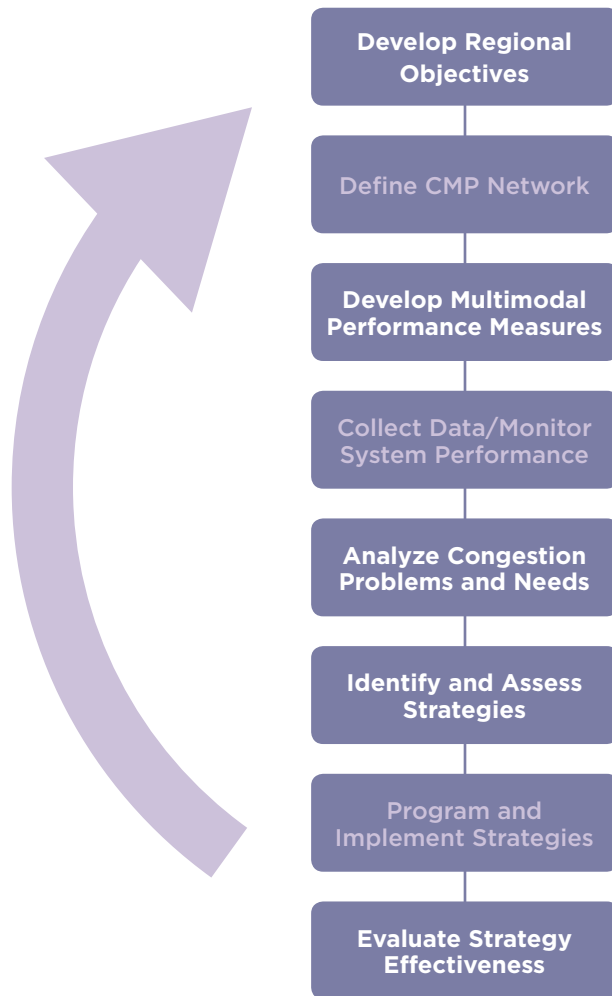


Figure 5. Chart. Highlighted Congestion Management Process Actions for Focusing on Incorporating Reliability

Source: *Congestion Management Process: A Guidebook*, Figure 2, Federal Highway Administration, FHWA-HEP-11-011.

Table 1 summarizes the resources referenced in this chapter.

Table 1. Resources for Incorporating Reliability into the Congestion Management Process

Congestion Management Process	The Second Strategic Highway Research Program Products					Other			
	L02	L05	L07	L08	L11				
	Reliability Monitoring: Guidebook	Reliability Project Programming Guide	Design for Reliability	Reliability Analysis Tools for HCM	Evaluating Operational Strategies	Advancing Metropolitan Planning for Operations: Desk References	Congestion Management Process: A Guidebook	National Performance Management Research Data Set	Operations Benefit/Cost Analysis Desk Reference
Develop Regional Objectives		●				●	●		
Develop Multimodal Performance Measures		●		●					
Analyze Congestion Problems and Needs	●		●	●				●	
Identify and Assess Strategies		●			●	●	●		
Evaluate Strategy Effectiveness	●		●	●				●	●

2.1 Objectives and Performance Measures

In order for the CMP to address reliability, it is necessary to have stated objectives and performance measures for reliability. These objectives and performance measures support broad goals that are typically established in the metropolitan transportation plan (MTP)². It is a good idea to review and update objectives and performance measures in light of new data and tools for predicting the reliability of the region's facilities. CMP updates provide frequent opportunities for these reviews.

An additional motivation for ensuring that reliability is incorporated into the CMP objectives and performance measures is that it establishes a business case for dedicating funds to operations strategies through the transportation improvement program (TIP).

Objectives and Performance Measures

Objectives are often tied directly to the performance measures chosen. A number of sample objectives listed in Table 2 utilize the following performance measures with which agency staff may be unfamiliar:

Travel-time index (TTI) is the total time needed for a traveler to arrive on-time for a user-defined percent of the time. For example, the **planning-time index (PTI)** is a special case of the TTI indicating the total time needed for a traveler to ensure on-time arrival 95 percent of the time.

Buffer index is the extra time a traveler would need to budget compared to the average travel time to ensure on-time arrival 95 percent of the time.

² MPO practitioners tend to refer to their MTP as their long-range transportation plan (LRTP)

Setting Reliability Objectives

The Federal Highway Administration (FHWA) report, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations* [6] found at <http://ops.fhwa.dot.gov/travel/plan2op.htm>, provides the wording for several example objectives that relate to reliability performance measures.

Generic examples shown in **Table 2** serve as a starting point for agencies seeking to establish reliability objectives. The examples include objectives for reducing non-recurring delay, the buffer index, the planning time index (PTI), travel time, and variability. There is also a sample objective for improving transit on-time performance.

Table 2. Generic Examples of Reliability Objectives

Category	Operations Objective
Non-Recurring Delay	Reduce total person hours of delay (or travel-time delay per capita) by time period (peak, off-peak) caused by: (Option 1) scheduled events, work zones, or system maintenance by X hours in Y years. (Option 2) unscheduled disruptions to travel by X hours in Y years. (Option 3) all transient events such as traffic incidents, special events, and work zones by X hours in Y years.
Buffer Index	Decrease the buffer index for (specific travel routes) by X percent over the next Y years. Decrease the average buffer index for (multiple routes or trips) by X percent over Y years. Reduce the average buffer time needed to arrive on-time for 95 percent of trips on (specified routes) by X minutes over Y years.
Planning Time Index	Reduce the average planning time index for (specific routes in region) by X (no units) over the next Y years. Reduce the average planning time for (specific routes in region) by X minutes over the next Y years.
Travel Time	Reduce the average of the 90th (or 95th) percentile travel times for (a group of specific travel routes or trips in the region) by X minutes in Y years. Reduce the 90th (or 95th) percentile travel time for each route selected by X percent over Y years.
Variability	Reduce the variability of travel time on specified routes by X percent during peak and off-peak periods by year Y.
Transit On-Time Performance	Improve average on-time performance for specified transit routes/facilities by X percent within Y years.

Source: Adapted from *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, Reference Tables 3.2.2, Federal Highway Administration, FHWA-HOP-10-027.

Another good source of information on the development of reliability objectives and performance measures is the SHRP 2 L05 report, *Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes: A Guide* [7], available at <http://www.trb.org/Main/Blurbs/168855.aspx>. As stated in the L05 guide, it is important to examine the current reliability performance of the system when setting MTP goals and CMP objectives. This is to ensure that the goals and objectives relate to the fundamental issues faced by the agency and are meaningful to the agency. Because MTP goals and CMP objectives are set through a collaborative process that includes stakeholders, it is important to provide the stakeholders with information on reliability to help facilitate these discussions. The L05 guide goes into more detail about the kind of data and types of information that will be useful in establishing agency reliability objectives, as shown in **Table 3**.

Setting Goals and Objectives

Goals for reliability are typically developed as part of the Metropolitan Transportation Plan. They are often broadly worded, such as “Improve System Reliability.”

Objectives can be developed in more detail to support the region’s reliability goals as part of the CMP.

Agencies should examine the current reliability performance of their system before adopting goals and objectives through a public process.

Table 3. Drafting Reliability Objectives

Improve Reliability			
... On In For By ...
...Interstates...	...urban areas...	...Freight...	...improving incident management.
...arterials...	...rural areas...	...Transit...	...improving storm management.
...National Highway System...	...key subareas...	...Commuters...	...improving safety.
...key corridors...		...Visitors...	...improving work zone management.
...key routes or corridors...			...managing demand.
			...improving special event management.
			...improving traffic operations.

Source: *Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes: A Guide*, SHRP 2 L05 report, Table 3-1, Transportation Research Board, Washington, DC, 2013.

Selecting Reliability Performance Measures

Travel-time reliability can be measured in several ways. The task is to take the entire distribution of travel times over the course of a year and represent it by a few numerical indices that can be used to measure progress towards the CMP objectives for reliability. The recently adopted Chapter 36 (Volume 4) of the Highway Capacity Manual (HCM) [8] identifies several candidate performance measures. The ones most applicable to the CMP are defined in **Table 4**.

Figure 6 illustrates these measures using a sample of a travel-time distribution for an entire year (excluding weekends and holidays and non-peak hours).

The Planning Time Index (PTI)

The PTI is identified in the *Highway Capacity Manual* as one of the most intuitive and consistent measures for reliability. A PTI of 1.5, for example, means that a traveler should plan on 50 percent more time for their trip compared to light traffic conditions for a 95 percent probability of arriving on time.

Table 4. Reliability Performance Measures for the Congestion Management Process

Reliability Measure	Definition
85th Percentile Travel Time Index (TTI)	The ratio of the 85th-percentile highest vehicle-hours traveled (VHT) on the CMP system divided by the VHT that would have been expended if the same trips could have been completed at their free-flow speed. (unitless)
Planning Time Index	95th Percentile TTI. The ratio of the 95th-percentile highest vehicle-hours traveled (VHT) on the CMP system divided by the VHT that would have been expended if the same trips could have been completed at their free-flow speed. (unitless)
Reliability Rating	Percentage of trips experiencing TTI less than 1.33 for freeways or 2.50 for urban streets. (These thresholds are generally at the speed where level of service (LOS) deteriorates from LOS “E” uncongested to LOS “F” congested). (unitless)
Failure Measure	Similar to Reliability Rating, but using agency-set minimum acceptable threshold speeds for the facilities rather than those specified by the HCM and its definition of levels of service. (unitless)

Note: Percentile TTI is the ranking from lowest to highest of a collection of travel time indices measured over the course of a year. The 95th percentile highest TTI, is the value that 95 percent of the observations fall below.

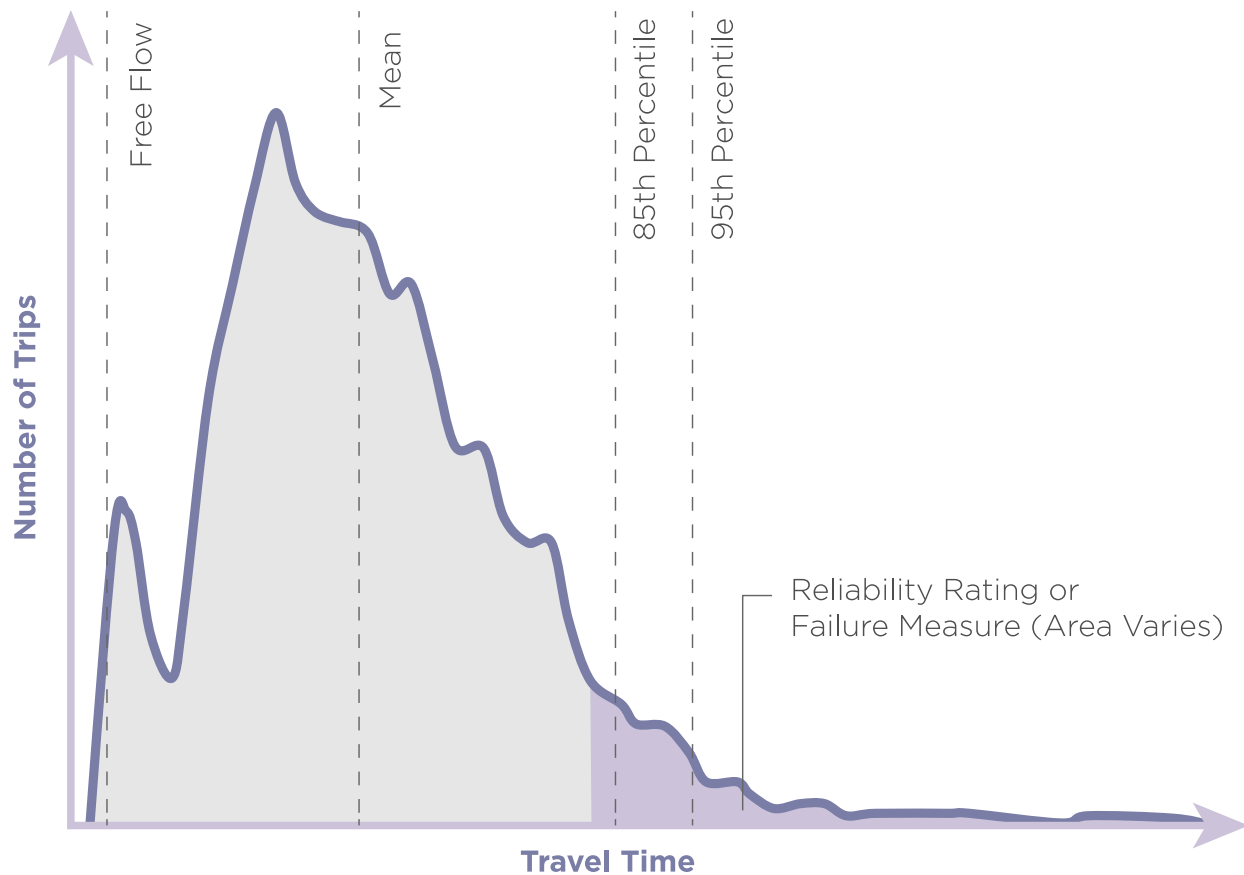


Figure 6. Graph. A Sample Travel-Time Distribution and Measures of Reliability

Source: Adapted from *Incorporating Reliability Performance Measures into the Transportation Planning and Programming Process: A Guide*, Figure 2-1, SHRP 2 Report L05, Transportation Research Board, Washington, DC, 2013

Local Resources for Objectives and Performance Measures

The agency might consider drawing on the following resources and stakeholders in developing its reliability objectives, identifying performance measures, and seeking data on reliability.

- Local and state public safety agencies (police, fire, and emergency responders)
 - Major employers and universities
 - Major venue operators
 - Freight and delivery companies
 - Local weather experts
 - Local and metropolitan tolling authorities
- General public
 - State departments of transportation
 - Local and metropolitan transit agencies
 - City and county public works departments
 - Local traffic signal operators and technicians

2.2 Diagnosing Causes of Reliability Problems

Once an agency has committed to establishing reliability goals, objectives, and performance measures, the next steps are to identify the existing reliability problems and to diagnose their causes. As described earlier, this analysis can provide important input to stakeholders for the development of goals, objectives, and performance measures.

Identifying Existing Reliability Problems

To identify existing reliability problems, the analyst must do the following:

- Choose the facilities and study periods for the reliability analysis;
- Collect data for reliability analyses;
- Estimate reliability from other data sources when direct measurements of reliability are not available; and
- Investigate and diagnose the causes of reliability problems.

Choosing Facilities and Study Periods for Reliability Analysis

Reliability analyses require more staff resources, more analysis resources, and more data sources than typical planning or operations analysis studies (although, much of this extra information can be handled with default inputs, as explained later). Consequently, it is wise to spend some time thinking through the exact focus of the reliability analysis.

There is little to be gained by expending analysis resources on lightly traveled times of day, days of year, and lightly traveled facilities. Also, including times of day and days of year for a facility when there are likely to be few reliability problems will tend to “wash out” the results, hiding peak-period reliability problems behind an excess of light off-peak traffic conditions.

Diagnosing Causes of Reliability Problems

SHRP 2 L02 - Establishing Monitoring Programs for Travel Time Reliability: A Guidebook [2] is a useful resource for understanding the different causes of congestion.

If lightly-traveled days are to be included then the analyst will want to consider whether the reliability results should be weighted according to the amount of travel each day.

There is currently no explicit requirement that reliability analysis be applied to all of the facilities and modes in the CMP. Consequently, it is wise for the analyst to expend his or her resources on evaluating those facilities, days of the week, and times of the day where reliability is likely to be a significant issue. Agencies that have invested significant resources into travel-time reliability, such as the Regional Transportation Commission of Southern Nevada, divide the year into seasons that reflect normal changes in travel demand for conducting historical analysis.

Reliability analysis is a three-dimensional analysis, expanding the typical single representative day analysis of a CMP to the entire year. The analyst must, therefore, specify the focus and limits of the reliability analysis both in terms of the typical CMP (peak-period, major facilities) and in terms of the days of the year covered by the analysis.

Figure 7 shows the typical dimensions of time, space, and days-of-the-year involved in a reliability analysis. The example shown here is for a single direction of a freeway (the horizontal axis of this figure). The horizontal axis represents distance along the freeway from upstream to downstream. The vertical axis shows the time dimension. In this example, it is the 3-hour weekday PM peak-period extending from 3 PM to 6 PM. These first two dimensions are covered by a typical, conventional CMP analysis. The “z-axis” (the diagonal direction in the chart indicating depth) represents the number of weekdays in the year (excluding holidays) for which the reliability analysis will be performed. The matrices (composed of green, yellow and red cells within each matrix) represent the snapshot of congestion on the freeway each day. These matrices show when and where congestion starts each day, how far up the freeway the queuing extends (the red areas in the matrices), and when the congestion dissipates.

Regarding the selection of facilities for inclusion in the reliability analysis, the significance of the reliability problem on a facility will vary according to the goals, objectives, and sensitivities of the region. Generally, if a facility does not regularly experience recurring peak-period congestion (whether on the weekdays or weekends and holidays), reliability is unlikely to be a significant problem from the perspective of most public agencies. However, exceptionally frequent crashes, incidents, special events, work zones, and weather-related blockages may cause reliability to be a significant problem from the point of view of the agency and local residents, regardless of the lack of recurring peak-period congestion.

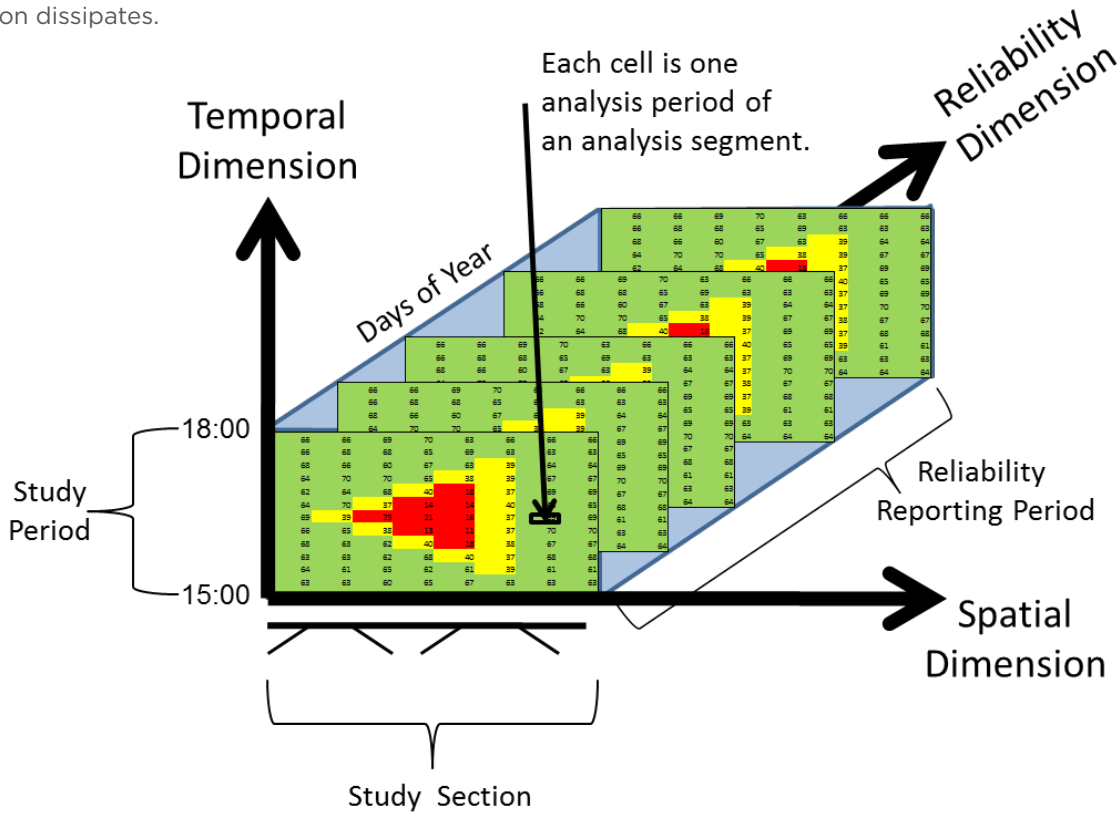


Figure 7. Graph. Dimensions of Reliability with Sample Data

Source: *Highway Capacity Manual*, Chapter 37 – Travel Time Reliability: Supplemental, Exhibit 37-21, Transportation Research Board, Washington, DC, 2012

How To Get Reliability Data

The National Performance Management Research Data Set (NPMRDS) is a travel-time data set for the National Highway System (NHS)—available to MPOs and state DOTs through FHWA—that can be used for reliability analyses. Agencies may also seek the data from commercial providers or from local traffic management centers (TMCs).

The National Performance Management Research Data Set (NPMRDS)

The NPMRDS contains five-minute average travel times for trucks (FHWA vehicle classes 7 and 8 only) and other motorized vehicles on the NHS (generally Interstate and the national aid highway system).³ The travel times are for traffic message channel segments, as defined by the private sector for providing driving instructions to the general public using Global Positioning Systems (GPS).⁴

Historical data is available starting from October 2011 for the Interstate and starting from July 2013 for all other roads on the NHS. The datasets are large and require some experience working with exceptionally large databases and Geographic Information Systems (GIS).

The NPMRDS is made available to state DOTs and MPOs to use for their performance management activities through a license acquired by FHWA. Updates to the data set are made available monthly (for the prior month). To request permission to access the data set, send an e-mail to Heretraffic.nhsdata@here.com. For more information go to: http://www.ops.fhwa.dot.gov/perf_measurement/index.htm

³Note that MAP-21 added principal arterials to the NHS.

⁴A traffic message channel segment ends when the guidance device must tell the driver to turn at the intersection or ramp gore point, when speeds change, or at state boundaries.

Monitoring and Identification of Causes of Congestion

California DOT (Caltrans) has invested heavily in measuring travel-time reliability and developing programs that improve operations, particularly in the San Diego region (District 11). The statewide Performance Measurement System (PeMS) is a web-based software system that collects data from over 30,000 detectors on the highway system every 30 seconds and automatically processes and stores the data. Data from other sources, such as the California Highway Patrol's Computer Aided Dispatch system, are fed into PeMS in real-time or as archived information. District 11 has taken this system further by incorporating an Arterial Performance Measurement System (A-PeMS) and a Transit Performance Measurement System (T-PeMS). More details can be found at <http://pems.dot.ca.gov/>.

Other Reliability Data Sources

There are also several other public and private sector sources of travel-time reliability data. The local TMC may be a good source of archived travel-time data for freeways in the urban area. Ideally, the travel-time data is obtained from timing the movement of vehicles along the facility. This is usually done by tracking GPS-equipped cell phones, Bluetooth devices, or toll-tags in the vehicles. Travel times may also be inferred from loop detector or video detector spot speeds. However, these estimates of travel times from spot-speed measurements will not be as good as direct point-to-point measurements of travel time.

Gathering Reliability Data

Generally, a minimum of one-year of travel-time data is needed to measure reliability. Other data, such as incident logs, weather conditions, road work logs, and 24/7 traffic counts for the same period are needed for determining what proportion of the reliability problems are related to incidents, weather, construction, and demand.

Estimating Reliability When Data Are Not Available

Various recently developed methods are available for estimating reliability when direct measurements of travel-time are not available (or where it is desired to predict future reliability under different future scenarios). These methods range from relatively quick planning methods requiring little data to more-elaborate operations analysis methods that enable the agency to test the reliability impacts of different advanced traffic operations improvements. These methods are briefly described below with references to where readers can go to get more information and to acquire the computational tools needed to employ them.

The SHRP 2 L07 (Design Guide) Reliability Models

The SHRP 2 L07 project, *Identification and Evaluation of Cost-Effectiveness of Highway Design Features to Reduce Nonrecurrent Congestion* [9], developed a spreadsheet tool to predict travel-time reliability distributions. The L07 reliability estimation model employs four variables to estimate the cumulative percentile travel-time indices for demand/capacity ratios less than or equal to 80 percent.

The L07 model requires the following inputs:

- The average annual demand/capacity ratio.
- Annual lane-hours lost due to incidents and work zones (a procedure is provided in the spreadsheet for estimating this input as a function of the hours of rainfall per year, and the hours of snowfall per year).

For more information on SHRP 2 L07 and the spreadsheet tools, go to the SHRP 2 research website at: <http://www.trb.org/StrategicHighwayResearchProgram2SHRP2/reliabilityinplanning.aspx>

The SHRP 2 L08 (*Highway Capacity Manual*) Reliability Models

The SHRP 2 L08 project [10] developed a method for estimating travel-time reliability that employs the *Highway Capacity Manual* (HCM). As such, the SHRP 2 L08 methodology, as documented in draft chapters 36 and 37 of the HCM, is a macroscopic, operations analysis-level approach to estimating reliability. Two methodologies were developed, one for freeway facilities, the other for arterial streets. Both methodologies involve the generation of different demand, weather, and incident scenarios, and then the application of the core HCM analysis methodology specific to each facility (freeway or urban street) to each scenario, as shown in **Figure 8**.

Both methodologies require HCM operations analysis-level geometric, control, and demand inputs for the study facility. Like in the original HCM methods, defaults can be used for many of the required HCM analysis inputs.

Data on demand variability is required, and both methodologies provide default demand variability factors. However, given the variation in demand variability between facilities in the same metropolitan area, it is recommended that local site-specific data on demand variability be used whenever feasible. The freeway methodology includes two sets of default demand variability factors, one for urban freeways, the other for rural freeways.

Data on weather events of the year are required. However, airport weather data for most major urban areas of the U.S. are included in both of the SHRP 2 L08 spreadsheets. The freeway methodology provides default weather event probabilities for 101 metropolitan areas of the United States. Facility-specific incident data are best, but can be estimated from crash data for the facility.

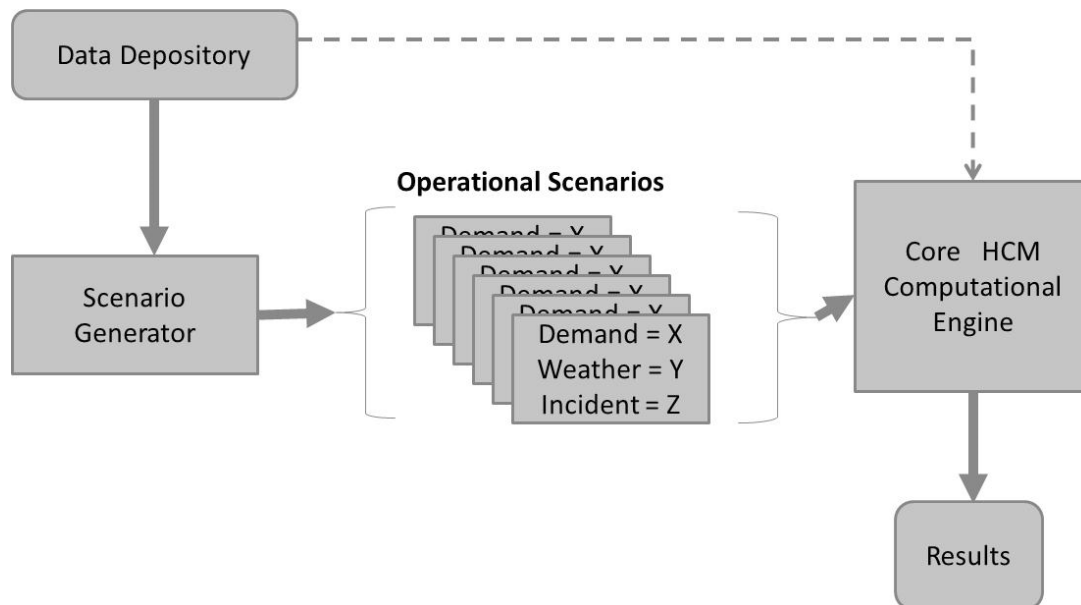


Figure 8. Chart. Overview of the Reliability Estimation Methodology from the Second Strategic Highway Research Program

Source: *Incorporation of Travel Time Reliability into the HCM*, draft final report for SHRP 2 Report L08, Exhibit 36-1, Transportation Research Board, Washington, DC, 2012

At a minimum, data on crash rates for the facility are required by both methodologies. Both methodologies provide lookup tables of factors for expanding crashes to lane-closure incidents by severity and duration.

For more information on SHRP 2 L08 and the spreadsheet tools, go to the SHRP 2 research website at: <http://www.trb.org/StrategicHighwayResearchProgram2SHRP2/reliabilityinplanning.aspx>

Diagnosing the Causes of Unreliability

If data for calculating reliability are available from NPMRDS or other travel-time archives of this type, then the procedures provided in SHRP 2 Project L02 [2] can be used for diagnosing the causes of reliability problems. The travel times measured in the field are grouped by segment and five-minute time period. The time periods are then designated “congested” or “uncongested” based on the observed travel times.

For each congested five-minute time period, the analyst scans logbooks of weather, work zones, crashes, and other incidents to assign a “cause” for the congestion. The last cause considered is “demand.” That cause is assigned to the five-minute time period only if no other cause has already been assigned to the congested time period and if the demand is two or more standard deviations above the mean. The analyst then sums up the vehicle-hours traveled (VHT) or vehicle-hours of delay (VHD) for each five-minute time period and segment and tallies the results by cause. Additional details are provided in the SHRP 2 L02 Guidebook [10], available at:

<http://www.trb.org/StrategicHighwayResearchProgram2SHRP2/DataandAnalysisfor.aspx>

If reliability is estimated (because data is not available), the tools used to estimate reliability will provide information for assessing the causes of unreliability. The specifics vary with the tool selected. Some tools generate results automatically while others require the user to examine the calculations and separately compute the additional desired information.

2.3 Generation of Strategies for Addressing Reliability

Strategies should directly correlate to the identified needs regarding reliability, but they should also link back to earlier actions in the CMP such as the objectives and overall goals the region is trying to achieve with respect to reliability. The performance measures identified should be used as the means to determine how well strategies perform in addressing the region's goals and objectives. As congestion can come in two forms—both recurring and non-recurring—identification of needs and relevant strategies should be developed under both conditions. Typical strategies for addressing reliability are shown in **Table 5**.

Reliability improvement strategies should be developed in coordination and collaboration with other government partners to maximize opportunities for consideration. It is valuable to include people with day-to-day operations planning knowledge, and others responsible for implementing operations strategies in a region.

Resources

For help with identifying strategies and treatments to address specific reliability problems, the following are useful resources:

- SHRP 2 L05 - *Incorporating Reliability Performance Measures into the Transportation Planning and Programming Process: A Guide* [7]
- SHRP 2 L11 - *Evaluating Alternative Operations Strategies to Improve Travel Time Reliability: Final Report* [11]



Objectives to improve travel-time reliability may include strategies such as dynamic messaging signs. Photograph courtesy of Kittelson & Associates, Inc.

Table 5. Example Strategies for Improving Reliability

Reliability Strategy Areas	Reliability Strategies
Demand Management Measures	<ul style="list-style-type: none"> • Programs that encourage transit use, ridesharing, telecommuting, and flexible work schedules • Guaranteed ride home • Car sharing and bike sharing • Pedestrian and bikeway improvements • Roadway congestion pricing • Parking management and pricing • Freight rail and port improvements to reduce truck travel on highways • Growth management (mixed use, higher intensity developments)
Operational Improvements	<ul style="list-style-type: none"> • Metering, reversible lanes, access management, temporary shoulder use • Signal optimization, geometric improvements, transit signal priority, traffic calming • Traffic incident management (more patrol cars, protocol for directing traffic, pullout areas) • Work zone rules (lane closures occur during periods of least demand, minimize the number of lane closures, provide walking and biking access where feasible) • Special event traffic plans • Snow or debris removal plans (response times, ensure clearance of roadways, bikeways and sidewalks, appropriately-sized equipment) • Traveler information • Freight management, including delivery window restrictions • Detection • Cameras • Changeable message signs • Active traffic management
Public Transportation Improvements	<ul style="list-style-type: none"> • More frequent service to address crowding • Service expansion in congested areas • Operational improvements (transit signal priority, bus bulb-outs, queue jump lanes) • Bus stop consolidation • Operational control strategies (i.e., changes to normal route operation in response to delay-causing events) • Fleet maintenance strategies (e.g., preventative maintenance, vehicle replacement)
Road Capacity Improvements	<ul style="list-style-type: none"> • New HOV/HOT lanes • New mixed flow lanes • Intersection widening • Interchange reconfiguration • Truck climbing lanes • Freeway widening at bottlenecks

Source: Adapted from *Congestion Management Process: A Guidebook*, Federal Highway Administration, FHWA-HEP-11-011.

Figure 9 illustrates the desired linkages between goals, objectives, and strategies for one example objective and a few example strategies. This figure shows how the single goal of improving system reliability can be tied to the objective of reducing non-recurring delay (one of several possible objectives that could be tied to the goal of improving system reliability). This single objective is then broken down into two more specific objectives: reducing scheduled delay (such as delay due to work zones and special events) and unscheduled delay (such as delay due to traffic incidents and emergency maintenance). Scheduled delay is then reduced by considering strategies such as improving work-zone management, and improving special-event management. Unscheduled delay is addressed with strategies that improve incident management, weather travel management, and emergency management. **Figure 9** also demonstrates, as an example, specific strategies that could be implemented to improve traffic incident management. Such strategies demonstrated here include reducing time for posting traveler alerts, increasing coverage by incident response teams, and increasing the number of traffic signals with emergency pre-emption. Agencies can employ a similar process to identify appropriate strategies for improving travel weather management and improving emergency management.

Unscheduled delay is addressed with strategies that improve incident management, weather travel management, and emergency management. **Figure 9** also demonstrates, as an example, specific strategies that could be implemented to improve traffic incident management. Such strategies demonstrated here include reducing time for posting traveler alerts, increasing coverage by incident response teams, and increasing the number of traffic signals with emergency pre-emption. Agencies can employ a similar process to identify appropriate strategies for improving travel weather management and improving emergency management.

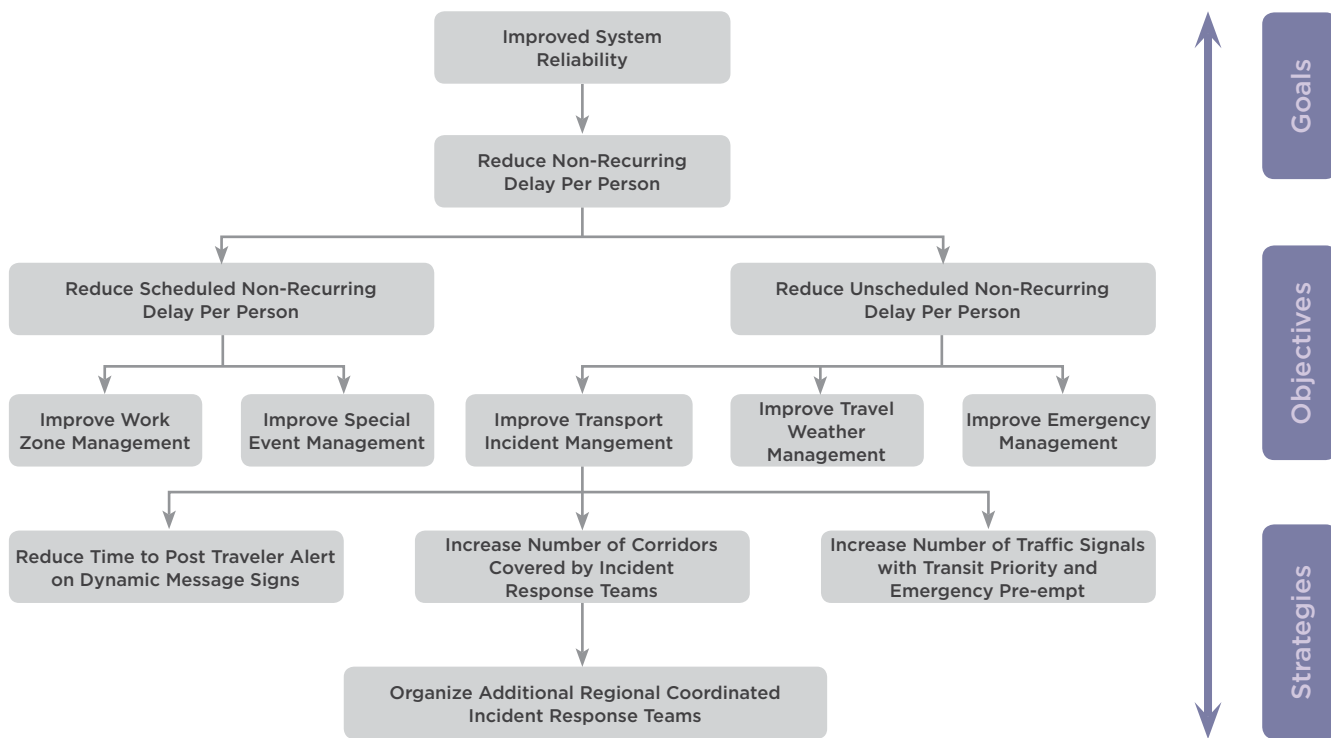


Figure 9. Chart. Goals, Objectives, and Strategies—An Example

Source: Adapted from *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, Figure 2, Federal Highway Administration, FHWA-HOP-10-027.

2.4 Evaluation of Strategies

An evaluation is conducted to estimate the expected benefits of the strategies in comparison to their expected capital and operating cost requirements. The analysis may be quantitative or qualitative depending on the nature of the strategies and the resources available to the agency. Similar to the strategies, the evaluation criteria used in the analysis should directly link to the MTP goals and CMP objectives, CMP network, and multimodal performance measures. Strategies that move forward into funded plans should indicate strong performance through an objectives-driven, performance-based approach. In addition to travel-time reliability performance, the evaluation will involve identifying the range of capital, staffing, technology, training, and maintenance requirements of operations deployments. **Table 6** presents the general range of benefits and cost-benefit ratios that can be expected for typical operations strategies.

As different sources of congestion typically affect a metropolitan region, the analysis should review major recurring and non-recurring congestion problems (demand fluctuations, bottlenecks, peaking, incidents, weather, safety, construction, special events, etc.) and match problems to functional (work, recreation, freight), regional (urban and rural), corridor (thoroughfare, interstate), and network (freeways, arterials, transit) intensity and significance. Methods for forecasting the reliability effects of different improvement strategies—including SHRP 2 tools L07 and L08—are described in **Section 2.2**, “How to Get Reliability Data,” in the subsection on “Estimating Reliability When Data Are Not Available.”

Table 6. Systems Operations Benefits

Strategy	Benefits and Benefit-Cost Ratios	Safety Impact	Mobility Impact	Energy/Environmental Impact
Traffic incident management	Incident duration reduced 30-50 percent	High	High	High
• Safety service patrols	2:1 to 42:1	High	High	High
• Surveillance and detection	8:1	High	High	High
Road weather information systems	2:1 to 10:1; crash rates reduced 7 to 80 percent	High	High	High
Traveler information dynamic message signs	3 percent decrease in crashes; 5 to 15 percent improvement in on-time performance	Low	High	Low
Work zone management	2:1 to 40:1; system delays reduced up to 50 percent	High	Medium	Medium
Active traffic management	Throughput increased by 3 to 7 percent; decrease of incidents of 3 to 30 percent	High	High	Medium

Source: Adapted from: U.S. Department of Transportation, Intelligent Transportation Systems Joint Program Office, 2009. For more information and for additional strategies see <http://www.plan4operations.dot.gov/topsbctool/index.htm>.

2.5 Monitoring Reliability Outcomes

Once an agency has incorporated reliability into the CMP, the next (and last) step is to monitor the outcomes of the improvements and strategies put into place by the CMP. **Section 2.2** describes data sources and estimation methods for monitoring reliability. See FHWA's *Use of Archived Operations Data in Transportation Planning* [12] for examples of current practice employing archived traffic operations data in planning analyses.

The monitoring cycle (the number of months or years between reviews of the system reliability) is determined by the agency. This cycle might coincide with the CMP update cycle. The frequency of monitoring depends on agency staff resources. The NPMRDS enables the agency to choose monitoring cycles as frequently as once a month.

Because the CMP is an iterative process, it is dynamic and expected to be responsive to actual system performance. Strategies and actions that performed as expected, with positive benefit, may be retained in subsequent CMPs, while those that underperformed would be considered for elimination. Care must be given to fully understand how much of the performance outcome is attributable to the CMP strategy, and how much is attributed to changes in background conditions.



Photograph courtesy of Kittelson & Associates, Inc.

Chapter 3 Getting Started

This chapter provides a checklist for agencies to use to get started on incorporating reliability into their Congestion Management Process (CMP).

3.1 Update Goals, Objectives and Performance Measures

1. Assess current goals, objectives, and performance measures.
 - a. Ensure alignment with The Moving Ahead for Progress in the 21st Century Act (MAP-21) performance rule for reliability.⁵
2. Work with stakeholders to develop reliability goals, objectives, and performance measures (see **Section 2.1**).
 - a. Develop business case(s) for including reliability in the CMP as well as the metropolitan transportation plan (MTP).
 - b. Conduct a pilot analysis of a prominent facility to test various reliability metrics and determine which metrics are most applicable and to educate stakeholders on how reliability can be applied.

Integrating Reliability into the Metropolitan Transportation Plan

SHRP 2 L05 - *Incorporating Reliability Performance Measures into the Transportation Planning and Programming Process: A Guide* [7] is a useful resource for integrating reliability into both the MTP and CMP.

- c. Review proposed changes with stakeholders.
3. Refine goals, objectives and performance measures to incorporate reliability based on stakeholder feedback.

⁵ Rule-making at the national level had not been released as of the date of this publication.

3.2 Assess Data Needs and Availability

1. Review current data collection program against recommendations in **Section 2.2**. If satisfactory, skip remaining sub steps and proceed to **Step 3.3**.
2. Check with local and national data sources to obtain one year of travel-time data along with corresponding incident logs, traffic counts, and other event conditions such as weather and construction.
 - a. The National Performance Management Research Data Set (NPMRDS) contains 5-minute travel-time data for freeways going back to October 2011 and for NHS roadways going back to July 2013.
 - b. Transportation management centers (TMC) may have archived data for select facilities from system detectors, toll tag readers, Bluetooth readers, or other probe measurements.
 - c. Private vendors: check to see if your state department of transportation (DOT) has purchased 3rd party travel-time data.
3. If data are not available, refer to the second Strategic Highway Research Program (SHRP 2) resources for estimating reliability using predictive tools.
 - a. Highly congested facilities;
 - b. Major freight routes;
 - c. Corridors of major significance (bridges, tunnels, etc.);
 - d. Routes that serve high volumes of seasonal recreational traffic;
 - e. Routes subject to inclement weather (snow, ice, and visibility);
 - f. Routes that receive complaints by system users; and
 - g. Routes in metropolitan areas designated under the Real-Time System Management Information Program (see <http://www.ops.fhwa.dot.gov/1201/>)
3. Select time of day (morning or evening peak-period) and days of year for reliability analysis.
4. Calculate reliability performance measures identified in **3.1.3** for facilities selected in **3.3.2**.
5. Diagnose causes of unreliability following recommendations in **Section 2.2**:
 - a. Demand fluctuation;
 - b. Incidents;
 - c. Weather;
 - d. Special Event; and
 - e. Construction.

3.3 Diagnose Causes of Unreliability for Select Facilities

1. Review current methods for identifying and diagnosing the causes of reliability problems against recommendations in **Section 2.2**. If satisfactory, skip remaining sub steps and proceed to **Step 3.4**.
2. Select facilities for analysis that are prone to reliability impacts, including:

3.4 Evaluate and Prioritize Reliability Strategies

1. Compare current method for identifying, evaluating, and prioritizing reliability improvement strategies against guidance in **Sections 2.3** and **2.4**. If satisfactory, skip remaining sub steps and proceed to **Step 5**.
2. Identify strategies to address causes of unreliability (see **Tables 4** and **5**).
3. Assess benefits, costs, and level of impact (see **Table 6**).
4. Set targets consistent with MAP-21.

3.5 Prepare CMP Update

1. Option 1: Annual Update
 - a. An annual update is not required, but may be desirable because it provides an opportunity to the metropolitan planning organization (MPO) to assess progress on achieving its targets. The performance of various strategies and actions that have been implemented is assessed for effectiveness. The CMP may be modified to focus on the most-effective strategies.
 - b. Assess if the CMP is integrated into the MTP.
2. Option 2: Major Update
 - a. A major update should be considered after adoption of the MTP (every 4 or 5 years depending on air quality attainment status).
 - Did the MTP goals and objectives change regarding the priority of congestion mitigation and recognition of non-recurring congestion?
 - Did baseline conditions change?
 - Are new analytic techniques available?

Below **Table 7** summarizes the Getting Started Checklist.

Table 7. Getting Started Checklist

Steps and Actions	No Action to Date	Beginning to Make Progress	Partially Achieved	Mostly Achieved	Fully Achieved
Update Goals, Objectives and Performance Measures					
Have the existing goals, objectives, and performance measures been reviewed?					
Have measures been evaluated for compliance with MAP-21 Performance Measures for Reliability?					
Has stakeholder input and support been gathered/achieved?					
Assess Data Needs and Availability					
Has the current data collection program been reviewed against reliability data requirements?					
Have supplemental local and national data sources been investigated?					
Have SHRP 2 tools been identified to perform predictions?					
Diagnose Causes of Unreliability for Select Facilities					
Have current methods for diagnosing reliability problems been investigated?					
Have facilities been identified that may be prone to reliability problems?					
Have the temporal conditions for reliability analysis been defined?					
Have reliability performance measures been calculated?					
Have the causes of unreliability by facility been diagnosed?					
Evaluate and Prioritize Reliability Strategies					
Have current prioritization methods been reviewed for applicability to reliability-based evaluations?					
Have strategies been identified to address causes of unreliability?					
Have benefits, costs and level of impacts been assessed?					
Have performance targets been set consistent with MAP-21?					
Prepare CMP Update					
Has the type of CMP Update been identified (annual or major update)?					
Have the necessary steps been taken to perform the update?					





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Chapter 4 Model Congestion Management Plan

This chapter provides a model congestion management plan (CMP) that demonstrates how reliability can be incorporated at appropriate steps. Addressing reliability and non-recurring congestion enhances and expands upon the current state of the practice for most CMPs. The model CMP is not intended to be a complete document; it is an assembly of excerpts intended to provide insight for metropolitan planning organization (MPO) developers of CMPs.

4.1 One Size Does Not Fit All

Each MPO operates in a unique circumstance, so this model CMP should be used as guidance and be considered in relation to your region's population, funding, governance, transportation system priorities, data availability, and staff capacity. Even if your MPO does not assign a high priority to congestion mitigation, or has a modest level of recurring congestion, the public and their elected officials may be supportive of improving the reliability of travel time by addressing non-recurring congestion.

4.2 Model Plan Excerpts

The following section shows examples of the different CMP components and how reliability can be integrated.

This section covers:

- Goals and Objectives
- Performance Measures
- Monitoring Plan
- Problem Identification
- Identification of Strategies
- Implementing Strategies and Monitoring Strategy Effectiveness

Goals and Objectives

MPOs enumerate their goals and objectives in the metropolitan transportation plan (MTP), including decisions on how to treat congestion mitigation and non-recurring congestion. The CMP should incorporate these goals and objectives, rather than create a new set of priorities.

The following excerpt from the Binghamton (NY) Metropolitan Transportation Study's 2035 Plan [13] is an example that gives priority to operational solutions:

Mobility Goal

To create a regional transportation system that provides travel choices so personal travel and goods movement can maximize efficiency.

Mobility Objectives

- 1** Invest in strategies to provide travel choices and alternatives to single-occupant vehicle personal travel
 - (1.1) Improve the availability and level of service of public transit

- 2** Invest in strategies that improve the efficiency of vehicle travel
 - (2.1) Complete the deployment of the ITS Regional Architecture
 - Robust traffic and transit management center
 - Pervasive traveler information systems
 - Best available traffic signal system technology
 - Incident management on all principal arterial highways
 - (2.2) Participate in statewide and bi-state efforts that support ITS Advanced Commercial Vehicle Operations
 - (2.3) Address congested areas with appropriate measures, including
 - Improving traffic signal timing
 - Transportation systems management strategies

Source: Binghamton Metropolitan Transportation Study's 2035 Plan, page 15

ITS: Intelligent Transportation Systems

Establishing goals and objectives is the first substantive step in the CMP and a key entry point for consideration of reliability.

The North Central Texas Council of Governments in Dallas-Fort Worth demonstrates how a goal from the MTP related to system operations can lead to objectives for improving operations and reliability can be translated into the CMP:

CMP Goal and Actions

Goal: Identify quick-to-implement low cost strategies and solutions to better operate the transportation system

Action: Implement quick-to-implement low cost strategies and solutions to better operate the transportation system

Objectives

Reduce SOV trips through travel demand strategies

Provide all users with travel alerts and alternative routes in the case of incidents, special events, weather, construction, and severe congestion at choke points.

Increase the number of intersections that are equipped and operating with traffic signals that enable real-time monitoring and management of traffic flow.

Reduce mean roadway clearance time per incident (defined as the time between awareness of an incident and restoration) of lanes to full operational status

Source: North Central Texas Council of Governments in Dallas-Fort Worth CMP (2013), Exhibit III-6

SOV: Single occupant vehicle

Performance Measures

The Moving Ahead for Progress in the 21st Century Act (MAP-21) establishes a paradigm of performance-based planning and programming (PBPP) for MPOs, transit operators, and state departments of transportation (DOTs). They will be required to be accountable for their investment decisions by measuring the results of project and programmatic actions. Performance measures must be credible and easily understood by the public and MPO decision-makers. “Did the money we spent on the Enhanced Incident Management Program improve travel-time reliability as much as we forecasted?” At right is an example from the Delaware Valley Regional Planning Commission in Philadelphia, emphasis added, where speed drop duration was analyzed over time to identify periods of non-recurring congestion.

The Madison (WI) Transportation Planning Board’s CMP [15] proposes a larger set of performance measures related to reliability. The existing measures highlight causes of non-recurring congestion, and therefore are only secondary indicators of reliability. The preferred measures, to be developed, are a more direct metric. Because the CMP is a continuous process, it is acceptable to define measures that can be developed to improve understanding of outcomes. In this case, the MPO shows the resource requirements in terms of capital funding and human effort for the proposed measures, summarized below in **Table 8**.

Objectives are supported by performance measures that are used to track and demonstrate outcomes of projects and actions that are designed to improve reliability.

Reliability

Archived operations data available through the I-95 Corridor Coalition Vehicle Probe Project was used to develop a criterion that measured reliability. **The specific measure analyzed was duration of congestion on all freeways and select arterials in the region.** The criterion identified road segments during the 5:00 to 6:00 PM peak hour, when travel speeds dropped below 70 percent of the posted speed limit, as well as the duration of the speed drop. This analysis produced a more robust measure of reliability than what was possible in past iterations of the CMP.

Source: Delaware Valley Regional Planning Commission

Table 8. Example of Resource Requirements for Performance Measures from Madison, Wisconsin

Principal Arterial Freeways -Type III (Non-Recurring Congestion)						
Measure	Resources Required	Extent/ Coverage	Update Frequency	Credibility	Public Understanding	Decision making
Existing						
Crash reports	Currently used	High	Ongoing	High	High	Low
Service patrol reports	Currently used	Low	Low	Modest	High	Low
Preferred						
Travel time index (TTI)	Capital: Programmed Human: Medium	Complete freeway coverage	3 years	High	High	Medium
Incident index	Human: High		Annually	High	High	High
Congestion duration	Capital: Programmed Human: Medium		Tri-annually	High	High	Medium

Note: Congestion duration is an important companion measure to TTI, indicating to travelers and decision makers the extent of the peak-period during which a poor TTI may be encountered.

Source: Madison Transportation Planning Board’s CMP (2011), Table 11

Monitoring Plan

Performance measurement is a continuous process. This is especially true for assessing impacts on reliability, where the basis is measuring variability over time. The CMP may include a monitoring plan that enumerates for each performance measure the agency that is responsible for data collection, analysis, and archiving; how often the measure will be updated; and how it will be reported.

A performance based, outcome-oriented CMP must include a plan to monitor the transportation system and report on improvements to travel-time reliability.

Table 9 below demonstrates the Performance Monitoring Plan from Madison Wisconsin.

Table 9. Example of a Performance Monitoring Plan from Madison, Wisconsin

Performance Monitoring Plan					
Performance Measure	Data Type	Collector	Analyst	Archive Owner	Update Cycle
Freeway LOS	Freeway volume	WisDOT	MPO	MPO & WisDOT	Annually
Freeway Travel Time Index	Corridor or segment travel time	Floating car: MPO Automated: WisDOT	MPO	MPO & WisDOT	Floating car: 3 year cycle Automated: quarterly
	Hourly traffic volume	WisDOT, City of Madison	City, MPO, WisDOT	City, MPO, WisDOT	Tri-annually on selected corridors
Freeway non-recurring delay	Crash records	Dane County Sheriff, TOPS lab	WisDOT	MPO, WisDOT	Annually
	Service patrol records	Dane County Sheriff, STOC	WisDOT	MPO, WisDOT	
Freeway Incident Index	Incident location, duration, lane closure	WisDOT, Dane County Sheriff	MPO	MPO, WisDOT	Annually

Source: Madison Transportation Planning Board's CMP (2011), Table 2

Problem Identification

This example shows how reliability is incorporated into the problem identification stage of the process. This example is from the Durham-Chapel Hill-Carrboro MPO, emphasis added.

This step of the CMP provides the MPO an opportunity to identify reliability problems related to non-recurring congestion, based on their adopted performance measures.

Problem Identification

To identify the causes of the problem for the reported corridors or intersections, the results of the following analyses will be carefully reviewed:

- Existing facility analysis (lane configuration, signal-timing plan, bus loading bay, bicycle/pedestrian facilities, surrounding land uses, and driveway density),
- Capacity analysis (V/C ratio during a peak-hour and daily),
- Intersection LOS analysis (control delay during a peak-hour),
- **Corridor analysis (intensity of travel time index during a peak-hour and daily),**
- **Temporal and spatial extension of congestion (V/C ratio or travel time index during daily), and**
- Collision analysis (crash types and incident severity during last 5 years)

This comprehensive analysis results will help to find the problem causes and lead to the development of an improvement strategy.

Source: Durham-Chapel Hill-Carrboro Metropolitan Planning Organization

V/C: Volume to Capacity
LOS: Level of Service

Identification of Strategies

The following excerpt from page 48 of the Genesee Transportation Council (Rochester NY) CMP [16] is a list of strategies for improving freeway operations, which should lead to improved reliability.

In this step, the MPO specifies the project, actions, and strategies it intends to undertake to improve reliability.

2. Urban Freeways - Operations

2.A. Incident Management

Definition: Incident management involves the coordination of three stages: detection/verification; response/clearance; recovery/information. The aim of incident management should be to quickly and efficiently clear incident scenes without endangering first responders or the traveling public. This returns the roadway to normal operations sooner and reduces the likelihood of secondary incidents. Many incidents are vehicle disablements that can be quickly cleared.

Congestion Mitigation Impacts: Reduced incident-related delay; fewer secondary incidents.

2.B. Highway Information Systems

Definition: Communicate dynamic information regarding existing traffic conditions to travelers en-route on the transportation system. These capabilities include technologies such as Dynamic/Variable Message Signs (DMS/VMS), Highway Advisory Radio (HAR), and in-vehicle/handheld systems such as Geographic Positioning Systems (GPS) and personal travel assistants.

Congestion Mitigation Impacts: Reduced speeds of vehicles nearing queues (fewer secondary crashes); diversion to alternate routes/modes.

2.C. Ramp Metering

Definition: Ramp meters are modified traffic signals placed at the end of highway entrance ramps. This controls the flow of vehicles onto highways by breaking up platoons of vehicles attempting to enter the highway, thus streamlining the merge process. Delays may be incurred for ramp traffic, but mainline capacities are protected and overall operational efficiency is improved.

Congestion Mitigation Impacts: Increased freeway capacity; reduced short freeway trips; increased volume/capacity ratio on highways; decreased crash rate.

2.D. Highway Pricing Strategies

Definition: Levy fees for driving during peak travel times or under congested conditions. Place a surcharge on parking in congested areas. Use electronic toll collection systems to ease congestion at toll booths.

Congestion Mitigation Impacts: Diversion to alternate routes; mode switches; destination changes; increased trip chaining.

2.E. Road Work Zone Management

Definition: Manage road work zones to mitigate their impact on traffic. Limit work activities to off-peak travel hours; phase work activities on a daily, weekly, or seasonal basis to minimize traffic impacts; conduct a public awareness program in advance of road work; identify and promote alternate routes; promote ridesharing or transit use.

Congestion Mitigation Impacts: Improved throughput around road work zones; minimized vehicle delays and speed reductions; reduced crash rate.

Source: Genesee Transportation Council CMP (2013), Page 48

Implementation Strategies and Monitoring Strategy Effectiveness

The following shows how reliability strategies can be implemented and monitored to assess effectiveness. This example is from the Durham-Chapel Hill-Carrboro MPO (emphasis added).

The ultimate purpose of the CMP is to create a rational approach to mitigating congestion. The policy board can weigh the highest priority CMP projects and strategies against other needs when the MPO develops its transportation improvement program (TIP).

Chapter 8 - Implementing Strategies and Monitoring Strategy Effectiveness

The previously identified improvement strategies should be incorporated into the regional transportation plan and the TIP. The implementation processes of the defined strategies will be closely monitored if the improvements are adopted in the TIP or other program with the financial commitment. The implementation of the improvement strategies will be led by the operating agencies, and the progress should be reported to the MPO every month.

The implemented strategies will be monitored to assess their effectiveness. Monitoring techniques and schedules will be dependent on the type of improvement that is implemented, and the data availability. It may take years to assess the benefits of safety-type improvements that are intended to reduce crash rates, crash severity, or incidents. Conversely, the benefits of capacity improvements are relatively easy to measure and assess. **Travel time reliability improvements will be monitored via the existing data collection methods within the region.**

The benefits of the implemented strategies will be documented in the biannual report. For the improvements that may not be accurately measured in a two year time frame, results will be presented with a description of the limitations of monitoring. Capacity projects and other improvements that are implemented through non CMP methods will still be monitored to determine their benefits. Based upon the monitoring results, the learned facts will provide feedback for the CMP to verify and update the used performance measures, the applied data analysis techniques, and the considered strategies. If necessary, the CMP objectives and the CMP itself will be adjusted.

Source: Durham-Chapel Hill-Carrboro MPO "Congestion Management Process: Procedures and Responsibilities Report", June 2011, p.31





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Chapter 5 Summary

Congestion management is the application of strategies to improve transportation system performance and reliability by reducing the adverse impacts of congestion on the movement of people and goods. System reliability is an important objective of congestion management that utilizes transportation systems management and operations (TSM&O) strategies. The application of TSM&O strategies has taken on greater significance over the years due to constraints on the nation's transportation system expansion. Many regions are experiencing more delay due to unplanned disruptions than delay due to peak demand, much to the dismay of the traveling public and freight shippers.

Until recently, metropolitan planning organizations (MPOs) and states that wanted to address travel-time reliability had few options for doing so. Data collection was expensive and analysis tools were primitive or unavailable. However, advances in probe data and system detection technologies and new analysis tools developed under the second Strategic Highway Research Program (SHRP 2) have significantly reduced data collection and analysis costs for reliability analyses.

The Congestion Management Process (CMP) is one of the most-effective ways to improve transportation system reliability. Congestion management programs are updated frequently and they focus on monitoring

conditions and developing strategies for alleviating congestion. A robust plan that addresses congestion in all of its forms, whether recurring or non-recurring, results in better system-wide reliability on the transportation network.

As of this writing, current Federal transportation law, Moving Ahead for Progress in the 21st Century Act (MAP-21), identifies a system-reliability goal for improving the efficiency of the national surface transportation system. CMPs that incorporate reliability provide a pathway to developing the performance-based planning and programming elements that help address legislative needs.

Materials developed by the Federal Highway Administration (FHWA), such as this primer and a series of training workshops, will help states and MPOs create more robust CMPs that result in improvements for travelers and freight shippers. Incorporating reliability goals, objectives, and performance measures into CMPs would respond to the concerns of local constituents, result in cost-effective strategies for alleviating congestion, and would assist the nation in meeting its goal of cost-effectively securing a more-reliable transportation system.





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Appendix: Congestion Management Process Refresher

Readers unfamiliar with the Congestion Management Process (CMP) should consult the Federal Highway Administration (FHWA) report, *Congestion Management Process: A Guidebook* [17]. This appendix provides a very brief overview of the CMP and FHWA's Planning for Operations program so that readers may see how the guidance in this primer fits within the overall CMP.

The CMP is a systematic approach to provide a credible basis for metropolitan planning organizations (MPOs) to invest in congestion mitigation across modes. The CMP is collaboratively developed with and implemented by member agencies. CMPs may identify demand reduction or operational management strategies to meet Regional Transportation Plan objectives. The CMP Actions are illustrated in **Figure 10**. The CMP Guidebook can be found online at http://www.fhwa.dot.gov/planning/congestion_management_process/cmp_guidebook/.

Planning for Operations is also a systematic process to help planning agencies, such as MPOs, engage in mutually beneficial activities with operations staff from other agencies or departments. Engaging operations staff drawn from a wide variety of sources, such as departments of transportation (DOTs) and transit operators, assists the CMP by providing an expanded toolbox of management and operations strategies. More information can be found at <http://ops.fhwa.dot.gov/travel/plan2op.htm>.

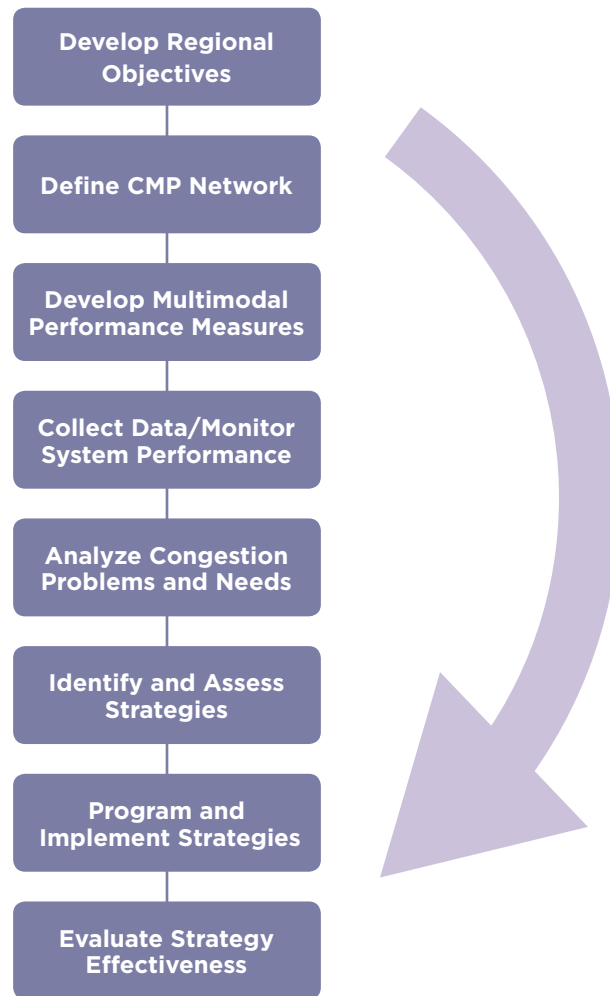


Figure 10. Chart. Actions for the Congestion Management Process

Source: *Congestion Management Process: A Guidebook*, Figure 2, Federal Highway Administration, FHWA-HEP-11-011.

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