Integrating Travel Time Reliability into Transportation System Management Final Technical Memorandum

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16. Abstract

This report documents a Federal Highway Administration (FHWA) project to address the need to connect system-level, goal and objective-setting in the transportation planning process and operations planning that occurs among operators. Through document-based research and input from an expert practitioner group, the project team developed a basic five-step methodology that provides a connection from system-level goals and objectives developed at the planning level to more detailed operational objectives, approaches, and tactics deployed at the corridor or network level. This methodology recommends the use of reliability data and analysis tools, when available, to move from one step to the next. The methodology is illustrated in its application to four scenarios in the appendix.

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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

ATM	active traffic management
ATMS	advanced traffic management systems
AV	automated vehicles
CAD	computer aided dispatch
Caltrans	California Department of Transportation
CAV	connected and automated vehicles
CCTV	closed circuit television
CDOT	Colorado Department of Transportation
CDTC	Capital District Transportation Committee (NY)
CMAP	Chicago Metropolitan Agency for Planning
CMAQ	Congestion Mitigation and Air Quality
CMP	Congestion Management Process
CMSP	(Minnesota) Congestion Management and Safety Plan
COMPASS	Community Planning Association (of Southwest Idaho)
DOT	department of transportation
DSS	decision support systems
ESS	Environmental Senor Stations
FAST	Fixing America's Surface Transportation (Act)
FHWA	Federal Highway Administration
HOV	high-occupancy vehicle
HSIP	Highway Safety Improvement Program
ICM	integrated corridor management
IDOT	Illinois Department of Transportation
ITS	intelligent transportation systems
MAP-21	Moving Ahead for Progress in the 21st Century (Act)
MIST	Management Information System for Transportation (NY)
MnDOT	Minnesota Department of Transportation
MPO	metropolitan planning organization
NCHRP	National Cooperative Highway Research Program
NHS	National Highway System
NOAA	National Oceanic and Atmospheric Administration
NPMRDS	National Performance Management Research Data Set
PennDOT	Pennsylvania Department of Transportation
PTI	planning time index
RDAT	reliability and data analysis tools
ROI	return-on-investment
RTC	Regional Transportation Commission
RTP	regional transportation plan
RWIS	road weather information system

SHRP2	Second Strategic Highway Research Program
SMART	specific, measurable, agreed-upon, realistic, and time-bound
SOV	single occupancy vehicle
TMC	transportation management center
TSMO	transportation systems management and operations
TTI	travel time index
TTRMS	travel time reliability monitoring system
TTTR	truck travel time reliability
VMT	vehicle miles traveled

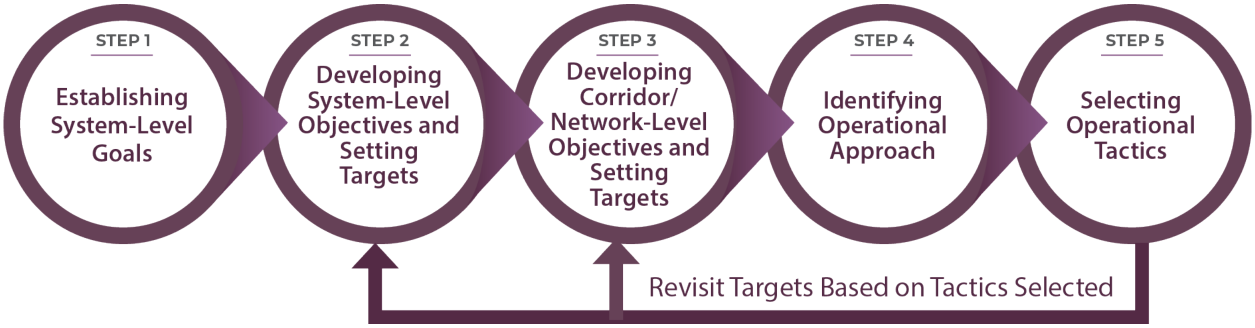
EXECUTIVE SUMMARY

This report documents a Federal Highway Administration (FHWA) project led by the Office of Operations to address the gaps between planning and operations. Its intent was to evolve the state of the practice by building a methodology supported by the data and analysis tools developed under the SHRP2 program. The project was motivated by the need to connect system-level, goal and objective-setting in the transportation planning process and operations planning that occurs among operators. Long-range transportation planning is typically not linked to detailed, tactical operations decisions made at the corridor or network level. The objectives of this project were to:

- Develop and demonstrate a framework or method for integrating travel time reliability concepts and analysis in systems management, operations, systems planning, and programming.
- Show how the framework can be used to connect planning-level reliability goals and objectives to operational objectives and transportation systems management and operations (TSMO) strategies and tactics.

The project team reviewed over 30 documents to identify examples and overarching guidance on the use of operational and reliability analysis to develop transportation system management goals, objectives, and performance targets and make planning, investment, and tactical decisions. The team found examples of State departments of transportation (DOTs) and metropolitan planning organizations (MPOs) using reliability or operational analysis in setting direction for performance targets and in identifying needs for system performance improvements. There was limited use found of reliability and operational analysis in forecasting the benefits of operational improvements or tactical decisions. The project team identified several barriers to the use of travel time reliability analysis tools in planning and implementing system management strategies including technical, institutional, and financial.

The document-based research and input from an expert practitioner group led to the development of a basic five-step methodology that provides a connection from system-level goals and objectives developed at the planning level to more detailed operational objectives, operational approaches, and tactics deployed at the corridor or network level. This methodology recommends the use of reliability data and analysis tools, when available, to move from one step to the next. By using this methodology, the operational tactics or actions taken to manage the transportation system are derived from and contribute to system-level goals and objectives. This methodology is iterative such that objectives and targets are revisited based on the actual or forecasted impact of the tactics. This methodology is shown in figure 1.



Source: FHWA.

Figure 1. Diagram. Methodology for linking from system-level goals and objectives developed at the planning level to more detailed operational objectives, operational approaches, and tactics.

Continued refinement of this methodology through future efforts should further explore correlations between this methodology and other processes to create a unified process that harmonizes terminology, anticipates the integration of emerging transportation services and technologies, and identifies opportunities to overcome structural constraints (e.g., funding timelines, institutional silos) that obstruct a seamless approach to systems management from planning through implementation.

CHAPTER 1. INTRODUCTION

With technical support from the Federal Highway Administration (FHWA), transportation organizations across the United States have been making progress toward integrating transportation systems management and operations (TSMO) into the metropolitan and statewide planning processes over the past 15 years. As a result, collaboration and coordination between planners and transportation system managers and operators has increased but there are still gaps that can lead to less efficient or effective transportation investments.

In addition to the work done by the FHWA, the purpose of the Second Strategic Highway Research Program (SHRP2) (2006 – 2018) was to find strategic solutions to three National transportation challenges: improving highway safety, reducing congestion, and improving methods for renewing roads and bridges. One of the primary focuses of the SHRP2 reliability research was to develop or enhance data and analysis tools to support the evaluation and modeling of travel time reliability that is necessary for including reliability in planning and decision-making.

This report documents an FHWA project led by the Office of Operations to address the gaps between planning and operations. Its intent is to evolve the state of the practice by building a methodology supported by the data and analysis tools developed under the SHRP2 program. This FHWA project, Integrating Travel Time Reliability Analysis into Transportation System Management, began in mid-2017 and was completed in early 2019.

PROJECT MOTIVATION

At a fundamental level, this project concerns linking long-range transportation planning to more detailed, tactical operations decisions made at the corridor or network level. Its goal was to address the disconnect between the system-level goal- and objective-setting that happens in the planning process and the operations planning that occurs at a lower level, primarily among operators.

Frequently, statewide or regional transportation goals and objectives are fairly high level and long range, they cover the entire system, and they may not fully include operational or travel time reliability needs. On the other hand, transportation system managers and operators often select and deploy operational tactics at the network or corridor level without developing operational objectives or an overall strategy for managing the corridor or network. The outcome of this project is a methodology designed to help guide planners, operators, and system managers connect system-level planning and operational decisions by using travel time reliability for purposes ranging from developing broad, planning-level goals and objectives to implementing tactics.

The objectives for this project were to:

- Develop and demonstrate a method for integrating travel time reliability concepts, analysis, and related decision support systems into ongoing TSMO activities and programs as well as into TSMO strategies and tactics at the network and corridor levels.

- Show how this method can be used to connect planning-level reliability goals and objectives to more detailed operational objectives, TSMO strategies, and tactics.

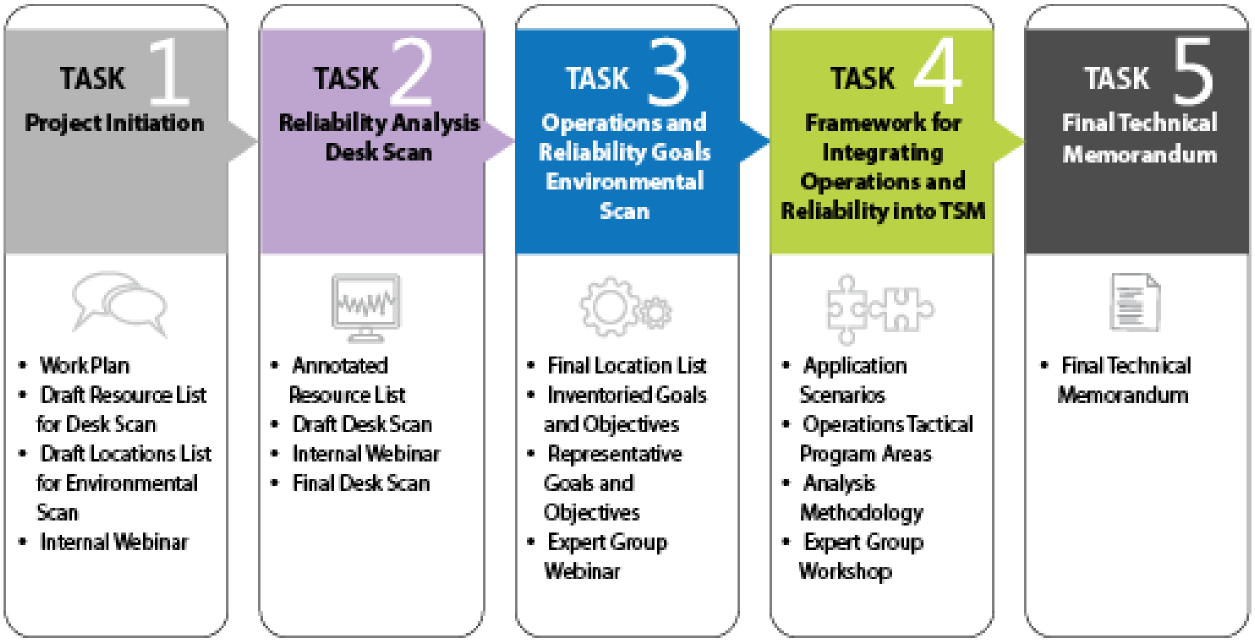
BUSINESS CASE

An important question to consider is why making this connection using data and analysis tools matters. What are the ramifications of not connecting system-level goals with tactics used on a corridor or network scale?

Intuitively, it makes sense that government agencies should do what they plan for and plan for what they do. Operational investments and tactics that are not developed as a means of achieving a higher-order objective or goal are much less likely to “move the needle” in terms of reaching agreed-upon goals or performance targets. Additionally, operational activities are not coordinated strategically across corridor or network boundaries to realize more performance benefits. This disconnect wastes time and money and leads to inefficient or ineffective solutions that may or may not address our greatest needs, detracting from the credibility of our transportation agencies. But by bridging this gap, the United States is better positioned to compete economically on a global scale.

OVERVIEW OF TASKS

The work of this project was broken down into five tasks that will be revisited throughout this report (see Figure 2). Task 1 covered the project initiation activities and prepared the team to undertake tasks 2 and 3. Task 2 consisted of a document review to better understand how transportation agencies, primarily State departments of transportation (DOTs) and metropolitan planning organizations (MPOs), incorporate reliability and operations performance measures, data, and tools into planning and system management. Task 3 focused on developing representative sets of system-level goals and objectives by first scanning planning documents to identify examples. To execute task 4, the project team hosted a workshop with planning and transportation system management experts at MPOs and State DOTs, and then developed and applied an analysis methodology to several hypothetical scenarios. Task 5 efforts were to document the project results through this report.



TSM = transportation system management
Source: FHWA.

Figure 2. Diagram. Task-based approach for project.

CHAPTER 2. RELIABILITY ANALYSIS DESK SCAN

As one of the first tasks in this project, the team conducted a review of over 30 documents to identify examples and overarching guidance on the use of operational and reliability analysis to develop transportation system management goals, objectives, and performance targets and make planning, investment, and tactical decisions. This section will summarize the approach and findings of the desk scan. Case studies developed from this desk scan are at the end of this section and include the following examples:

- Reliability Performance Management at the Colorado Department of Transportation (DOT).
- Iowa DOT Interstate 80 Automated Corridor Study – Travel Time Reliability Analysis for Investment Planning.
- Wisconsin DOT Reliability and Benefit-Cost Update: Enhanced Project Selection through Travel Time Reliability Analysis.
- Minnesota DOT Congestion Management Safety Plan – Enhanced Project Selection through Travel Time Reliability Analysis.

SUMMARY OF APPROACH

The project team reviewed State DOT, metropolitan planning organization (MPO), Federal Highway Administration (FHWA), and National research papers in an effort to answer as many of the following questions as possible:

- Where and how are operational and reliability analyses—both qualitative and quantitative—being used to develop:
    - Goals?
    - Objectives?
    - Performance targets?
- How is reliability integrated with or kept separate from other performance objectives?
- Where and how are operational and reliability analyses—both qualitative and quantitative—being used to decide:
    - What to include in a plan, for example, capacity expansion, operational improvements, multimodal development, land use? How the transportation system or network evolves or will be modified as a result of planned improvements?
    - What to invest in?
    - How to implement transportation systems management and operations (TSMO) tactics and strategies?
- How are decision support systems (existing or emerging) being used for any of the activities above (e.g., integrating reliability or operations analysis in planning or operations)?
- How is reliability or operations analysis integrated into business processes? Are there any emerging or prospective institutional approaches?

- What models or frameworks exist that show how integration can or should occur (e.g., from FHWA guidebooks or other literature)?
- What methodology and reliability analysis—or any type of operations analysis—do agencies use to identify both operations objectives for managing systems and strategies to achieve outcome-based strategic objectives?
- How are smaller scale (e.g., network, corridor) operations objectives developed to support system-wide objectives? What operations or reliability analysis is used?
- What are the motivations for using reliability and operational analysis in planning, system management, and implementation?
- What is the actual and perceived value and return-on-investment (ROI) for transportation operations and reliability analysis?
- Are private companies involved? If so, how?
- What are the critical issues, barriers, and gaps in using reliability/operations analysis for planning, system management, and implementation?
- What are the trends, themes, and opportunities?

DESK SCAN FINDINGS

This section summarizes the project team's literature review results. The findings are grouped as follows:

- Reliability and operational analysis used in setting direction.
- Reliability and operational analysis for planning and investment decisions.
- Reliability and operational analysis for implementation and tactical decisions.
- Decision support systems.
- Frameworks for including reliability and operational analysis in transportation system planning, programming, strategic, and tactical decisions.
- Gaps and barriers.
- Trends and opportunities.

Reliability and Operational Analysis Used in Setting Direction (Goals, Objectives, and Targets)

To implement the transportation performance management framework established by the Moving Ahead for Progress in the 21st Century (MAP-21) Act and the Fixing America's Surface Transportation (FAST) Act, FHWA established performance rulemakings. The travel time reliability measures require State DOTs and MPOs to develop targets and measures for travel time reliability on the Interstate and non-Interstate National Highway System (NHS). All State DOTs, as well as MPOs with Interstate and/or non-Interstate NHS roads within their metropolitan planning area, are required to conduct operational reliability analyses for performance target calculation. The National Performance Management Research Data Set (NPMRDS) is the required data for analysis.(19)

The FHWA report *Advancing Transportation Systems Management and Operations through Scenario Planning* can be a helpful resource for planners and decision makers to support the development of goals, objectives, and targets for their long-range plans. The primer provides general guidance on the use of data and analysis tools to test multiple scenarios and their impacts on desired outcomes identified as part of a scenario planning process.(17)

The team identified examples of MPOs in Portland, Oregon,(23) and New York(26) that include travel time reliability goals in their long-range plans. In addition, Iowa DOT(30) and Texas DOT(57) established reliability goals for specific transportation systems management programs.

Reliability and Operational Analysis for Planning and Investment Decisions

The project team identified numerous reports and other documents describing the use of operational and travel time reliability analysis in the process of selecting strategies for transportation plans and making investment decisions. The primary guidance in this area comes from the Second Strategic Highway Research Program (SHRP2) Reliability and Data Analysis Tools (RDAT) bundle of products.(14) The RDAT bundle helps agencies address travel time reliability in their assessment of transportation alternatives so they can consider a more complete set of benefits in their decisions. The bundle includes:

- L02 - Guide to Establish Monitoring Programs for Travel Time Reliability.
- L05 - Handbook for Incorporating Reliability Performance Measures into Transportation Planning and Programming.
- L07 – Reliability by Design.
- L08 – Incorporating Travel Time Reliability into the Highway Capacity Manual.
- C11 – Tools for Assessing Wider Economic Benefits of Transportation.

Agencies can use the RDAT tools resulting from the L07, L08, and C11 initiatives to evaluate strategies and to make informed planning and investment decisions. The analysis tools were tested and piloted by transportation agencies, which applied strategies such as median barrier, ramp metering, incident response, bottleneck removal, separated high-occupancy vehicle (HOV) lanes, and transit service.

The project team also found several examples that demonstrated agencies using travel time reliability analysis for more than just a single project, but also systematically as a business process. Agencies are leveraging travel time reliability analysis to link strategy selection to agency objectives or stakeholder-derived objectives for the corridor or region. For example, the Iowa DOT I-80 Automated Corridor Study analyzed alternatives to achieve the objective to reduce vehicle crashes and non-recurring congestion. Travel time reliability analysis helped the department to promote strategies that advance connected and automated vehicles (CAV) to meet those objectives.(29)

Examples of a systematic use of travel time reliability analysis include:

- California Department of Transportation (Caltrans) Corridor System Management Plans – The development of Corridor System Management Plans is a planning approach that uses travel time reliability with other operational analyses to develop tiered solutions to improve corridor congestion. Solutions that are prioritized earliest for implementation tend to be transportation system management strategies due to their low cost.(62)

- Minnesota Congestion Management and Safety Plan (CMSP) – This is a recurring, system-wide study that targets low-cost and high-benefit solutions based on methods that were recently enhanced with travel time reliability analysis. Several of the solutions are operational in nature.(35)

- Florida DOT Multimodal Mobility Performance Measure Program – The program uses operational performance measures (trip-based travel time reliability included) to evaluate improvement alternatives as part of the statewide programming and prioritizing of projects.(27)

- Regional Transportation Commission of Southern Nevada Congestion Management Process – Through this process, the MPO prioritizes improvements that address congestion based on four components of congestion: intensity, duration, extent, and reliability.(17) (18)

- Capital District Transportation Committee (CDTC) (NY) – The MPO used the New York State DOT's Management Information System for Transportation (MIST) data set to understand and evaluate the costs and benefits of investments to address non-recurring and recurring delay. This contributed to establishing operations and incident management as strong priorities at CDTC.(15)

- Iowa DOT I-80 Automated Corridor Study – Iowa analyzed various alternatives to determine the impact on operations, safety, and travel time reliability. They established an Iowa standard for corridor planning for evaluating travel time reliability to support the department's TSMO goals.(29)

Reliability and Operational Analysis for Implementation and Tactical Decisions

While the study team found a few examples of *operational* analysis usage by agencies to identify how, when, and where to implement transportation systems management strategies, no specific uses of *reliability* analysis were found during the literature review. The Michigan and Missouri DOTs use operational analysis methods to manage traffic around work zones. For example, the Michigan DOT used modeling and simulation tools to prepare for the closure of a freeway and to optimize work zone traffic control strategies.(42) The Missouri DOT has developed two spreadsheet analysis tools to help with planning work zones. The Work Zone Impact Analysis Spreadsheet estimates queuing and traffic delays during work zones.(37) The agency also developed a Traffic Pacing Spreadsheet Tool to help plan and facilitate the traffic pacing work zone strategy,[1] in which pacing vehicles are used to slow all lanes of traffic concurrently to create a gap between traffic and the mobile work crew, facilitating the safe operation of short-duration work.

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[1] This strategy is called by various names, including rolling road block, continuously moving work zone, precision rolling slowdown, etc.

Decision Support Systems

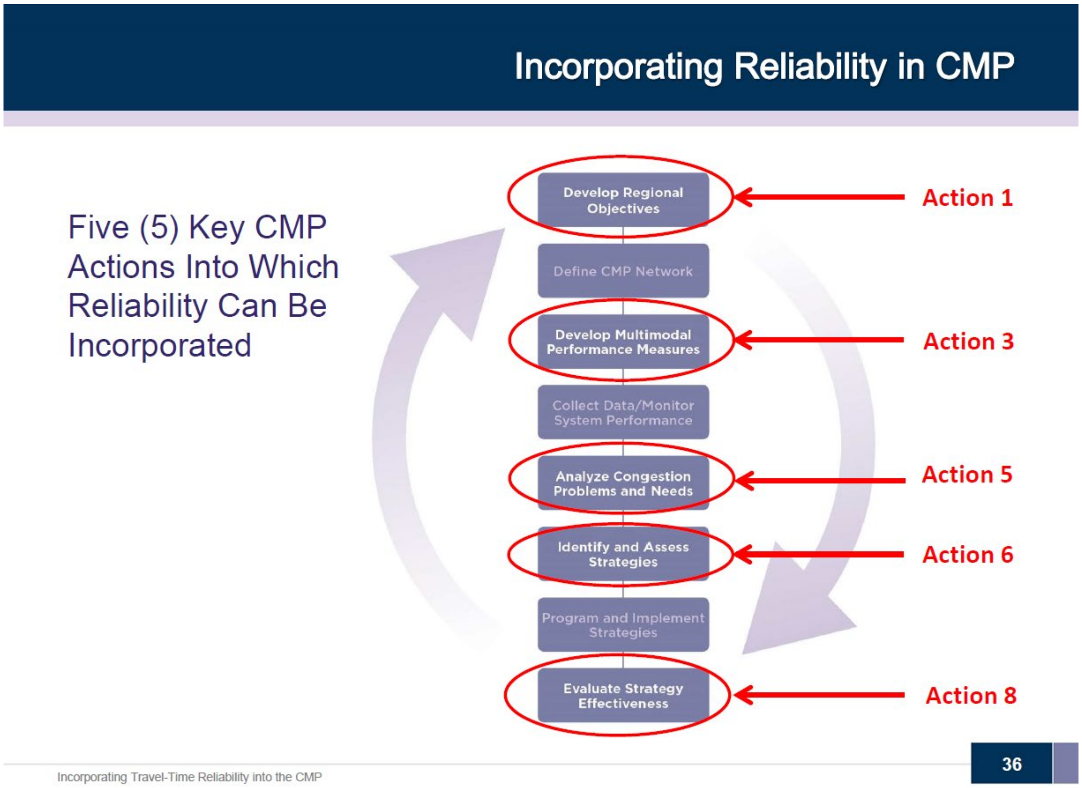
Decision support systems (DSS) have been used in many industries to facilitate tasks or processes in a structured manner based on current conditions and past successful practices. In the transportation field, DSS have a strong practical application, often being used by transportation management center (TMC) operators to help them respond effectively to developing congestion and incidents. The spread of DSS in the transportation industry is connected to the evolution of highly interrelated agency practices at the TMC between system operators and emergency service personnel. More recently, DSS is used in the practice of integrated corridor management (ICM).(38) For ICM, the primary literature surveyed in this study discussed pilot ICM deployments in San Diego, California, and Dallas, Texas.(13) (59)

DSS are also being considered for use in decision-making at the program level among transportation system management planners and operators. The National Cooperative Highway Research Program (NCHRP) is conducting a research project to assess current processes and analysis methods that are foundations for how core decision-making processes occur: (1) within TSMO programs, (2) in conjunction with associated and encompassing agency functions, and (3) in an integrated and supportive fashion by data and information associated with on-going operations. The research will identify and consider how effective and emerging business intelligence practices, models, or approaches from other industries can be applied to TSMO and transportation agency program management processes. Particular attention will be paid to business intelligence practices that reduce the cost of providing services or improve the quality and effectiveness of decision-making capabilities.(58)

Frameworks for Including Reliability and Operational Analysis in Transportation System Planning and Programming and in Strategic and Tactical Decisions

Reliability is quickly becoming a critical objective for transportation system performance, but there is no full framework that either demonstrates how that objective can be drawn through each stage of system management or offers analysis results to guide decisions. A framework is needed to guide transportation system management practitioners in using reliability and operational analysis to connect the elements of planning, programming, and implementing system management strategies and tactics. As part of the desk scan task, the study team identified and reviewed several frameworks, which are described below.

The FHWA Office of Operation’s workshop on Incorporating Reliability into the Congestion Management Process (CMP) teaches five key actions that MPOs can use to incorporate reliability into the CMP (see figure 3).(17)



Incorporating Reliability in CMP

Five (5) Key CMP Actions Into Which Reliability Can Be Incorporated

Develop Regional Objectives

Define CMP Network

Develop Multimodal Performance Measures

Collect Data/Monitor System Performance

Analyze Congestion Problems and Needs

Identify and Assess Strategies

Program and Implement Strategies

Evaluate Strategy Effectiveness

Action 1

Action 3

Action 5

Action 6

Action 8

Incorporating Travel-Time Reliability into the CMP

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Figure 3. Diagram. Actions to incorporate reliability into the congestion management process.(17)

According to the workshop slides, the CMP is a natural process in which to incorporate reliability, but most CMPs focus on recurring congestion.

- Action 1 – The first step to incorporating reliability into the CMP is to develop regional objectives that contain language and factors relating to reliability. The workshop recommends that each region have a foundational understanding of reliability performance prior to setting goals and objectives. This understanding will help a region better grasp the magnitude of change that could be achieved and would help set realistic expectations. This will require data collection and performance analysis. The objectives should include performance targets.

- Action 3 – The next key action is to develop multimodal performance measures specifically related to reliability. The workshop provides an overview of several common reliability performance measures and recommends developing them in conjunction with partnering agencies.

- Action 5 – This step involves analyzing congestion problems and needs. This serves to identify existing reliability problems and diagnose their causes. The following SHRP2 products are recommended as resources:

    - Establishing Monitoring Programs for Travel Time Reliability: A Guidebook (SHRP2 L02).
    - Incorporating Reliability into Planning and Simulation Models (SHRP2 L04).
    - Design Guide for Addressing Non-recurrent Congestion (SHRP2 L07).
    - Incorporation of Travel Time Reliability into the HCM (SHRP2 L08).(17)
- Action 6 – This step involves identifying and assessing strategies.
- Action 8 – The last action is to monitor and evaluate the effectiveness of the implemented strategies.

While this framework provides a solid outline for integrating reliability into several of the key points in planning, additional details are needed to determine both the appropriate analysis tools as well as when and how to apply them to logically progress from outcome-oriented objectives to activity-based objectives, strategies, and tactics.

Gaps and Barriers

During the literature review, the study team identified a set of gaps and barriers pertaining to the practice of using reliability and operational analysis in transportation system management planning, programming, strategic, and tactical decisions.

From the perspective of providing national guidance, the following are overarching gaps that motivate this project:

- Broad planning-level goals and objectives inconsistently linked to TSMO systems engineering and deployment.
- Misalignment or no alignment of planning objectives with operational objectives.
- No overarching framework for traffic operations performance analysis of goals and objectives translated into strategies and tactics.(22)

During the literature review, the team identified technical, institutional, and financial barriers to using travel time reliability analysis tools in planning and implementing system management strategies. The barriers to the adoption of travel time reliability analysis have largely been recorded in the SHRP2 RDAT proof-of-concept pilots conducted by the Minnesota DOT and the Florida DOT. The primary challenges collected from stakeholder panels during these projects are:

- Staff time and resources.
- Resistance to change.
- Maturity of software tools for conducting travel time reliability analysis.

The first two challenges cited by these project stakeholders are typical of challenges to all innovation, but may be overcome through experience with benefits. The maturity of the software tools were stressed during the proof-of-concept tests, and this led to further enhancement of these RDAT tools.

Follow-on implementation projects still found gaps in how the tools evaluate reliability and how the reliability analysis between several RDAT tools do not interface consistently. They also recognized a lack of breadth in the built-in TSMO strategies that can be directly evaluated within the RDAT tools. These implementation projects include:

- Iowa DOT Reliability Pilot – Inconsistency between travel time reliability monitoring, analysis, and benefit monetization tools.
- Rhode Island Statewide Freight Plan – Travel time reliability analysis limited by a single year timeframe, other shortcomings.(46)
- Wasatch Front Central Corridor Study – Tools not applicable to transit and incentive strategies.(61)

Another area where the study team identified gaps is in the organizational readiness of agencies for transportation system management. The literature review identified an active project that aims to fill gaps in system management, NCHRP 03-128 *Business Intelligence Techniques for Transportation Agency Decision Making*, which has been scoped to focus on enterprise data management practices, data analytics, predictive analytics, and business performance management to improve system management.(58)

Another project, NCHRP 20-07 Task 365 Transportation System Management and Operations Program Planning – Experiences from the SHRP 2 Implementation Assistance Program, details the challenges to widespread adoption of TSMO program planning. The document examined agencies that have not begun developing a TSMO program plan. Reasons for not pursuing development of a TSMO program plan included:

- Focusing more on maintaining existing initiatives with their limited resources and funding.
- Postponing TSMO planning until they can first address other operations issues.
- Lacking of a particular champion of TSMO planning.
- Policymakers who are neutral on the issue of TSMO planning or who do not understand the benefits of TSMO.(6)

Trends and Opportunities

Trends and opportunities in the areas of travel time reliability analysis and organizational readiness for TSMO suggest potential growth in both of these areas may promote their mutually beneficial integration.

Use of travel time reliability analysis has grown based on the success of the SHRP2 program and its dedicated implementation assistance program. SHRP2 initially piloted the RDAT tools in four States and then expanded deployment through two rounds of implementation assistance. Through that program, the tools have been tested by more than a dozen agency partnerships. From that momentum, practices have been established that bring travel time reliability analysis into more standard use in States like California, Minnesota, Florida, and Wisconsin. Stakeholders of the Minnesota DOT proof-of-concept testing saw nearly equal opportunity for travel time reliability analysis to help categorize existing sources of delay, support improved project evaluations, enhance benefit-cost analysis by capturing modeled delay of nonrecurring events, and improve the planning and programming process.(47)

Through its SHRP2 project, Florida DOT developed the *Planning for Travel Time Reliability Guide*, which notes that Florida DOT (FDOT) "has been a pioneer in developing performance measures that address reliability. Likewise, the agency has developed a mature TSMO program and is currently working to maximize efforts to incorporate TSMO improvements into planning and corridor studies."(24) FDOT intends for the *Planning for Travel Time Reliability Guide* to build on their prior TSMO work and provide FDOT employees and consultants with guidance on how travel time reliability is incorporated into FDOT's planning processes for capacity expansion and operational improvements. It describes how to fund improvements that address travel time reliability and identifies opportunities for collaboration and tools for incorporating travel time reliability in planning.

The Federal rulemaking on performance measurement that includes several travel time reliability measures increases the potential number of travel time reliability analysis users significantly.(19) The potential swell of travel time reliability analysis related to the Federal rulemaking may prove an opportunity to increase agency willingness and interest in the use of reliability analysis.

CASE STUDIES

Reliability Performance Management at the Colorado DOT

The 2013 revision of the State Measurement for Accountable, Responsive and Transparent Government Act formalized performance measurement in Colorado and provided a framework for performance planning, management, data collection, reporting, and evaluation.(8) The Act requires State departments in Colorado, including the Colorado Department of Transportation (CDOT), to develop performance management plans with ongoing target setting and performance evaluation. In its annual performance measurement plans, CDOT establishes strategic policy initiatives, strategies, and processes supporting those initiatives, and output and outcome measures indicating performance levels.

From 2013 to 2017, CDOT has included travel time reliability as part of its strategic policy initiatives. CDOT sets an annual target in terms of a statewide planning time index (PTI), a measure of the total travel time that should be planned for a trip. The PTI is calculated as the 95th percentile travel time divided by the free-flow travel time.

CDOT set separate PTI targets by direction for two primary Colorado freeways: Interstate 25 (between Northwest Parkway and C-470); and Interstate 70 (between Vail and C-470).(50) CDOT set the targets using historical probe-based travel time data for each corridor and direction. The established targets were generally higher than historical values because CDOT took into consideration increasing population and traffic volumes.

The following are example strategies for improving travel time reliability that CDOT has included in their annual plans:(10)

- Improve traffic incident management (TIM) and clearance times through statewide training that leverages the FHWA National TIM Responder Training program.
- Target corridor improvements, such as bottleneck reductions, through the Highway Safety Improvement Program (HSIP).
- Implement managed lanes through tolling, variable speed limits, peak-period shoulder lane operations, and active traffic management (ATM).
- Add ramp meters to manage system flow better.
- Use intelligent transportation systems (ITS) to provide real-time weather and roadway information to travelers.
- Develop command-level partnerships with law enforcement to implement integrated event traffic management.
- Implement new, innovative technologies.

In addition, CDOT's annual plan translates the policy goals into operational measures that include reducing average incident clearance times and reducing average road closure event times. These operational measures and associated targets help to offset the growth in PTI along Interstates 25 and 70. They also measure the effectiveness of selected operational processes (e.g., train first responders and conduct after-action reviews of incident clearance) in supporting the travel time reliability policy initiative. CDOT conducts a quarterly evaluation of system performance against the established PTI goals.

In the performance plan for CDOT's 2017-2018 fiscal year, CDOT renamed its policy from "the travel time reliability policy initiative" to "the travel time policy initiative." CDOT also adopted a new performance measure: average travel time (instead of PTI), but the targeted corridors and strategies remain the same as in previous plans.(9)

Iowa DOT Interstate 80 Automated Corridor Study – Travel Time Reliability Analysis for Investment Planning

In Iowa, Interstate 80 (I-80) connects Iowa's major cities and serves as a vital corridor to transport people and goods. Originally built in the 1950s and 1960s, I-80 needs new infrastructure, design improvements, additional capacity, and enhanced safety features. In 2015, Iowa DOT initiated the I-80 study to direct future investment in the corridor.

Using the Planning Environmental Linkages framework, Iowa DOT conducted planning-level evaluations of multiple factors, including the effect that automated vehicles (AV) could have on operations (recurring and non-recurring congestion) and safety.(29) The study used recent research to develop projections for increased demand, increased capacity, harmonized speeds, and reduced crash frequencies due to the integration of AVs into non-automated traffic streams. Using forecasted AV impacts on recurring congestion and predicted crashes, the project team conducted a travel time reliability analysis to capture the potential for AV to improve operations even when considering non-recurring congestion.

The project used the SHRP2 L07 model (RDAT bundle of products) to estimate travel time index (TTI) curves for multiple scenarios representing different demand levels and levels of AV market penetration. Iowa DOT developed the TTI curves, which spanned multiple periods and potential futures, into summary measures. The study showed that the best investment in the corridor includes capacity expansion using a design to support AV technology. The travel time reliability analysis supported agency objectives, like reliable travel for passenger and freight vehicles, and confirmed the need to invest in corridor-wide communication technology to allow traveler information and system management and future system engineering for smart corridor infrastructure. Figure 4 shows the I-80 Automated Corridor Study performance measures used to guide selection of a preferred alternative, with the reliability-based performance measure highlighted for emphasis.

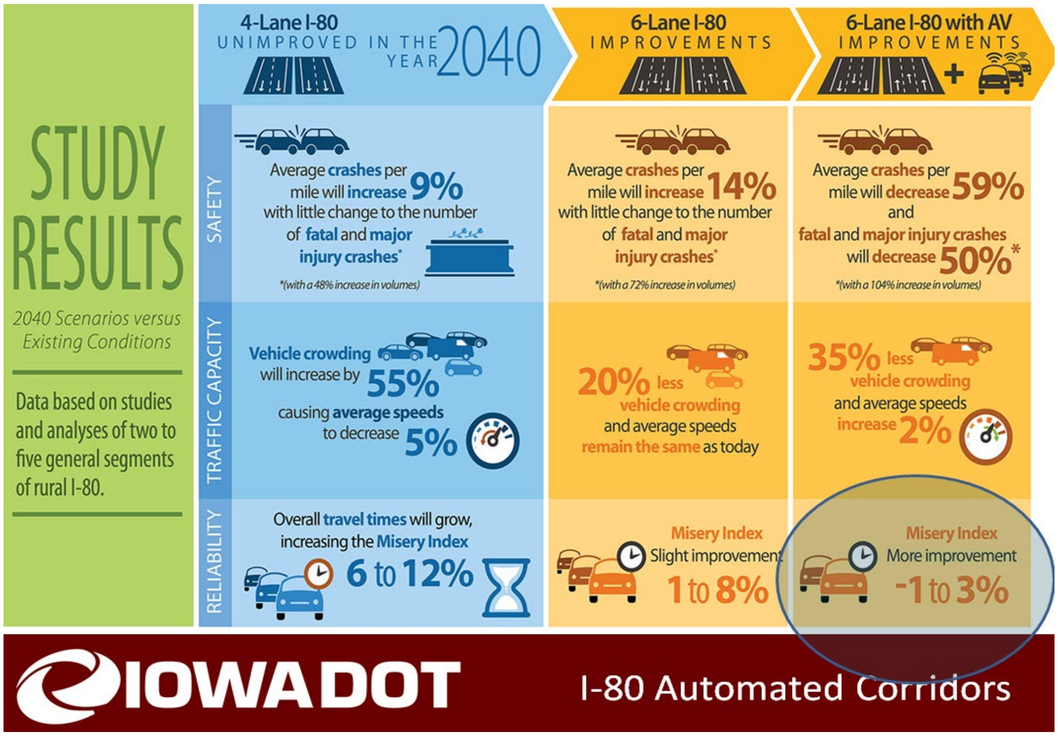

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Figure 4. Infographic. Iowa Department of Transportation results of the I-80 Automated Corridors Study.(29)

Wisconsin DOT Reliability and Benefit-Cost Update: Enhanced Project Selection through Travel Time Reliability Analysis

Historically, Wisconsin DOT has included a basic benefit-cost analysis component during the evaluation of its major highway projects. Recently, Wisconsin DOT's benefit-cost analysis methodology and tools were improved upon when the agency updated the travel time models used to determine user costs resulting from non-recurring delay.(63)

The models can be used for any roadway improvement project to assess the benefits of reducing recurring and non-recurring congestion regardless of geography or facility type. The models developed separate facility performance conditions between normal and non-recurring congestion conditions. Each type of condition occurs based on a probabilistic approach similar to the SHRP2 L08 scenario generation method (RDAT bundle). The Wisconsin DOT tool focuses on link-based annual travel metrics (e.g., vehicle miles traveled, vehicle hours traveled, crashes, etc.) that compare the base to improvement scenarios. Analysts have the flexibility to evaluate operational improvements as well as infrastructure investment scenarios. The travel time reliability analysis tool is being used to enhance the department's ability to evaluate and implement projects targeting reliability, like transportation system management.

Minnesota DOT Congestion Management Safety Plan – Enhanced Project Selection through Travel Time Reliability Analysis

The Congestion Management Safety Plan (CMSP) is a funding program that seeks to implement low-cost, high-benefit improvements to address congestion and safety problems on Minnesota DOT's (MnDOT) Metro District highway system. During the multi-phase CMSP process, researchers gather data to identify problem locations and potential solutions to address issues at the locations.

The MnDOT Phase 4 iteration of the CMSP was enhanced through the addition of travel time reliability analysis.(20) (35) Researchers leveraged guidance provided by the SHRP2 L02 framework and methodologies from the L07 and C11 tools to include travel time reliability as a performance measure equivalent to congestion and safety in the decision-making process. With this enhancement, Minnesota DOT gains a better understanding of areas that have bottleneck and reliability problems, including locations that are more severely impacted than expected from typical bottleneck-related congestion. The results of the CMSP are project location recommendations, backed by data-driven analysis, with a high potential for reducing congestion and crashes and improving travel time reliability.

Figure 5 captures the relationship between reliability and recurring congestion that helped MnDOT determine that their CSMP required formal consideration of a reliability measure during screening to identify low-cost, high-benefit projects.

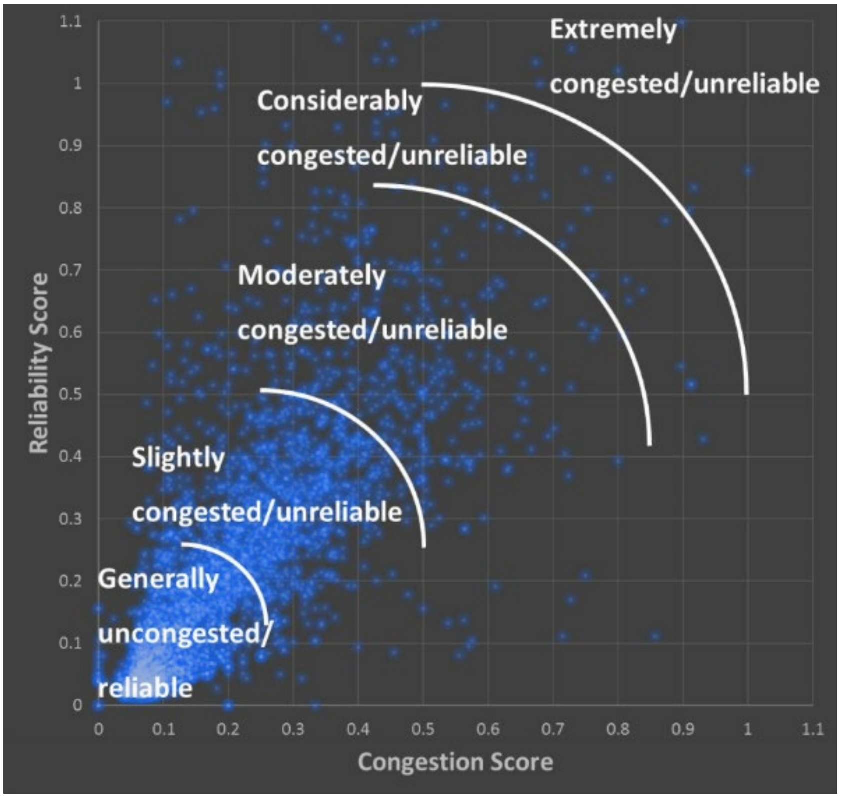

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Figure 5. Diagram. Relationship between reliability and congestion.(35)

Figure 6 depicts the growing number of factors required to complete analysis when moving between congestion, safety, and reliability analysis. By reaching the point of consideration of non-recurring factors, the method is inherently more sensitive to transportation system management improvements, but the cost or data requirements to consider non-recurring factors represents only a marginal increase over the existing methods for conducting safety analysis.

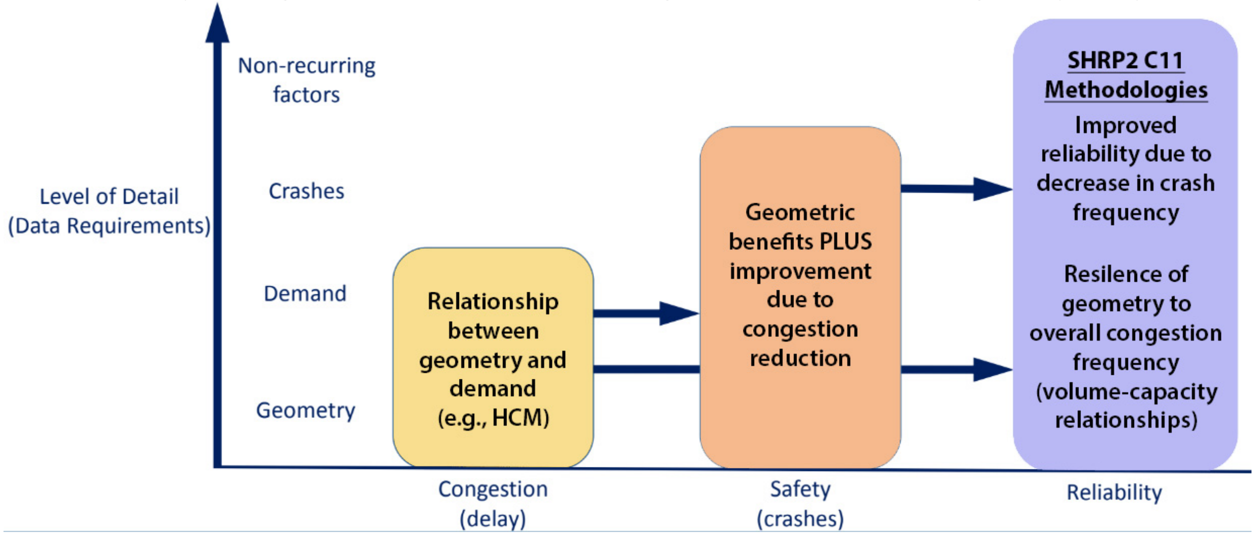

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Figure 6. Diagram. Increasing number of factors required to complete analysis when moving between congestion, safety, and reliability.(35)

CHAPTER 3. SYSTEM-LEVEL GOALS AND OBJECTIVES FOR OPERATIONS AND RELIABILITY

Following the desk scan, the project team scanned planning documents to inventory system-level goals and objectives for operations and travel time reliability. The purpose of this task was to build representative samples of system-level goals and objectives at both the State and metropolitan scales. The section summarizes the inventoried goals and objectives and describes the representative goals and objectives.

ENVIRONMENTAL SCAN

The environmental scan of system-level goals and objectives for operations and reliability covered plans and reports from more than 40 locations in the United States. The project team focused primarily on State department of transportation (DOT) and metropolitan planning organization (MPO) long-range transportation plans, operations-focused strategic and programmatic plans, congestion management process documents, corridor studies, and system performance reports. Many of the planning documents contained goals and objectives that focused on travel time reliability and operational performance. Below are some of the examples found during the scan, organized by type of planning document.

Transportation Systems Management and Operations/Intelligent Transportation Systems Strategic and Program Plans

The ***Iowa DOT Transportation Systems Management and Operations (TSMO) Program Plan***(30) has several high-level goals: safety, reliability, efficiency, convenience, coordination, and integration. The program plan also has a hierarchy of system-level objectives and program-level objectives. Examples of system-level objectives are improving travel time reliability and increasing the resilience of the transportation system to floods, winter weather, and other extreme weather events. An example of a program-level objective is to respond to and clear traffic incidents as quickly as possible. This was the only example of a plan in the scan that created a hierarchical relationship between system-level objectives and program-level objectives.

The ***Caltrans Traffic Operations Strategic Plan***(4) integrates reliability into goals; for example, using leadership, collaboration, and strategic partnerships to develop an integrated transportation system that provides reliable and accessible mobility for travelers. Additionally, the goal of the plan is to increase accessibility to all modes of transportation and improve travel time reliability for all modes.

One of ***Maryland DOT TSMO Plan***(32) goals is to improve travel time reliability for both people and freight. Several of its objectives include implementing a comprehensive, system-level performance measurement program to monitor mobility and reliability targets by June 2017 and including reliability in existing traffic analyses and travel forecasting and modeling tools. The Maryland DOT also includes a reliability goal in its 2016 Annual Attainment Report: the agency will seek to maintain or improve travel reliability for key transportation corridors and services.

The goals from the ***South Dakota DOT Transportation Systems Management and Operations Program Plan*** (48) include implementing TSMO in order to optimize system operation, improve safety, and manage system reliability. Other goals include developing and implementing a methodology that incorporates travel time reliability to evaluate the effectiveness of winter operations.

One of the ***New York City DOT 2016 ITS Strategic Plan*** (39) goals is having a reliable, safe, sustainable, and accessible transportation network that meets the needs of all New Yorkers and supports the city's growing economy. Several of its objectives are to increase overall rail transit capacity into the Manhattan Central Business District by 20 percent between 8 a.m. and 9 a.m. by 2040, and to double the number of bicyclists, tracked by the NYC In-Season Cycling Indicator, by 2020.

Statewide Long-Range Transportation Plans, Programs, and Performance Reports

Several of the key objectives of the **Pennsylvania DOT** ***Long-Range Transportation Plan***(41) include providing infrastructure and technology advancements to eliminate bottlenecks and improve system efficiency and trip predictability.

The **Colorado DOT** ***Strategic Actions for the Statewide Transportation Plan***(7) lists several of the more traditional goals including safety, mobility, economic vitality, and maintaining the system.

The **Arizona DOT** ***What Moves You Arizona Long-Range Transportation Plan 2010 – 2035***(1) includes goals to improve mobility and accessibility, preserve and maintain the system, support economic growth, and enhance safety and security. Its objectives include optimizing mobility and reliability in the transportation of passengers and freight and developing and operating a State transportation system that provides for the reliable movement of people and freight throughout the State.

One of the goals stated within the **Florida DOT** ***Long-Range Program Plan for Fiscal Years 2018-2019 through 2022-2023***(25) is to provide efficient and reliable mobility for people and freight. The Florida DOT 2017 Strategic Plan has several mobility goals, one of which is to improve travel time reliability.

The ***Moving Michigan Forward 2040 State Long-Range Transportation Plan***(34) has as a stated goal to continue to improve transportation safety and ensure the security of the transportation system. The plan also mentions addressing system bottlenecks, improving travel time reliability and predictability for passengers and freight, and enhancing the transportation experience through better, timelier travel information.

The ***Illinois State Transportation Plan: Transforming Transportation for Tomorrow***(28) mentions several reliability goals, including maintaining the performance of the Illinois transportation system to provide a high level of reliability to ensure the efficiency and on-time performance of transportation services. The State will also explore the use of new technologies to improve transportation operations, traveler convenience, and system reliability. Some of the

DOT's objectives include identifying, measuring, and monitoring system bottlenecks, constraints, and deficiencies.

The ***Oregon DOT's State of the System***(40) report indicates that the agency's goal is to promote transportation choices that are reliable, accessible, and cost-effective.

The ***Missouri DOT Tracker: Measures of Departmental Performance***(36) cited a goal of operating a reliable and convenient transportation system.

Metropolitan Transportation Plans

The ***Maricopa Association of Governments' 2040 Regional Transportation Plan***(31) contains many of the big picture, high-level goals seen in other plans, including a goal for reliability: maintaining a reasonable and reliable travel time for moving freight into, through, and within the region.

The ***Southern California Association of Governments Regional Transportation Plan 2012 – 2025***(49) has several key goals, including increasing and maximizing mobility and accessibility for the region's residents and visitors, improving regional economic development and competitiveness, and ensuring travel safety and reliability for all people and goods in the region.

The ***Puget Sound Regional Council's Draft Regional Transportation Plan 2018***(44) has several goals, among which are to improve travel time and reliability, to increase access to jobs, to provide transportation choices, to maintain and preserve the transportation system, and to create a safe and secure transportation system.

The ***Metropolitan Washington Council of Government's Congestion Management Process***(33) states a set of goals that includes ensuring adequate system maintenance, preservation, and safety and maximizing the operational effectiveness and safety of the transportation system. To assess its progress, the council is measuring the percentage of the interstate system providing for reliable travel and the percentage of the non-Interstate National Highway System (NHS) providing for reliable travel.

The ***Atlanta Region's Plan 2040 Regional Transportation Plan (RTP)***(2) also has reliability performance measures that track the percentage of person-miles traveled on Interstates that are reliable, the percentage of person miles traveled on non-Interstate NHS that are reliable, and a truck travel time reliability index.(17)

The ***Birmingham 2040 Regional Transportation Plan***(45) produced by the Regional Planning Commission of Greater Birmingham (Alabama) includes several goals pertaining to developing a sustainable regional transportation system and advancing regional transportation system policies and investments to support economic growth and global competitiveness. A related performance measure is the use of a travel time reliability index.

The **Community Planning Association (COMPASS) of Southwest Idaho's *Communities in Motion 2040***(11) plan contains goals for enhancing the transportation system to improve accessibility and connectivity to jobs, schools, and services and ensuring the reliability of travel by all modes.

Similarly, the ***Pikes Peak Area Council of Government's Moving Forward 2040***(43) plan goals include improving the operation of transportation systems and services to enhance emergency response, minimizing travel times and maximizing service quality for all modes of commercial and private travel throughout the region, improving system connectivity within and between modes and accessibility for everyone, and increasing resiliency and redundancy of the transportation system.

Corridor Plans and Concepts of Operations

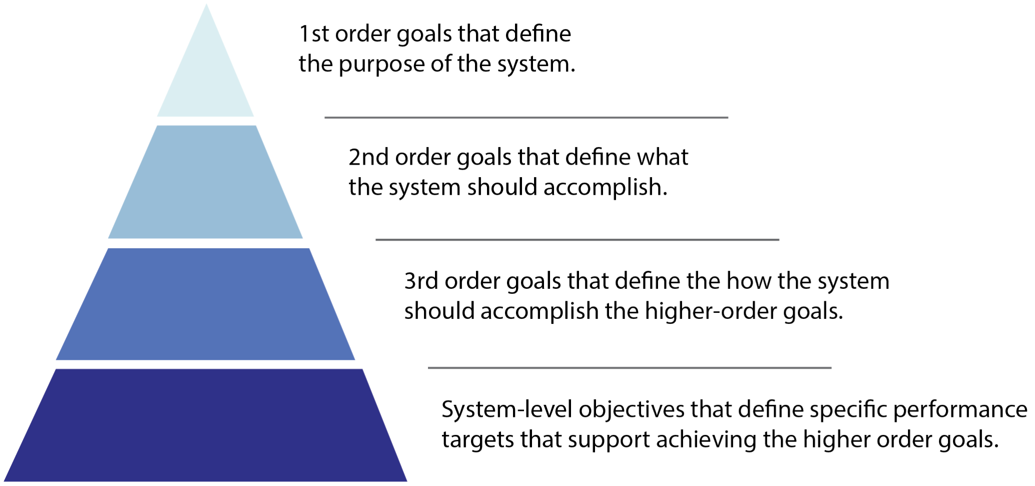
Objectives of the ***Caltrans Interstate 80 and Capital City Freeway Corridor System Management Plan***(3) include reduced travel time or delay; improved connectivity, travel time reliability, and safety; expanded mobility options; and increased access.

The ***Concept of Operations for the US-75 Integrated Corridor***(60) in **Dallas, Texas** has similar goals, such as increasing corridor throughput and improving travel time reliability. Some of its objectives are to reduce overall trip and person travel time through the corridor; improve travel predictability; maximize the efficient use of any spare corridor capacity, such that delays on other saturated networks may be reduced; and improve commercial vehicle operations through and around the corridor.

REPRESENTATIVE GOALS AND OBJECTIVES

This section provides two sets of system-level goals and objectives that the study team developed based on examples found during the environmental scan. One set is for a State-level transportation system and the second set is for a metropolitan region typically associated with the planning area of an MPO.

The goals and objectives were developed in a hierarchy (see Figure 7). At the top level, the "1st order goal" represents the ultimate purpose of the system. Below that, are the "2nd order goals," which describe what the system should accomplish in service of the system purpose. The last level is the "3rd order goals," which describe what system managers should accomplish to achieve the 2nd order goals. The system-level objectives then identify specific performance targets that support achieving the 3rd order goals.



Source: FHWA.

Figure 7. Diagram. Hierarchy of system-level goals and objectives.

Goals and Objectives for a State Transportation System

Below is the set of goals and objectives for a generic State transportation system.

1st Order Goal for State-level System:

- Connect people and goods across all modes to desired destinations within the State or across State (or national) borders.

2nd Order Goals for State-level System:

- Support the **economic vitality** of the State by helping people and goods to access markets efficiently within the State and across State borders.
- Provide for the movement of **emergency management** personnel, supplies, and populations (evacuations) throughout the State and across the State borders to avoid or limit loss of lives, injuries, and property damage during natural or man-made emergencies.
- Provide for **social welfare and livability,** including access to jobs, healthcare, recreation, and education.
- Provide for the **security of the State and Nation** by allowing the movement of military personnel and equipment to destinations required for defense.

3rd Order State-level System Goals:

- Manage **risk** on the system to provide safety, reliable trip times, and system resilience.
- Manage system **resources** toward efficient system performance.

- Provide a system that is **flexible** and provides equitable options for travel.

System-level Objectives:

Safety

Reduce the 5-year rolling averages on all highways and primary arterials within the State for each measure below by X percent within Y years:

- Number of fatalities.
- Rate of fatalities per 100 million vehicle miles traveled (VMT).
- Number of serious injuries.
- Rate of serious injuries per 100 million VMT.
- Number of non-motorized fatalities and non-motorized serious injuries.

Reliability

- Increase the percentage of person-miles traveled on all Interstates within the State that are reliable by X percent within Y years where a reliable road segment is defined as having a level of travel time reliability Z. (Level of travel time reliability is defined as the ratio of the 80th percentile to the 50th percentile using the Federal Highway Administration's (FHWA) National Performance Management Research Data Set (NPMRDS) or equivalent.)

- Increase the percentage of person-miles traveled on all non-Interstates within the State that are reliable by X percent within Y years where a reliable road segment is defined as having level of travel time reliability Z.

- Reduce the truck travel time reliability (TTTR) index on all highways and primary arterials in the State by X points within Y years.

- Reduce the average buffer time needed to arrive on-time for 95 percent of trips (all modes) on [specified routes] by X minutes over Y years.

Efficiency

- Reduce by X percent within Y years the annual hours of peak hour excessive delay per capita where excessive delay is defined as travel on the National Highway System (NHS) within the State at 20 miles per hour or 60 percent of the posted speed limit (whichever is greater).

- Reduce hours of delay (all modes) per capita by X percent by year Y.

Options

- Increase the percentage of trips where there is at least one non-single occupancy vehicle (SOV) modal option that is within 25 percent of the travel time and cost of the SOV trip.

Goals and Objectives for a Regional Transportation System

Below is a set of goals and objectives for a generic regional transportation system.

1st Order Regional System-level Goal:

- Connect people and goods across all modes to desired destinations within the region.

2nd Order Regional System-level Goals:

- Support the **economic vitality** of the region by helping people and goods to access markets and employment efficiently within the region.

- Provide for the movement of **emergency management** personnel, supplies, and populations (evacuations) throughout the region to avoid or limit loss of lives, injuries, and property damage during natural or man-made emergencies.

- Provide for **social welfare and equity** including access to jobs, healthcare, recreation, and education.

- Provide for a healthy environment by promoting **environmental sustainability** and fostering **efficient development** patterns.

3rd Order Regional System-level Goals:

- Manage **risk** on the system to provide safety, reliable trip times, and system resilience.

- Manage system **resources** toward efficient system performance and environmental sustainability.

- Provide a system that is **flexible** and provides equitable options for travel.

Regional System-level Objectives:

Safety

Reduce the 5-year rolling averages on all highways, primary arterials, and secondary roads within the region for each measure below by X percent within Y years.

- Number of fatalities.
- Rate of fatalities per 100 million VMT.

- Number of serious injuries.
- Rate of serious injuries per 100 million VMT.
- Number of non-motorized fatalities and non-motorized serious injuries.

Reliability

- Increase the percentage of person-miles traveled on all interstates within the region that are reliable by X percent within Y years where a reliable road segment is defined as having a level of travel time reliability Z. (Level of travel time reliability is defined as the ratio of the 80th percentile to the 50th percentile using the FHWA's NPMRDS or equivalent.)

- Increase the percentage of person-miles traveled on all non-interstates within the region that are reliable by X percent within Y years where a reliable road segment is defined as having level of travel time reliability Z.

- Reduce the TTTR index on all highways and primary arterials in the region by X points within Y years.

- Reduce the average buffer time needed to arrive on-time for 95 percent of trips (all modes) on [specified routes] by X minutes over Y years.

Efficiency

- Reduce by X percent within Y years the annual hours of peak hour excessive delay per capita where excessive delay is defined as travel on the NHS within the State at 20 miles per hour or 60 percent of the posted speed limit (whichever is greater).

- Reduce hours of delay (all modes) per capita by X percent by year Y.

Sustainability

- Reduce smog-forming pollutants for all vehicle types (daily pounds per capita) by X percent within Y years.(12)

Options

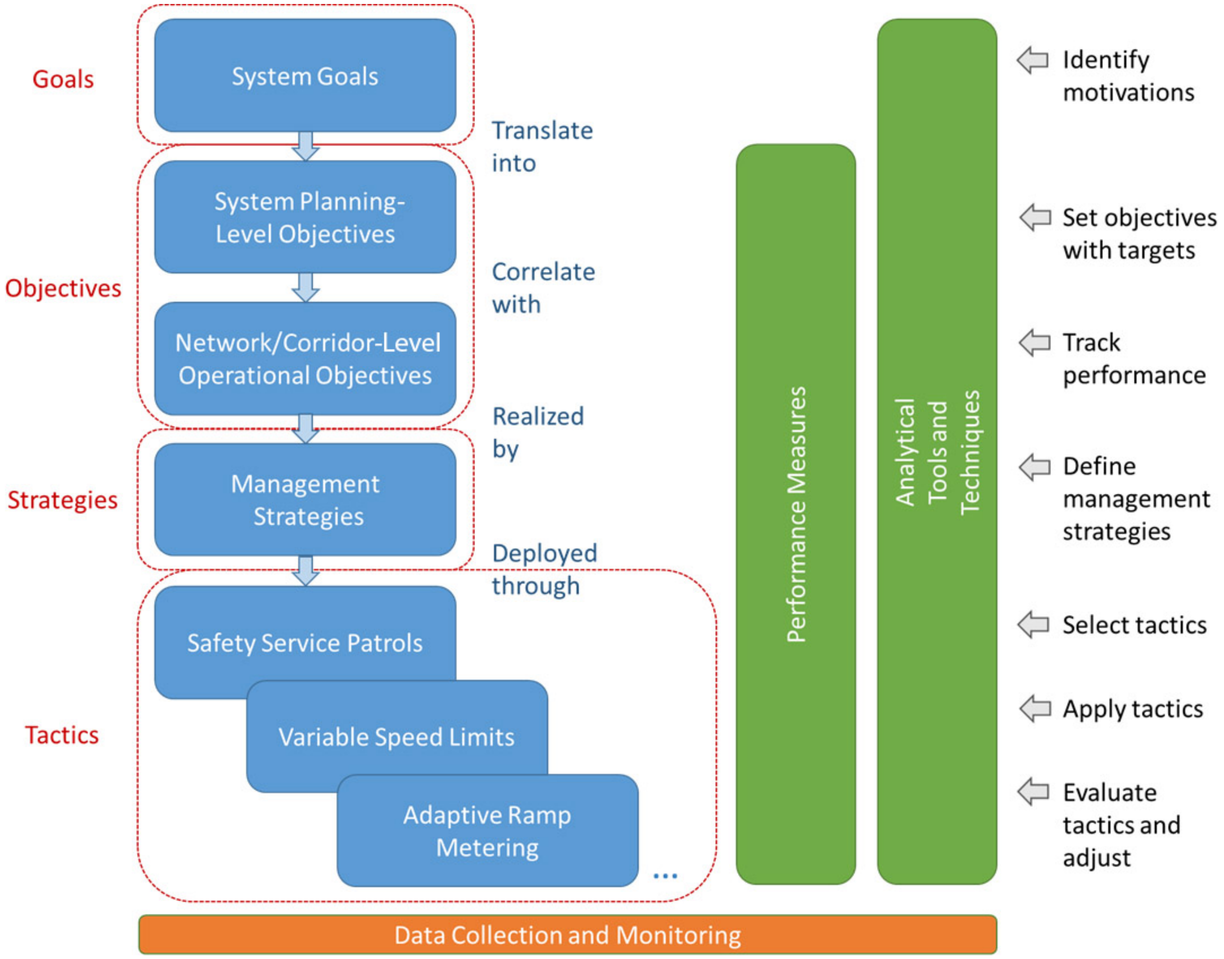
- Increase the percentage of trips where there is at least one non-SOV modal option that is within 25 percent of the travel time and cost of the SOV trip.

- Increase the percentage of homes within one-half mile of a transit stop by X percent within Y years.(12)

CHAPTER 4. TACTICAL PROGRAM AREAS

This section proposes an organizing structure for understanding the relationship between the overall strategies for transportation operations, the underlying tactical program areas, and the tactics or functions that work together to support a strategy. It also describes the implications of the tactical program areas for travel time reliability as well as how reliability data and analysis tools could be used to help implement the tactical areas.

Figure 8 depicts how the goals and objectives feed into the process of identifying strategies and tactics. This section focuses on the strategic and tactical level of the diagram. The strategies and tactics (or functions) of this framework exist within the larger methodology that translates system goals and objectives into network- or corridor-level operational objectives, which are realized by strategies and tactics.



Source: FHWA.

Figure 8. Diagram. Connections between goals, objectives, strategies, and tactics.

For the purposes of this framework, management strategies are defined as the policy or "game plan" for achieving the operational objectives. The management strategies describe the overall approach for solving the issue or meeting the operational need. In this framework, the study team identified three overarching management strategies at a high level. It is possible to characterize management strategies for operations in many other ways, but this categorization is useful for further classifying tactical program areas. Other management strategies will be developed as part of the application of the methodology to the scenarios in the appendix.

The study team first divided the strategies for managing and operating the transportation system into addressing congestion that arises from events or incidents on the system and addressing base-level congestion. The team then further divided the approach to addressing base-level congestion into efforts to impact how much, when, and where demand occurred on the system and efforts to manage existing traffic on the system (figure 9). One may think of this division as distinguishing between supply and demand for transportation.

Source: FHWA.

Figure 9. Diagram. High-level tactical program area framework.

The tactical program areas represent categories of operational tactics, such as road weather management or work zone management. The study team developed these areas primarily based on the Federal Highway Administration (FHWA) Office of Operations' program areas, with some exceptions. This framework separates out those tactical areas that focus on managing demand, such as congestion pricing and travel demand management. The team added freight management to the traffic management category as a specific type of traffic to be managed. The demand management tactical program area includes congestion pricing, parking management, and those strategies that focus on increasing the use of multi-occupant travel modal options (shared-use mobility) such as transit or ride-sharing. Many of these tactical program areas overlap; for example, all of the event- or incident-related tactics are conducted in the context of managing freeways, arterials, or transit services.

The tactics or functions beneath each tactical program area are specific actions that transportation operators or managers can perform in service of an objective. Table 1 maps technologies to the tactical program areas they support. The lists of tactical program areas is not exhaustive, but is meant to be representative of some of the most common tactics associated with a program area. Some tactics cut across several program areas; for example, providing variable speed limits supports the goals of the traffic incident management and emergency transportation operations, work zone management, planned special event management, freeway management, and arterial management program areas, among others. Technology supports most of the tactics listed in the framework and tends to cluster into themes such as surveillance and monitoring systems, information dissemination technologies, and traffic control and decision support systems. These are factors that agencies can take into account when deciding which investments in management and operations will have the greatest impact or application.

Table 1. Mapping operations-related technologies to the tactical program areas they support.

	Road Weather Management	Traffic Incident Management and Emergency Transportation Operations	Work Zone Management	Planned Special Event Management	Freeway Management	Arterial Management	Integrated Corridor Management	Freight Management	Active Traffic Management	Congestion Pricing	Parking Management	Public Transportation and Ridesharing Management
Environmental sensor stations (ESS)	X											
Road weather information systems (RWIS)	X											
Closed circuit television (CCTV) cameras	X	X	X	X	X	X	X	X	X	X		X
Dynamic message signs	X	X	X	X	X	X	X	X	X	X	X	
Flashing beacons atop static signs	X							X		X		
511 systems	X	X	X	X	X	X	X	X	X			
Highway advisory radio	X	X	X									
Websites and smartphone apps	X	X	X	X	X	X	X	X	X	X	X	X
Decision support systems	X	X	X	X	X	X	X		X	X	X	
Transportation management centers (TMCs)	X	X	X	X	X	X	X		X	X		

Table 1. Mapping operations-related technologies to the tactical program areas they support. (Continued)

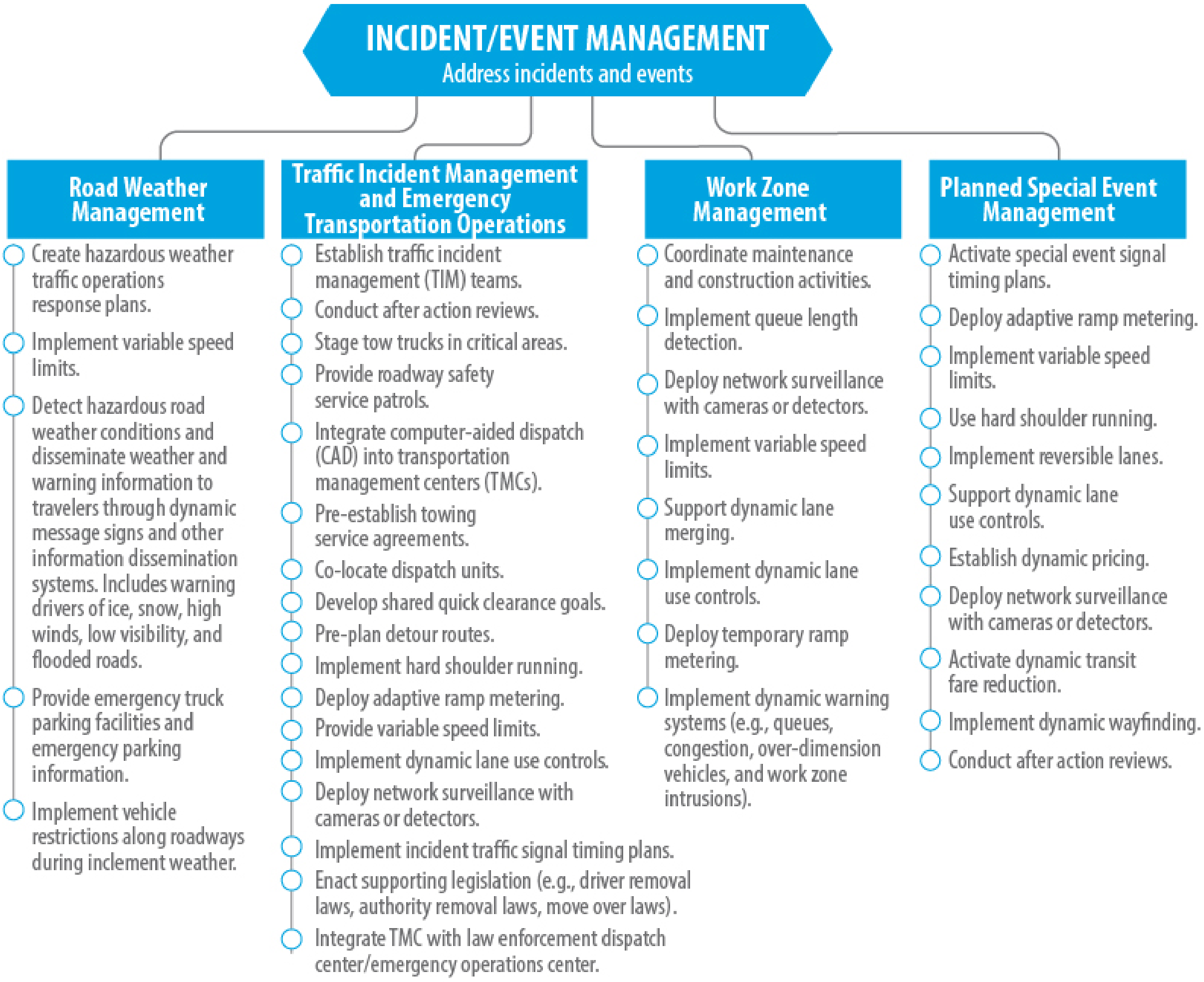
	Road Weather Management	Traffic Incident Management and Emergency Transportation Operations	Work Zone Management	Planned Special Event Management	Freeway Management	Arterial Management	Integrated Corridor Management	Freight Management	Active Traffic Management	Congestion Pricing	Parking Management	Public Transportation and Ridesharing Management
Advanced traffic management systems (ATMS)	X	X	X	X	X	X	X		X			
Signal timing plans	X	X	X	X		X	X		X			
Computer aided dispatch (CAD) systems		X										
Automated crash notification systems		X										
Incident prediction systems		X										
Safety service patrol trucks		X										
Ramp meters and adaptive ramp metering systems		X	X	X	X		X		X			
Signal control systems		X	X	X		X	X		X			
Electronic lane control signs		X	X	X	X	X			X	X		
Variable speed limit signs		X	X	X	X	X			X	X		
Portable electronic traffic control boards		X	X	X		X	X					

Table 1. Mapping operations-related technologies to the tactical program areas they support. (Continued)

	Road Weather Management	Traffic Incident Management and Emergency Transportation Operations	Work Zone Management	Planned Special Event Management	Freeway Management	Arterial Management	Integrated Corridor Management	Freight Management	Active Traffic Management	Congestion Pricing	Parking Management	Public Transportation and Ridesharing Management
Automated queue length detectors			X	X	X					X		
Emergency vehicle signal preemption system						X						
Transit signal priority system						X	X					X
Electronic truck screening systems						X		X				
Truck signal priority systems							X	X				
Truck parking management systems								X				
Electronic toll/payment/fare collection systems										X	X	X
Parking surveillance or detection systems											X	

INCIDENT AND EVENT MANAGEMENT

Incident and event management includes several tactical program areas that address major sources of travel time unreliability (see figure 10).



Road Weather Management

- Create hazardous weather traffic operations response plans.
- Implement variable speed limits.
- Detect hazardous road weather conditions and disseminate weather and warning information to travelers through dynamic message signs and other information dissemination systems. Includes warning drivers of ice, snow, high winds, low visibility, and flooded roads.
- Provide emergency truck parking facilities and emergency parking information.
- Implement vehicle restrictions along roadways during inclement weather.

Traffic Incident Management and Emergency Transportation Operations

- Establish traffic incident management (TIM) teams.
- Conduct after action reviews.
- Stage tow trucks in critical areas.
- Provide roadway safety service patrols.
- Integrate computer-aided dispatch (CAD) into transportation management centers (TMCs).
- Pre-establish towing service agreements.
- Co-locate dispatch units.
- Develop shared quick clearance goals.
- Pre-plan detour routes.
- Implement hard shoulder running.
- Deploy adaptive ramp metering.
- Provide variable speed limits.
- Implement dynamic lane use controls.
- Deploy network surveillance with cameras or detectors.
- Implement incident traffic signal timing plans.
- Enact supporting legislation (e.g., driver removal laws, authority removal laws, move over laws).
- Integrate TMC with law enforcement dispatch center/emergency operations center.

Work Zone Management

- Coordinate maintenance and construction activities.
- Implement queue length detection.
- Deploy network surveillance with cameras or detectors.
- Implement variable speed limits.
- Support dynamic lane merging.
- Implement dynamic lane use controls.
- Deploy temporary ramp metering.
- Implement dynamic warning systems (e.g., queues, congestion, over-dimension vehicles, and work zone intrusions).

Planned Special Event Management

- Activate special event signal timing plans.
- Deploy adaptive ramp metering.
- Implement variable speed limits.
- Use hard shoulder running.
- Implement reversible lanes.
- Support dynamic lane use controls.
- Establish dynamic pricing.
- Deploy network surveillance with cameras or detectors.
- Activate dynamic transit fare reduction.
- Implement dynamic wayfinding.
- Conduct after action reviews.

Source: FHWA.

Figure 10. Diagram. Incident and event management strategy, related tactical operations program areas, and supporting tactics.

Road weather management is a tactical program area that addresses issues related to hazardous weather. It offers tactics, such as operational response plans and variable speed limits that do not eliminate a primary cause of travel time unreliability—poor weather—but have the potential for reducing the impact of weather on travel time reliability. Agencies can collect historical information on weather from the National Oceanic and Atmospheric Administration (NOAA) or commercial websites. This information can be communicated to the public through road weather information systems (RWIS) or used to predict travel time unreliability during operational planning.

Traffic incident management and emergency transportation operations offers a set of tactics to address crashes, non-crash incidents, and other emergency situations. These events can create unexpected delays and contribute to unreliability. Tactics such as traffic incident management (TIM) teams and pre-staged tow trucks allow authorities to clear crashes faster and return roadways to typical operations. Variable speed limits, dynamic lane control, and hard shoulder running allow agencies to take advantage of available infrastructure to prevent unusual travel conditions from worsening. For planning purposes, law enforcement often collects crash records and shares them with transportation agencies. Traffic management centers can collect incident management information, such as dispatch logs, that can be used in planning operational responses to disruptions.

Work zone management allows agencies to control and limit the unexpected delays that work zones impose on travelers. Tactics such as temporary ramp metering coupled with network surveillance help to improve travel time reliability. Agencies can use historical information from construction administration and traffic management incident logs related to road work as inputs in planning future work zone management and in selecting tactics to address traffic impacts.

Planned special event management helps to lessen unexpected delays imposed on travelers not participating in the event as well as improve the travel experience for participants. Special event signal timing plans allow agencies to address the unusual demands associated with special events, while after action reviews promote learning from previous actions. Tactics such as adaptive ramp metering, hard shoulder running, and reversible lanes allow agencies to maximize the use of available infrastructure, while dynamic pricing, wayfinding, and transit pricing work to match travel demand to the available supply. Agencies should share information on planned special events at major neighboring facilities as part of travel time reliability planning.

TRAFFIC MANAGEMENT

While incident or event management strategies address atypical events that cause travel time unreliability, traffic management strategies manage the movement of people and goods during everyday conditions (see figure 11). Even during typical conditions, fluctuations in travel demand can lead to unreliable travel conditions. Traffic management strategies allow the transportation network to adapt to unreliability, including variations in travel demand.

Source: FHWA.

Figure 11. Diagram. Traffic management strategy, related tactical operations program areas, and supporting tactics.

Freeway management and arterial management provide tactics tailored to freeways and arterials, respectively. Tactics such as adaptive ramp metering and enhanced signal timing help agencies use existing infrastructure to respond to unusual peaks in demand. Other tactics, such as truck-only lanes and transit signal priority support improved travel time reliability for goods movement and for transit modes. Historical data on travel times collected by sensors or probe vehicles can help agencies plan operational responses to unreliable travel on freeways and arterials.

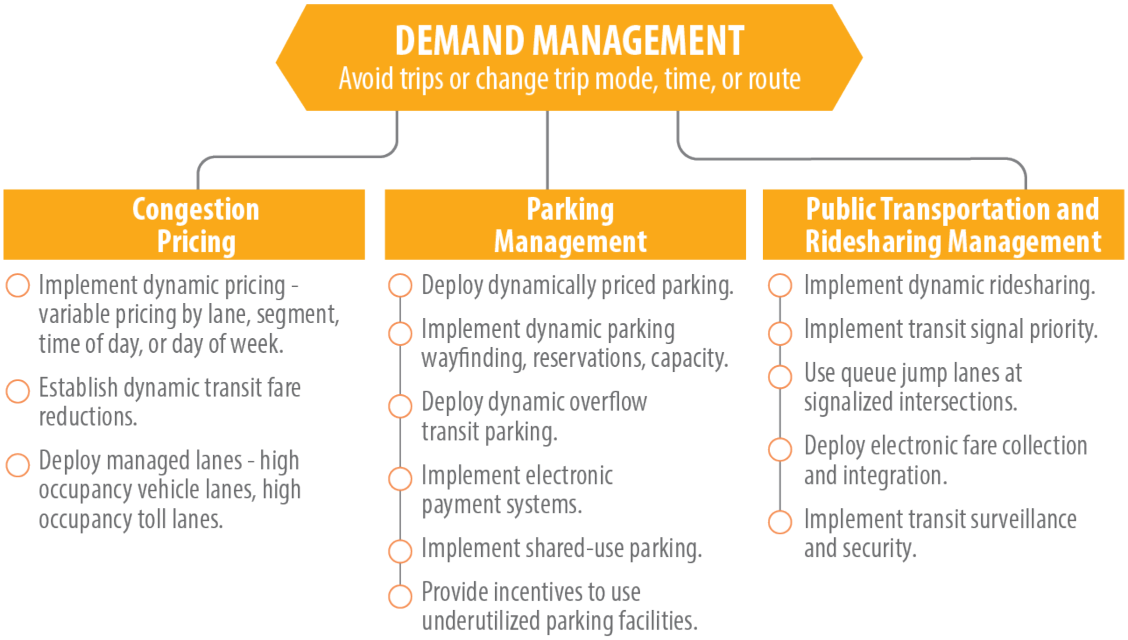
Active traffic management offers a more robust response to changing traffic conditions. Tactics like dynamic lane use, hard shoulder running, and dynamic warning signs allow agencies to modify the available supply of roadway infrastructure to current conditions, particularly changes in travel demand. These tactics can work in tandem with incident and event management tactics to address other causes of unreliability, such as weather, special events, and incidents. Active traffic management requires detailed data on current traffic conditions, short-term forecasts of future conditions, and predictions of how traffic responds to tactics based on historical data.

Integrated corridor management tactics leverage the capacity available across modes to better match infrastructure with travel demand. These tactics can be adaptive and allow agencies to respond to travel time unreliability. Many of the tactics in use by agencies deploying an integrated corridor management (ICM) initiative support other tactical program areas. ICM tactics require data from transit agencies and other modes.

Freight management tactics provide options for freight handlers and carriers to mitigate unreliable travel conditions for both trucks and other travelers. For example, truck signal priority makes last-mile freight travel more reliable, and truck climbing lanes reduce delay impacts to other vehicles. Tracking logistics information, data on freight flows, and detailed information on freight networks help with planning for freight management.

DEMAND MANAGEMENT

Demand management provides tactics that reduce underlying demand by helping travelers avoid trips or change the mode, timing, or route of trips (see figure 12). This makes non-recurring congestion less likely to occur and improves travel time reliability.



Source: FHWA.

Figure 12. Diagram. Demand management strategies, related tactical operations program areas, and supporting tactics.

Congestion pricing offers dynamic tactics that make travel on roadways less attractive or alternative modes more attractive in response to demand. This allows transportation infrastructure to accommodate variations in demand, resulting in more reliable travel times. Congestion pricing requires detailed information on traffic and demand elasticity estimates. High occupancy toll and managed lanes require additional information on vehicle occupancies, while dynamic transit fare reductions require data on transit fares, schedules, and capacity.

Parking management matches parking supply to fluctuations in demand. These tactics are generally not related to travel time reliability, but dynamically priced parking can moderate variations in travel demand, which is one cause of travel time unreliability. Effective parking management requires information on parking availability and demand.

Public transportation and ridesharing management provides modal alternatives to single occupant vehicle travel. While these strategies do not address the causes of travel time unreliability directly, they can help to reduce demand during high peak periods. Implementation requires data on traveler origins and destinations, desired travel times, and transit schedules.

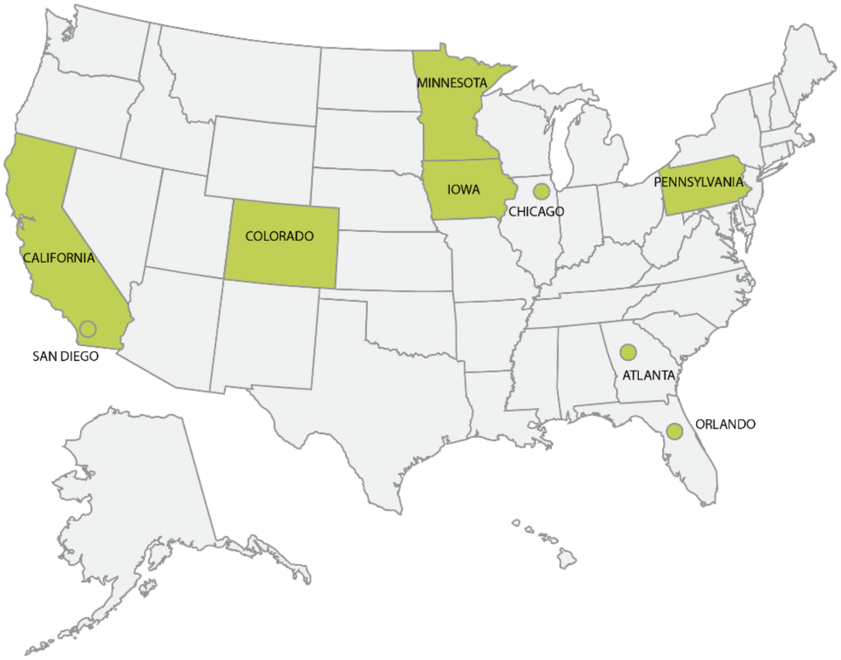
CHAPTER 5. TECHNICAL EXPERT GROUP WORKSHOP

On June 28, 2018, the team held an expert group workshop for this project in Arlington, Virginia, at the National Highway Institute. The purpose of the workshop was to assess advancements made by several agencies in the use of travel time reliability within transportation system management and obtain feedback on a strawman methodology to incorporate travel time reliability into transportation system management at various levels.

Workshop participants included nine transportation planning and operations professionals from State departments of transportation (DOT) and metropolitan planning organizations (MPO) across the United States to discuss their experiences and the project's methodology.

Representatives from the following State and regional organizations attended:

- Colorado DOT (CDOT)
- MetroPlan Orlando
- California DOT (Caltrans)
- Atlanta Regional Council (ARC)
- San Diego Association of Governments (SANDAG)
- Pennsylvania DOT (PennDOT)
- Minnesota DOT (MnDOT)
- Iowa DOT (IDOT)
- Chicago Metropolitan Agency for Planning (CMAP)



Source: FHWA.

Figure 13. Diagram. Map of the United States with geographic locations of technical expert group participants.

Table 2 contains the agenda and objectives for the workshop.

Table 2. Technical expert group agenda.

Workshop Objectives: • Gain insight into the application of reliability analysis at expert agencies. • Test methodology for applying transportation operations reliability program analysis. • Identify additional tactical programs or application scenarios that methodology should encompass. • Begin a dialog on integrating travel time reliability analysis into transportation system management.	
9:00 am	Welcome and Introductions • Federal Highway Administration welcome. • Participant introductions. • Workshop overview.
9:30 am	Project Background and Motivation
10:00 am	Presentations from Peers on Use of Reliability Analysis and Concepts in Transportation Systems Management and Operations (TSMO) Program Activities and Planning for Operations • Examples of system-level goals and objectives. • Examples of tactical program areas.
11:30 am	Presentation and Discussion of Strawman Methodology for Applying Reliability Analysis to Translate System-Level Goals down to Tactics for System Management
12:30 pm	Lunch
1:30 pm	Small Group Activity: Applying Methodology to Hypothetical Scenarios
2:30 pm	Report Back and Feedback from Breakout Groups
3:00 pm	Methodology Review • Discussion and review of core components of methodology in light of feedback from breakout groups.
4:00 pm	Adjourn

INTEGRATING RELIABILITY ANALYSIS AND CONCEPTS INTO SYSTEM PLANNING AND TRANSPORTATION SYSTEMS MANAGEMENT

The project team led a presentation and discussion on the reliability data and analysis tools that are available to help agencies and MPOs examine alternative strategies for addressing reliability issues and forecast impacts. Participants discussed needing specialized modeling staff to use some of the tools and the challenges to using many of the tools this presents. The representative from one organization said that his agency tried mesoscopic modeling, but applying the tool to 50 or 200 projects took too much effort and time, and they had to abandon the practice pretty quickly. Vendors are starting to incorporate these tools into their modeling packages, but in the long term, reliability thinking and analysis need to be incorporated into the standard tools, according to workshop participants.

The State and local agency participants reported on their experiences integrating reliability analysis into systems planning and transportation systems management. Participants were asked to provide information about how their agencies have used reliability analysis and concepts in TSMO program activities and planning for operations and to provide examples of using system-level goals and objectives to influence the selection of operations activities within their agency.

Notable examples of reliability in plans include Caltrans using travel time reliability in the strategic objectives, performance measures, and targets (buffer time index) presented in the 2015 *Caltrans Strategic Management Plan*.(5) IDOT developed a TSMO strategic plan that included reliability as a goal, and then connected those strategic goals and objectives to its TSMO service layer plans. MetroPlan Orlando is planning to include new performance measures, including reliability, as part of the update of its long-range transportation plan.

The participants in the workshop are also making progress on developing or using analysis tools that incorporate reliability or operations. Caltrans is working with the University of California, Berkeley, to develop a tool similar to FREEVAL. MnDOT developed a travel time analysis system for the Twin Cities metro area with the University of Minnesota, Duluth. MnDOT tested many of the Second Strategic Highway Research Program (SHRP2) tools with a consultant but it is having challenges implementing the tools themselves in their agency. PennDOT is developing a tool similar to the SHRP2 L02 tool to supporting monitoring reliability.

There was also a discussion of using reliability measures and data for project evaluation. MetroPlan Orlando will be giving projects that improve reliability more weight during future prioritization processes. CMAP uses reliability measures as part of its reliability evaluation processes in a number of activities, including Congestion Mitigation and Air Quality (CMAQ) funding. State partners at Illinois DOT have started to do this for their freight plan as well. CMAP has identified some of the procedures using the SHRP2 L07 project to support evaluations on the regional plan. CMAP is mainstreaming this as well as analytics into its regular processes. This has resulted in more TSMO activities on the ground, according to the CMAP representative. CDOT relies heavily on local knowledge and experience to identify operational needs and strategies, but they are not yet measuring these things or depending on performance measures.

STRAWMAN METHODOLOGY FOR APPLYING RELIABILITY ANALYSIS TO TRANSLATE SYSTEM-LEVEL GOALS TO TACTICS FOR SYSTEM MANAGEMENT

The project team presented a strawman methodology for applying reliability analysis to translate system-level goals down to tactics for system management and discussed the relationship between goals, objectives, strategies, and tactics. The strawman methodology starts with the goals, which are translated into objectives, which are realized by strategies, which are deployed through tactics. To evaluate how well the operational tactics satisfy the goals, data collection and monitoring are important.

The strawman methodology is outlined as follows:

1. Establish system-level goals. These are mission statements of what the agency wants to do.

2. Develop system-level objectives and set targets. The goal is made more robust and includes a target.

3. Develop corridor/network-level objectives and set targets. When defining tactics, it is necessary to circle back to the objectives to see if the objectives are realistic and achievable given the tactics. Circling back allows agencies to see what is feasible to achieve.

4. Define management strategies to realize corridor- or network-level objectives.

5. Select tactical program areas and tactics to implement management strategies.

Participants observed that many agencies do not apply steps 3 (developing corridor/network level objectives and setting targets) and 4 (defining management strategies to realize corridor- or network-level objectives); instead, they jump straight to selecting tactics. This also led to a discussion about the need to create a plan (or a milestone within a 20-year plan) that has a shorter time horizon (e.g., 10-year) so as to align better with the shorter term timeline of TSMO projects and objectives.

The participants were divided into two groups to work through a different hypothetical scenario with the strawman methodology. Participants discussed system goals, system-level objectives, and data for analysis; defined management strategies; and selected tactical program areas and tactics.

METHODOLOGY REVIEW AND KEY TAKEAWAYS

The participants discussed the methodology in light of the small group activity. Participants mentioned that they thought this methodology would be helpful, although one participant mentioned that he did not think it was much different from the congestion management process.

Key takeaways from the discussion and exercises can be summarized as follows:

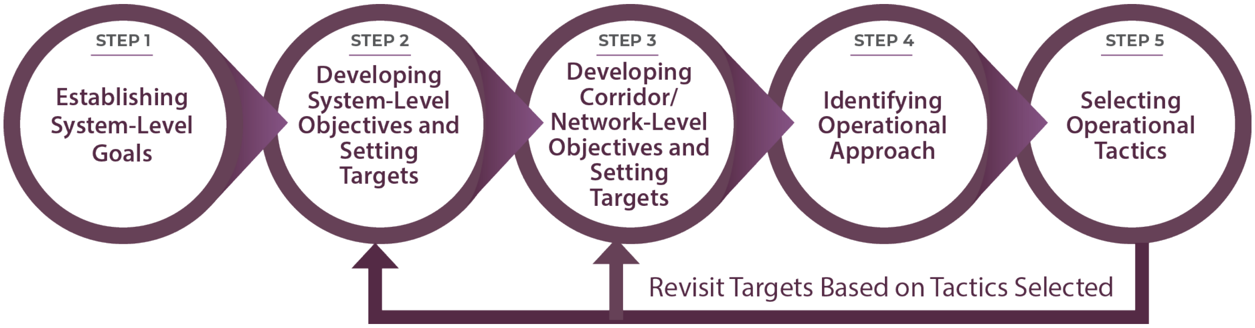
- There is a benefit to having traffic engineers and operations engineers both as part of the planning process, and this methodology helps them find a place to meet in the middle.
- Participants viewed it as more of a new way of thinking versus a new process.
- The methodology can be tailored for different audiences or projects, and likely will not be used for every individual project.

CHAPTER 6. METHODOLOGY FOR LINKING GOALS TO TACTICS

This section describes an analytical methodology based on the materials presented at the workshop. Hypothetical scenarios that illustrate the application of the analysis framework are presented in the appendix.

OVERVIEW

This section proposes a five-step methodology or process that provides a connection from system-level goals and objectives developed at the planning level to more detailed operational objectives, operational approaches, and tactics. This methodology recommends the use of reliability data and analysis tools (RDAT), when available, to move from one step to the next. By using this methodology, the operational tactics or actions taken to manage the transportation system are derived from and contribute to system-level goals and objectives. This methodology is shown in figure 14.



Source: FHWA.

Figure 14. Diagram. Five-step methodology for linking system-level goals to the selection of operational tactics.

The appendix demonstrates the use of this methodology in four scenarios. Two of the scenarios show how this methodology could be used for a corridor within a State and the other two scenarios are from the perspective of a small and large metropolitan region. The appendix provides a graphical illustration of the sample corridors and regions and detailed flow diagrams containing abbreviated output from each step and the connections between the steps. It walks through each step of the methodology for each scenario and discusses the applicability of reliability data and analysis tools for supporting those steps.

Below is a description of each of the steps of the methodology and the data and analysis tools that agencies and planning organizations may use to support that step. This methodology may not be conducted from beginning to end by the same staff members or organization. The methodology begins in the area of system-level transportation planning in Step 1 and moves into the traditional purview of transportation operators and engineers by Steps 4 and 5. While the lead or ownership of the methodology may shift across the steps, it is important for planners to inform the later steps and operators to provide input to the earlier steps. This involvement from planners and operators helps to bridge the gap normally experienced between the two disciplines.

STEP 1: ESTABLISHING SYSTEM-LEVEL GOALS

System-level goals are high-level goals for the surface transportation system. They are derived through the connection of the general purposes of transportation, local views regarding the unique aspects of the community, and the community's current challenges. Both local challenges and unique community preferences are termed motivators as part of the proposed methodology and they must be articulated and available for Step 1 of the process, which is to develop system-level goals.

***Application of Reliability Data and Analysis Tools (RDAT)*:** The Second Strategic Highway Research Program (SHRP2) L05 performance measures guide provides guidance on incorporating reliability into transportation system (and agency) goals.(52) In addition, at the goal-setting stage, a useful reliability tool is the travel time reliability monitoring system (TTRMS), described in the SHRP2 L02 monitoring guide.(55) If a region had such a system in place, it could be used to help identify some of the motivators that guide the development of system goals.

STEP 2: DEVELOPING SYSTEM-LEVEL OBJECTIVES AND SETTING TARGETS

The second step of the methodology is to develop system-level objectives and set targets. In this step, more aspirational goals must be distilled into specific areas of focus. The methodology employs the SMART definition of the system objectives, meaning that each objective derived from a goal should be **s**pecific, **m**easurable, **a**greed-upon, **r**ealistic, and **t**ime-bound (SMART) while supporting at least partial achievement of the associated system-level goal. Setting objectives also requires understanding the context of the system and community within which the goal has been established. For example, transportation is about connectivity, yet for rural communities connectivity may necessarily focus on removing physical bottlenecks while urban community connectivity may be about providing system options. To have a measurable objective, the establishment of system-level goals must be carefully framed around specific performance measures that describe progress toward the goal. Background information on selecting performance measures is available on the Federal Highway Administration (FHWA) website.(21)

After determining system-level objectives, Step 2 includes the setting of targets. There are two important elements to target setting. The first is electing the appropriate performance measure. If the system-level objective is SMART, the performance measure is often embedded within the objective. The second element to target setting is determining the amount of improvement that can be accomplished within the anticipated resources. At this stage in the methodology, targets can be estimated but they will need to be re-visited after planners better understand the expected impacts of the selected strategies and tactics.

Application of RDAT Tools: At the stage of setting system-level objectives and targets, the primary usefulness of RDAT tools is in the establishment of existing and historical conditions to support the following:

- Set a baseline: The SHRP2 L02 monitoring guide details methods to acquire, impute, visualize, and manage such data. It also covers a variety of use cases. The SHRP2 L05 performance measures guide describes ways to roll this data into system-wide visualizations and assessments.(52) Setting the baseline allows the analyst to identify existing systematic reliability problems, which in turn can guide the process for establishing objectives at a high level. It is important at the data collection stage to be thinking about how predictive RDAT tools (such as the SHRP2 L07 evaluation tool, FREEVAL, and the C11 Benefit-Cost Analysis tool) will be used to evaluate strategies and tactics in Steps 4 and 5 so that the data collection ultimately can be used in comparisons of unimproved and improved conditions.(56)(51)(54)

- Identify sources of congestion: Knowing the sources of system-wide congestion (both recurring and non-recurring) can help agencies focus their system-wide objectives. Because the data collection for reliability statistics is at a granular level, operating agencies and planning organizations can use the data to identify individual segment and corridor deficiencies and to help identify sources of congestion by correlating reliability data with weather, incident, special event, and work zone data.

- Establish system-level performance measures: The SHRP2 L05 guide provides assistance with developing system-level measures, most notably by methods to aggregate measures from the corridor level to the system level.(52)

- Set thresholds: The SHRP2 L05 guide provides direction and examples related to setting reliability thresholds. The L05 guide gives guidance on incorporating reliability into goals and objectives, and is a useful reference at this stage of the evaluation.(52)

STEP 3: DEVELOPING CORRIDOR/NETWORK-LEVEL OBJECTIVES AND SETTING TARGETS

Network- and corridor-level objectives are derivatives of system-level objectives and are connected to a much more specific geographic context. Between Step 2 and Step 3, it can be common for the leaders or owners of this process to change from transportation planners to operations engineers. During that switch, there can be a tendency to either skip Step 3. The goal of this methodology is to resist the urge to identify tactics from the system-level objectives and the corridor or network context and instead to subdivide the system-level objectives into corridor- or network-level objectives. Each corridor- or network-level objective can then be an interrelated piece of an overall solution rather than a purpose and need statement for a narrowly defined design project or solution.

Application of RDAT Tools**:** At the corridor and network level, RDAT tools have a level of usefulness similar to that at the system level. In fact, as mentioned in the Step 2 narrative, system-level performance measures must be built up or aggregated from the corridor or segment level. Thus, the applications described in the Step 2 narrative—setting a baseline, identifying sources of congestion, establishing performance measures, and setting thresholds—also apply to Step 3, and the same RDAT tools are relevant.

STEP 4: IDENTIFYING AN OPERATIONAL APPROACH

Identifying an operational approach and defining supportive tactical program areas is Step 4 of the methodology. If the corridor/network-level objectives have been defined in a user-focused manner, the choice of tactical program areas may be the first time that the agency engages in discussions of whether the objectives are best met through a design treatment, operations strategy, or revised business process. Context filters down in this step through corridor/network-level objectives, but also must be considered in the review of tactical program areas to avoid applying strategies misaligned with the corridor/network context. In this step, a universe of tactical program areas is available and then assessed against corridor/network-level objectives.

Application of RDAT Tools: Once performance thresholds are defined in Steps 2 and 3 and data has been collected to establish a baseline, identifying areas with reliability issues (not meeting performance targets) can support the selection of tactical program areas to address these issues. The SHRP2 L02 monitoring guide and L05 performance measures guide both describe the ways to calculate and visualize performance measures, and L05 addresses comparing them to targets.(55)(52)

STEP 5: SELECTING OPERATIONAL TACTICS

Selecting operational tactics in Step 5 requires expert judgment of leaders within each tactical program area to determine how well the corridor or network fits with potential tactics. The experts within each area must be consulted in a collaborative fashion to negotiate the best selection of assorted tactics from divergent tactical program areas to make sure each tactic is applied in a complementary fashion. A lack of coordination during this stage may lead to tactics in one program area that call for using physical space on the roadway or designating a specific tactical area to support one objective that, based on design, could be in contrast with another corridor- or network-level objective. An integrated approach to selecting tactics allows the tactics to be applied in a cooperative fashion and can help rule out tactics that do not support the greater aim.

Application of RDAT Tools: At the tactics stage, predictive reliability tools come into play. These tools are designed to forecast outcomes of various tactics, and these outcomes can be used to extract predicted performance measures consistent with those selected in Steps 2 and 3.

- FREEVAL (as updated in SHRP2 L08) allows the user to manipulate inputs that affect non-recurring congestion: incidents (frequency and duration), demand variations (month and day-of-week), and work zones (type, physical extent, duration, etc.).(51) FREEVAL generates a series of scenarios and builds a travel-time distribution, from which various reliability performance measures can be extracted. FREEVAL is strictly for freeways and operates at a corridor level.

- STREETVAL, a related software tool, allows analysis similar to FREEVAL, but for arterial corridors.(53)

- The SHRP2 L07 tool, like FREEVAL, is freeway-based, but is primarily geared toward highway design treatments (as opposed to operational strategies and tactics). It does offer customizable treatment options that could allow operational strategies to be analyzed as well. The tool provides reliability statistics at the segment (not corridor) level (using the SHRP2 L03 "data rich" models). It also provides monetized benefit estimates.(56)

- The SHRP2 C11 Accounting Framework tool has a reliability module that allows users to calculate reliability metrics and congestion costs at the freeway segment (not corridor) level (using the SHRP2 L03 "data poor" models).(54)

The RDAT tools require the user to map the effects of tactics to changes in tool inputs. The L07 report provides guidance in this area.

CHAPTER 7. NEXT STEPS

The goal of this effort was to develop and demonstrate a methodology for integrating travel time reliability concepts and analysis into ongoing transportation system management activities and programs as well as into transportation system management strategies and operational tactics at the network and corridor levels.

This section describes several actions that the Federal Highway Administration (FHWA) or other organizations can take to advance this methodology with planners and system managers and operators at State and local departments of transportation and metropolitan planning organizations. The practitioners who participated in this project's workshop stated that they thought this methodology would help planners and operators find a way to "meet in the middle" and connect the planning goals and objectives with the more detailed operational objectives, strategies, and tactics.

CONTINUED REFINEMENT OF THE OVERALL APPROACH

This research highlights the need to refine, harmonize, and integrate the collection of processes for planning, implementing, and managing transportation systems, beginning with long-range transportation system planning and extending to corridor- or facility-level systems engineering and tactical deployment. The methodology developed through this project provides a conceptual framework for linking these processes into an integrated and holistic approach that enables planners and operators to connect their plans in ways that ensure responsiveness to higher level plans, which are informed by operational needs, opportunities, and possibilities. This effort complements but does encompass or replace other related methodologies and processes that also support planning for operations.

Continued refinement of this framework should further explore correlations between this methodology and other processes to create a unified process that harmonizes terminology, anticipates the integration of emerging transportation services and technologies, and identities opportunities to overcome structural constraints (e.g., funding timelines, institutional silos) that obstruct a seamless approach to systems management from planning through implementation.

OUTREACH, COMMUNICATIONS, AND TECHNICAL ASSISTANCE

Currently, the methodology is not in a format that is easily understood and adopted into existing processes. Communications products such as a brochure and presentation could be developed to explain the methodology to each primary audience and why it would benefit them. As part of adopting this methodology, planners and operators in the same region or State would need to work together to identify how to use this methodology to connect their efforts. Providing a facilitated forum for planners and operators to convene in a region or State and be led through these discussions would help with adapting their current practices.

ANALYTICAL FOUNDATION FOR METHODOLOGY

As noted by the workshop participants, many of the analysis tools currently available to evaluate reliability and operations strategies require highly skilled staff or outside consultants. While some tools or methods can help agencies with this methodology, as mentioned in previous sections of this report, more is needed to reduce this obstacle to using the methodology with quantitative analysis. This methodology may benefit from guidance on how to more definitively identify operational strategies or tactics that will help achieve operational objectives.

ENRICHING OF MANAGEMENT STRATEGIES

One step in the methodology that could use more research and definition is the development of management strategies for a corridor or network. While this is meant to represent an overarching strategy for reaching the operational objectives, it tends to be more of a collection of tactical program areas. This is key to helping agencies develop the management portion of TSMO as opposed to just operating the system.

PILOT TESTING

Testing the methodology in multiple States or regions could provide FHWA valuable insights into its strengths and weaknesses so that it can evolve and improve the methodology for greater acceptance across the United States. The pilot sites could also serve as examples that can draw the interest of other States or regions in using the methodology.

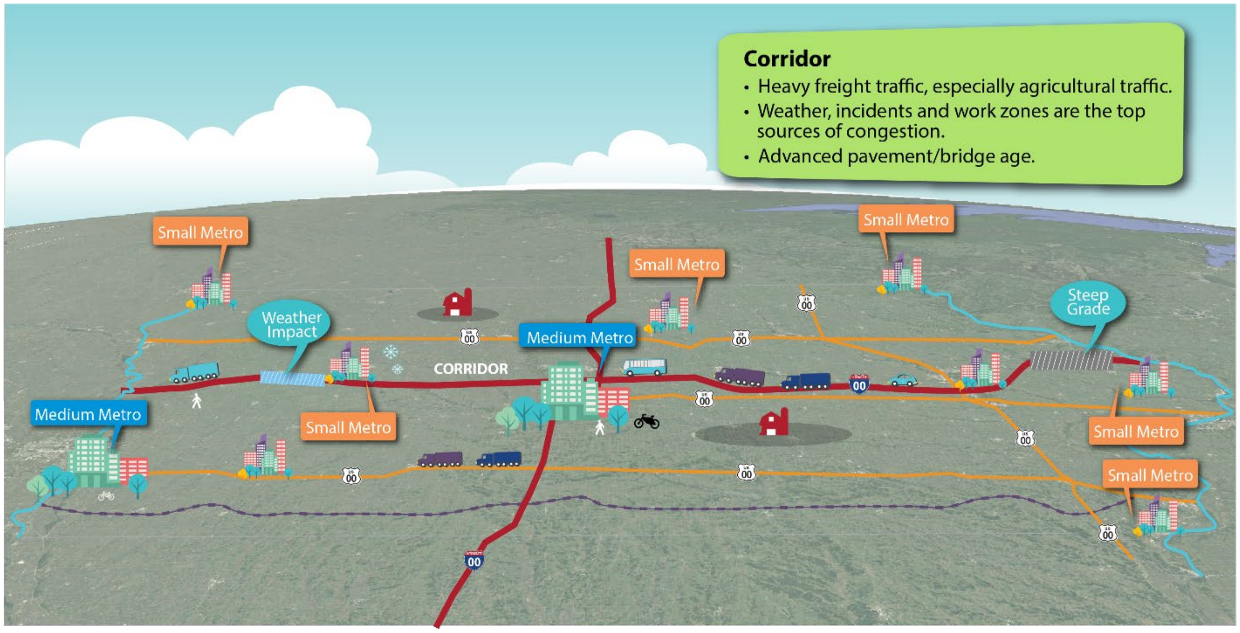
APPENDIX. HYPOTHETICAL SCENARIOS

The appendix presents the application of the methodology to four hypothetical scenarios developed in the project:

- Scenario 1: Statewide Rural Interstate Corridor.
- Scenario 2: Freight Corridor Important to Interstate Commerce.
- Scenario 3: Small City.
- Scenario 4: Large Urban Subarea.

SCENARIO 1: APPLICATION OF METHODOLOGY TO STATEWIDE RURAL INTERSTATE CORRIDOR

This section describes the first of four scenarios that will be used to illustrate the methodology. Scenario 1 is focused on a rural, east-west interstate corridor, as illustrated in figure 15.



Source: FHWA.

Figure 15. Map. Scenario 1: A rural east-west interstate corridor and geographic context.

Context of the Statewide Rural Corridor

The geographic, multimodal, and freight transportation context for the corridor is described below. It should be assumed that transportation agencies within the State have a baseline of operational capabilities on which to build.

Geographic Setting

- The State is inland with a mostly flat topography.

- The State's land area is approximately 50,000 square miles, and is within the middle third of U.S. States for land area.
- The State has a single east-west corridor over a distance of 300 miles that is dominated by an interstate with distant parallel State highways. A second corridor serves traffic traveling north and south.
- The east-west interstate is the focus corridor.

National Highway System and Freight Context

- Multiple interstate highways and routes on the National Highway System cross the State.
- The main interstate corridor experiences heavy east-west travel between the coasts and major metropolitan areas.
- The east-west corridor also carries interregional travel and intra-city traffic for a small metropolitan region located along the corridor.
- The freight system relies heavily on long-haul trucking to carry intrastate freight and primarily utilizes short-haul trucking to freight hubs for locally produced goods.
- An extensive freight railroad network crisscrosses the State, primarily carrying commodities through the State. A freight rail line parallels the east-west interstate corridor.

Population

- The State population is less than five million.
- The State includes 10 small to medium sized metropolitan areas (greater than 50,000 population).
- Five of the relatively larger metropolitan areas are connected by the east-west corridor. Other metropolitan areas are dispersed with several founded as river-based communities and now operating as multistate metropolitan areas.

Highway Characteristics and Usage

- The State contains one nationally significant east-west interstate corridor and one nationally significant north-south interstate corridor.
- The State includes several other regionally significant U.S. highways and portions of State highways that support interstate commerce.
- The two largest metropolitan areas have more extensive National Highway System (NHS) coverage connecting suburban communities to the urban core.
- The focus corridor runs 300 miles in the State, through five metro areas and rural land areas.
- The corridor's pavement and some bridges are nearing the retirement stage.
- Nearly 30 percent of the volume on the corridor are freight trucks. Freight growth is expected to continue to increase dramatically over the next 30 years.
- The corridor experiences hot summers and snow-filled winters, leading to maintenance and operation challenges to preserve pavement quality while maintaining traffic flow.

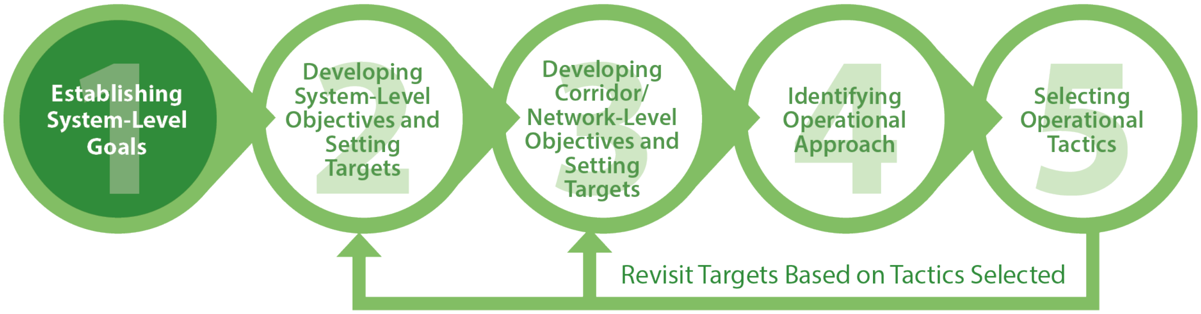
- The corridor experiences predominantly non-recurring delays in rural areas from work zones, severe weather, and traffic incidents.

Multimodal Network

- People use predominantly single occupancy vehicles (SOVs) for the journey to work in metropolitan areas.
- Larger metropolitan areas have fixed-route buses and demand-responsive service for the mobility impaired.
- The State has a strong recreational bike and pedestrian culture, predominantly around urban special uses or the mature scenic trails network.
- The corridor of focus carries exclusively passenger cars and trucks, except where crossing metropolitan boundaries and buses are in operation on the highway.

Establishing System-Level Goals

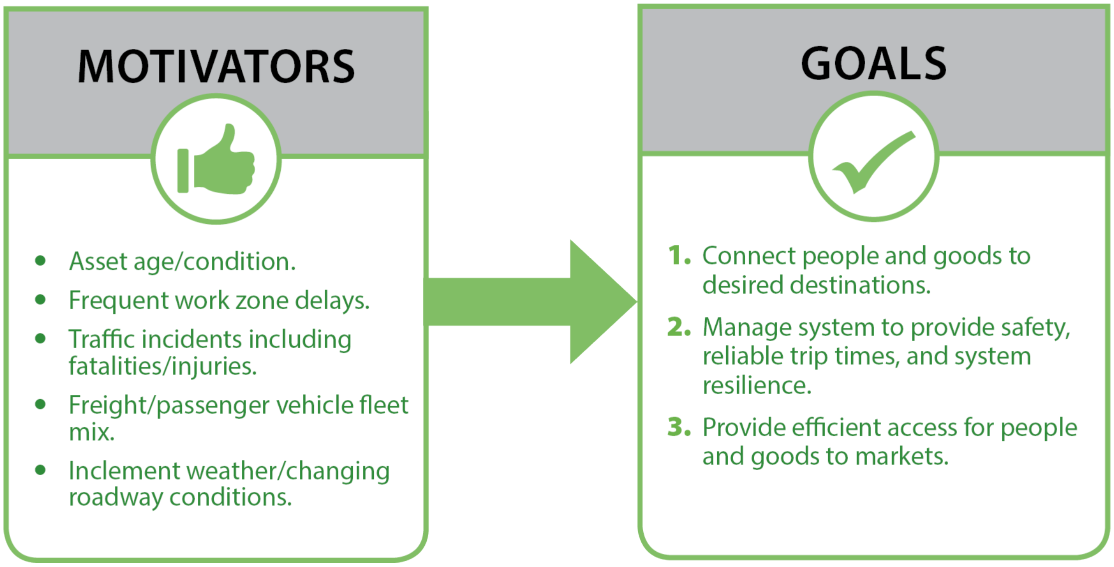
The development of system-level goals is the first step in the methodology (figure 16). System-level goals are derived from the list of motivators as shown in figure 17.



Source: FHWA.

Figure 16. Diagram. Scenario 1: The first step of the methodology is establishing system-level goals.

Application of Reliability Data and Analysis Tools (RDAT): At the goal-setting stage, a useful reliability tool is the travel-time reliability monitoring system (TTRMS) described in the Second Strategic Highway Research Program (SHRP2) L02 monitoring guide. It could be used to help identify some of the motivators listed in figure 17—most notably in this scenario, work zone delays, incidents, and inclement weather.

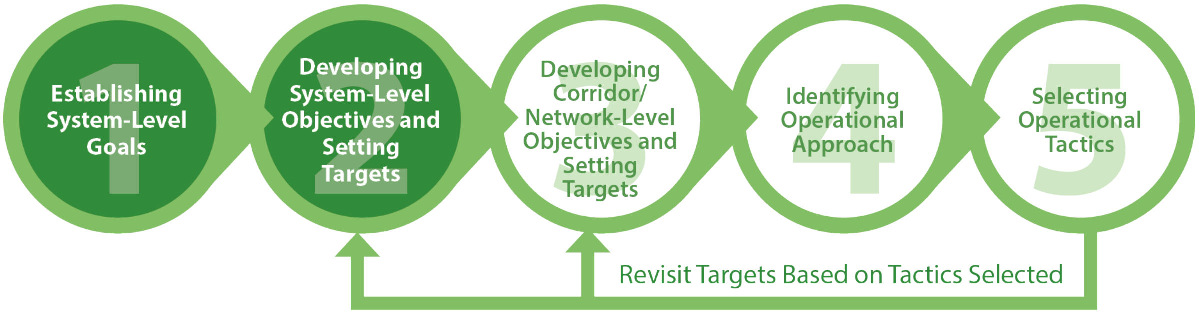


Source: FHWA.

Figure 17. Diagram. Scenario 1: Motivators for improvement in the corridor lead to goals.

Developing System-level Objectives and Setting Targets

The second step of the methodology is developing system-level objectives and setting performance targets, as shown in figure 18.



Source: FHWA.

Figure 18. Diagram. Scenario 1: The second step of the methodology is to develop system-level objectives and set targets.

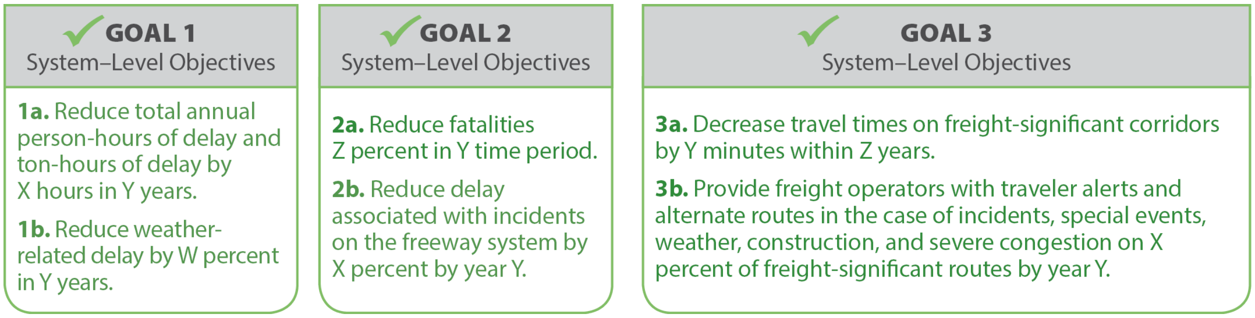
Application of RDAT Tools: At the stage of setting system-level objectives and targets, the primary usefulness of RDAT tools is in the establishment of existing and historical conditions to support the following:

- Setting a baseline: Collecting system-wide travel-time data along a statewide corridor can be a challenging task. The SHRP2 L02 monitoring guide and SHRP2 L05 performance measures can support this step. In this scenario, travel-time distributions, especially in the rural areas, would have a long tail (i.e., a large number of times far from the center of the distribution) due to the contributions of non-recurrent congestion. This could be further analyzed by breaking down congestion sources, which could then influence objectives.

- Identifying sources of congestion: In this scenario, Objective 2b (figure 19) is related to delay associated with incidents. Although infrequent in rural areas, incidents can have significant effects on travel times due to limited capacity on rural facilities as well as limited options for diversion. Objective 3b, related to travel alerts for freight operators, is similar but broader, covering incidents, work zones, special events, and weather.

- Establishing system-level performance measures: Although many of the measures described below are more related to average delay and not variation in delay, reliability measures are worth developing at this stage.

- Setting thresholds: At the statewide level, it is important to keep measures disaggregated by facility type, because the reliability issues on rural facilities are much different than those on urban and suburban facilities. The L05 handbook discusses setting thresholds based on data from comparable national corridors versus setting them based on local expectations.



✓ **GOAL 1**
System–Level Objectives

1a. Reduce total annual person-hours of delay and ton-hours of delay by X hours in Y years.

1b. Reduce weather-related delay by W percent in Y years.

✓ **GOAL 2**
System–Level Objectives

2a. Reduce fatalities Z percent in Y time period.

2b. Reduce delay associated with incidents on the freeway system by X percent by year Y.

✓ **GOAL 3**
System–Level Objectives

3a. Decrease travel times on freight-significant corridors by Y minutes within Z years.

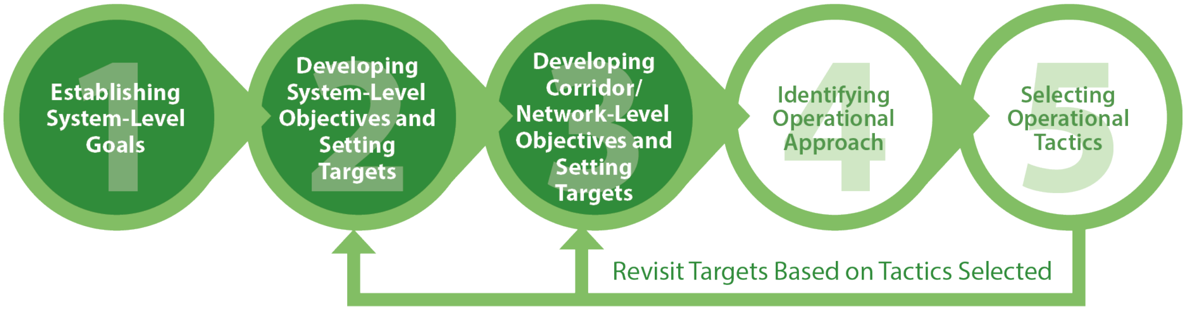
3b. Provide freight operators with traveler alerts and alternate routes in the case of incidents, special events, weather, construction, and severe congestion on X percent of freight-significant routes by year Y.

Source: FHWA.

Figure 19. Diagram. Scenario 1: System-level objectives and targets for realizing system goals.

Developing Corridor-Level Objectives and Setting Targets

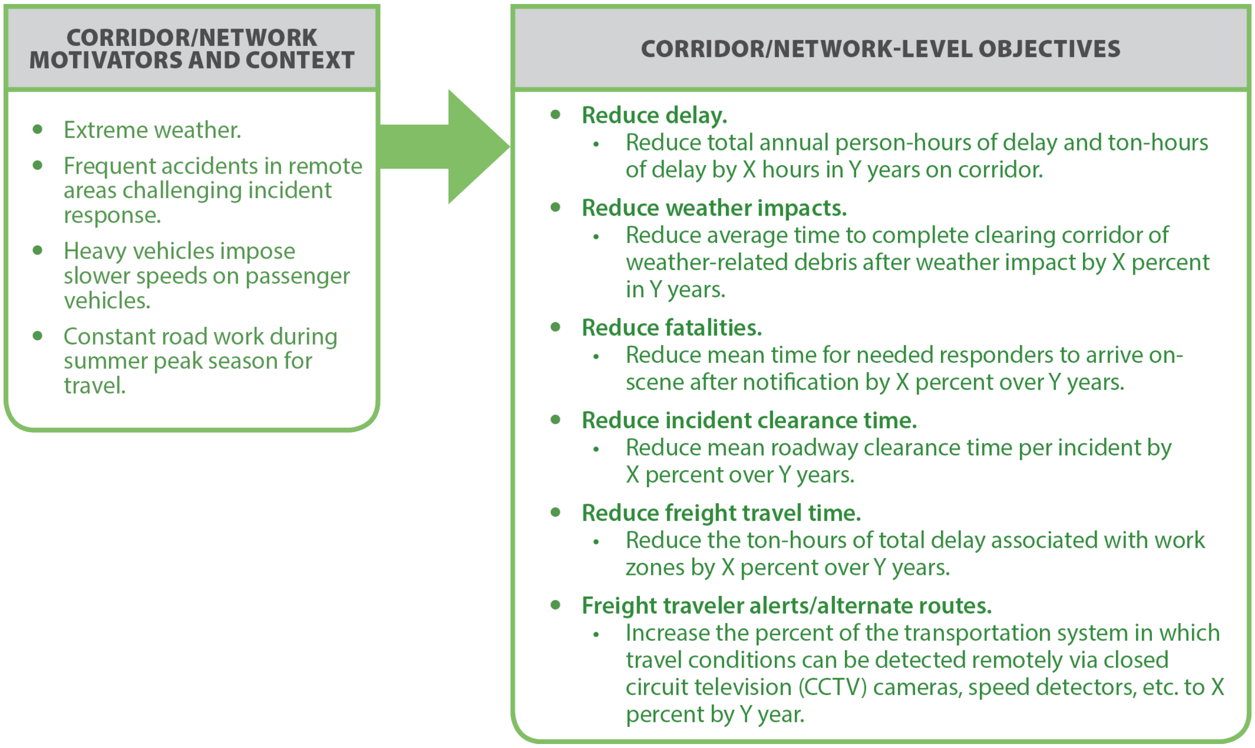
In the third step of the methodology, corridor-level objectives are developed to support the achievement of the system-level objectives (figure 20). Each system-level objective for State 1 was linked to a single corridor-level objective, although there could be many corridor-level objectives that would also support the system-level objectives defined in figure 21.



Source: FHWA.

Figure 20. Diagram. Scenario 1: The third step of the methodology is to develop corridor-level objectives and set targets.

Application of RDAT Tools: On the focus corridor for Scenario 1, reliability performance measures are considered more important than they are at the statewide level. Incident response time, incident clearance time, weather-related debris clearance, and traveler alerts all have direct relationships to reliability.



CORRIDOR/NETWORK MOTIVATORS AND CONTEXT

- Extreme weather.
- Frequent accidents in remote areas challenging incident response.
- Heavy vehicles impose slower speeds on passenger vehicles.
- Constant road work during summer peak season for travel.

CORRIDOR/NETWORK-LEVEL OBJECTIVES

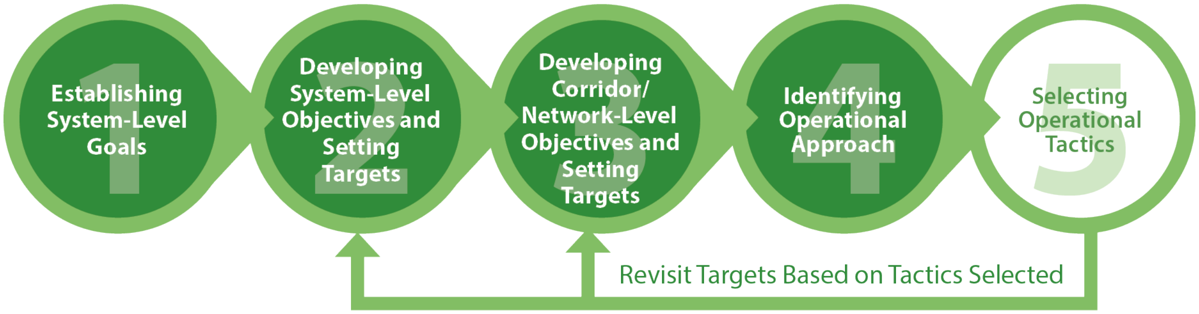
- **Reduce delay.**
    - Reduce total annual person-hours of delay and ton-hours of delay by X hours in Y years on corridor.
- **Reduce weather impacts.**
    - Reduce average time to complete clearing corridor of weather-related debris after weather impact by X percent in Y years.
- **Reduce fatalities.**
    - Reduce mean time for needed responders to arrive on-scene after notification by X percent over Y years.
- **Reduce incident clearance time.**
    - Reduce mean roadway clearance time per incident by X percent over Y years.
- **Reduce freight travel time.**
    - Reduce the ton-hours of total delay associated with work zones by X percent over Y years.
- **Freight traveler alerts/alternate routes.**
    - Increase the percent of the transportation system in which travel conditions can be detected remotely via closed circuit television (CCTV) cameras, speed detectors, etc. to X percent by Y year.

Source: FHWA.

Figure 21. Diagram. Scenario 1: Corridor motivators and system-level objectives drive the development of the corridor-level objectives and targets.

Identifying an Operational Approach

In this step (figure 22), an overarching approach for managing and operating the corridor or network is created. A universe of tactical program areas is available to support this step. These are then assessed against corridor-level objectives. In this example, only the one or two most practical technical program areas were selected from this universe to form the next-level decision in identifying tactics. Once the example tactical program areas were assigned for all corridor-level objectives, the corridor-level objectives were depicted as a tree sprouting off all included tactical program areas (figure 23).



Source: FHWA.

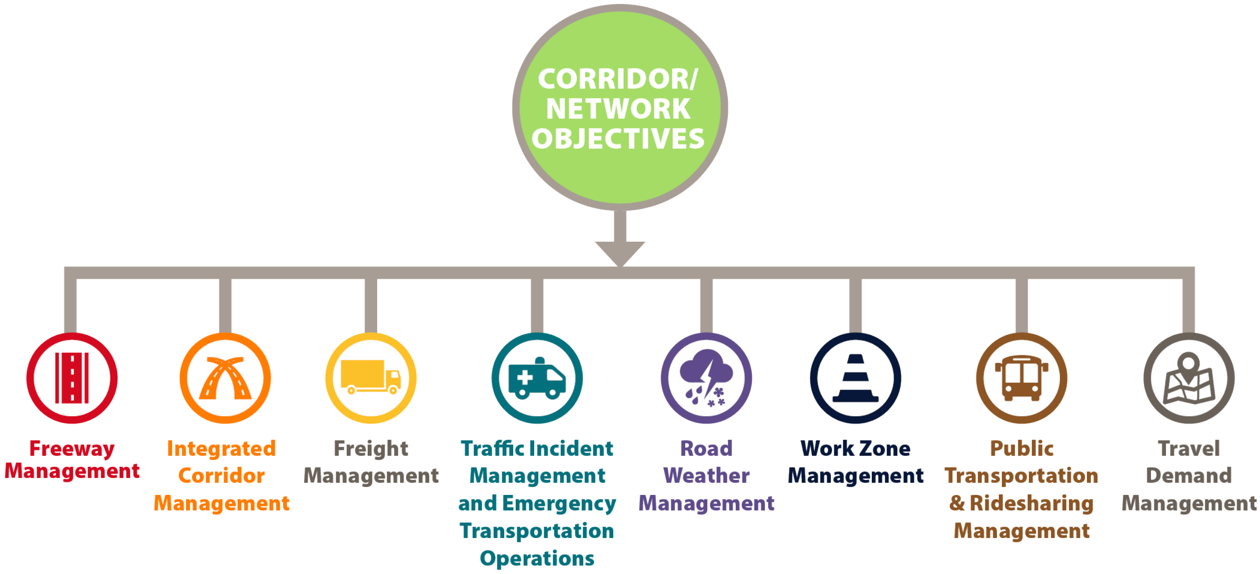
Figure 22. Diagram. Scenario 1: The fourth step of the methodology is to identify an operational approach for achieving the corridor-level objectives.

Application of RDAT Tools: In this scenario, identifying reliability issues, and the congestion sources associated with them, could point the way toward reliability-related program areas such as freeway management, road weather management, and traffic incident management/emergency transportation operations.

The tactical program areas identified to support each corridor-level objective are listed below:

- Reduce total annual person-hours of delay and ton-hours of delay by X hours in Y years on corridor.
    - **Freeway Management** and **Freight Management.**
- Reduce average time to complete clearing corridor of weather-related debris after weather impact by X percent in Y years.
    - **Road Weather Management.**
- Reduce mean time for needed responders to arrive on-scene after notification by X percent over Y years.
    - **Traffic Incident Management and Emergency Transportation Operations.**
- Reduce mean roadway clearance time per incident by X percent over Y years.
    - **Traffic Incident Management and Emergency Transportation Operations.**
- Reduce the ton-hours of total delay associated with work zones by X percent over Y years.
    - **Work Zone Management.**

- Increase the percent of the transportation system in which travel conditions can be detected remotely via CCTV, speed detectors, etc. to X percent by Y year.
  - **Traffic Incident Management and Emergency Transportation Operations.**



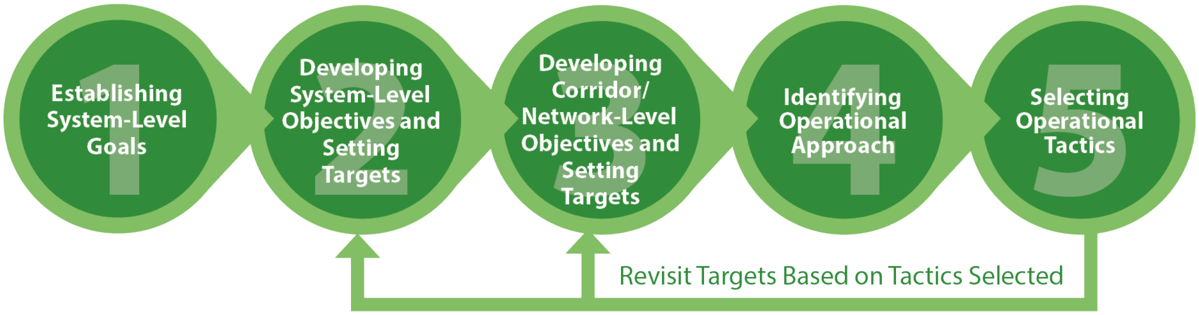
Source: FHWA.

Figure 23. Diagram. Scenario 1: The operational approach contains tactics from one or more tactical program areas.

Selecting Operational Tactics

Shown in figure 24, Step 5, selecting tactics, requires expert judgment of leaders within each tactical program area to determine the corridor's fit with potential tactics. The experts within each area must be consulted in a collaborative fashion to negotiate the best selection of assorted tactics from divergent tactical program areas to make sure each tactic is applied in a complementary fashion.

Following the process to this stage may lead to tactics in one program area that call for using physical space on the roadway or a specific tactical area to support one objective that, based on design, could be in contrast with another corridor-level objective. An integrated approach to selecting tactics allows the selected methods to be applied in a cooperative fashion and can help rule out tactics that do not support the greater aim.



Source: FHWA.

Figure 24. Diagram. Scenario 1: The fifth step of the methodology is to select operational tactics to execute the operational approach.

Application of RDAT Tools: Example RDAT applications for this scenario include:

- FREEVAL and SHRP2 L07 could be used to analyze tactics related to the sources of non-recurring congestion—tactics such as hazardous weather response plans, quick clearance goals, towing service agreements, computer-aided dispatch (CAD), traffic incident management (TIM) teams, intelligent work zones, and freight-targeted traveler information.

- The SHRP2 L02 monitoring guide also has an application at this stage, supporting the feedback loop shown between Step 5 and Steps 2 and 3. An ongoing monitoring program can gauge the effectiveness of implemented tactics, and allow operating agencies or planners to refine objectives and targets on a longer-term basis.

Because these tools are based on segments and corridors, results need to be developed for each segment or corridor and aggregated to a system level, a fairly cumbersome task (especially at the statewide level). For scenario 1, it might be best to choose a representative sample of highway corridors/segments for analysis and aggregation.

Below are the tactics identified to support the achievement of each corridor-level objective (see figure 25):

- Reduce total annual person-hours of delay and ton-hours of delay by X hours in Y years on corridor.
    - **Freeway Management** and **Freight Management.**
        - Construct physical operations improvements (e.g., auxiliary lanes).
        - Install truck climbing lanes.
        - Implement roadside truck electronic screening/clearance.

- Reduce average time to complete clearing corridor of weather-related debris after weather impact by X percent in Y years.
    - **Road Weather Management.**
        - Interagency cooperation.
        - Create hazardous weather traffic operations response plans.

- Reduce mean time for needed responders to arrive on-scene after notification by X percent over Y years.
    - **Traffic Incident Management and Emergency Transportation Operations.**
        - Co-locate dispatch units.
        - Develop shared quick clearance goals.
        - Conduct after action reviews (AARs).

- Reduce mean roadway clearance time per incident by X percent over Y years.
    - **Traffic Incident Management and Emergency Transportation Operations.**
        - Pre-established towing service agreements.
        - Integrate CAD.
        - Establish TIM teams.

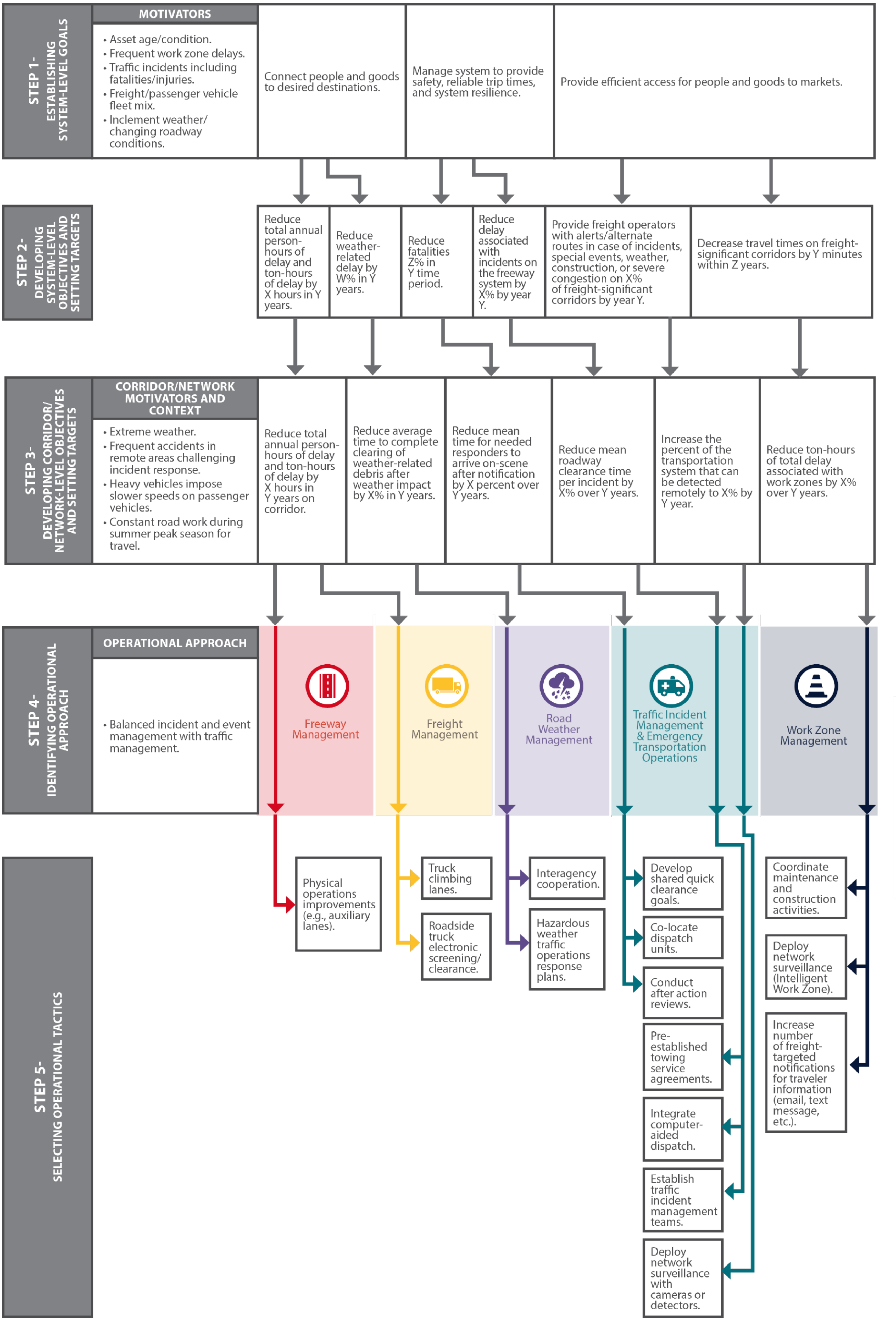
- Reduce the person hours (or vehicle hours) of total delay associated with work zones by X percent over Y years.
    - **Work Zone Management.**
        - Coordinate maintenance and construction activities.
        - Deploy network surveillance (Intelligent Work Zone).
        - Increase number of freight-targeted notifications for traveler information (e.g., e-mail, text message) by X percent in Y years.

- Increase the percent of the transportation system in which travel conditions can be detected remotely via cameras, speed detectors, etc., to X percent by Y year.
    - **Traffic Incident Management and Emergency Transportation Operations.**
        - Deploy network surveillance with cameras or detectors.

Source: FHWA.

Figure 25. Diagram. Scenario 1: Tactics from these tactical program areas were selected for the operational approach.

Figure 26 illustrates the application of the full methodology for a statewide rural interstate corridor, as illustrated in this scenario, and shows connections between the steps. The linkages between the steps is typically much more iterative than shown in this more simplified illustration. As information is gained or decisions are made in later steps, the output of earlier steps will be revisited.

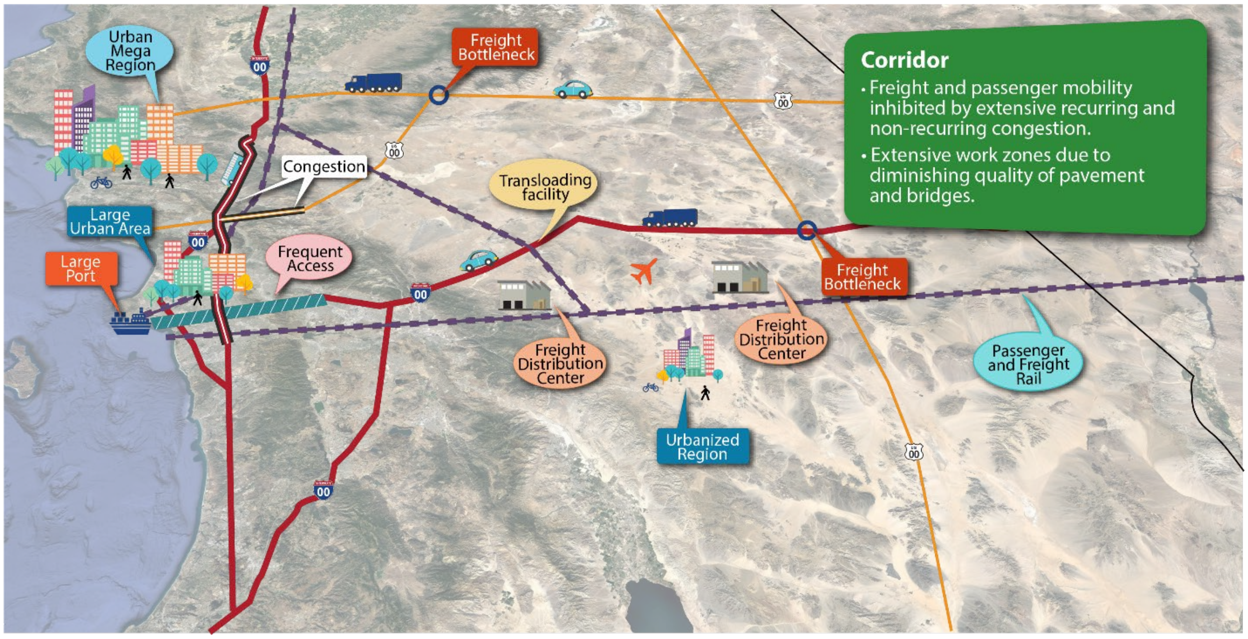


Source: FHWA.

Figure 26. Diagram. Scenario 1: Application of methodology to statewide rural interstate corridor.

SCENARIO 2: APPLICATION OF METHODOLOGY TO A FREIGHT CORRIDOR IMPORTANT TO INTERSTATE COMMERCE

This section describes the second of four scenarios that will be used to illustrate the methodology. Scenario 2 is an east-west freight corridor, as illustrated in figure 27.



Source: FHWA.

Figure 27. Map. Scenario 2: An east-west freight corridor and geographic context.

Context of the Freight Corridor

The geographic, multimodal, and freight transportation context for the corridor is described below. It should be assumed that transportation agencies within the corridor have a baseline of operational capabilities on which to build.

Geographic Setting

- The corridor is in a large State with a land area of approximately 100,000 square miles and is bordered by an ocean.
- The focus corridor has an east-west orientation and has a major shipping port and large urban areas on its west end and agricultural areas to its east and north. The port is a significant international port of entry.

National Highway System and Freight Context

- The State containing this corridor is the terminus for multiple interstate highways and routes on the NHS.

- The State has an extensive highway network with direct connections to metropolitan areas in adjacent States as well as connections to large and small communities within the State.
- The corridor has extensive freight railroad lines tied to ports and regional freight distribution centers.
- The corridor has significant air traffic due to its dense population centers and distance from producers and consumers in other States.
- The urban megaregion is served by a Class 1 railroad.
- A major rail intermodal facility supports transferring shipping containers between rail and trucks.

Population

- The State has a population greater than 15 million.
- The State includes a few very large urban areas and thousands of small communities due to its large land area.

Highway Characteristics and Usage

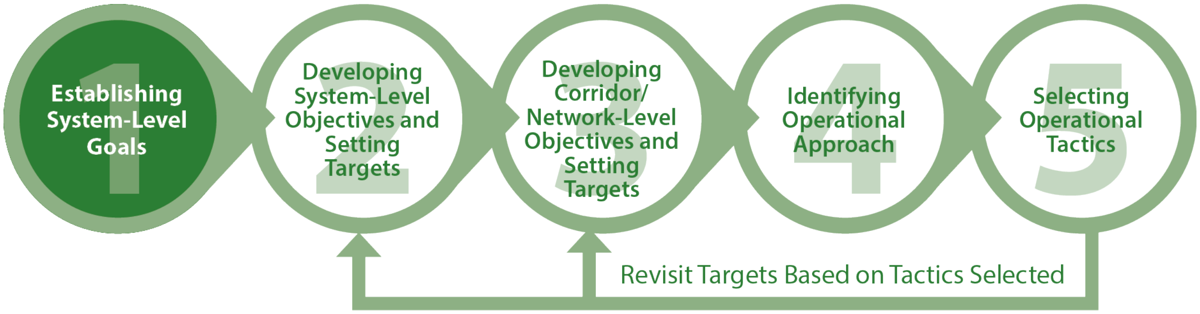
- Nationally significant corridors in the State traverse metro areas and rural communities, connecting ports and airfields, intermediate buyers, manufacturing, and retail suppliers.
- The focus corridor connects all of these freight parties both within the State and within adjacent States before products are dispersed through the wider national freight system.
- The corridor includes a major interstate and freight rail line. It covers just under 200 miles within the State and crosses a few other nationally significant highways outside the urban core area that are freight bottlenecks.
- The major interstate along the corridor provides interchange access within the urban core nearly every mile for 60 miles in the densest portion of the metro.
- The corridor provides high-occupancy vehicle lanes between the suburbs and the urban core.

Multimodal Network

- The State sees a mix of single occupant vehicles, shared ride services, medium and large trucks, metro and regional transit buses, light rail, a subway, airports near major roadways, and bicycle and pedestrian infrastructure in the urban core, recreational areas, and supportive suburban communities.
- The corridor experiences the multimodal traffic through heavy and light-rail, urban buses, and freight trucks.
- The corridor parallels a multi-track freight rail that has a shared-use agreement to provide infrequent interstate passenger rail service.

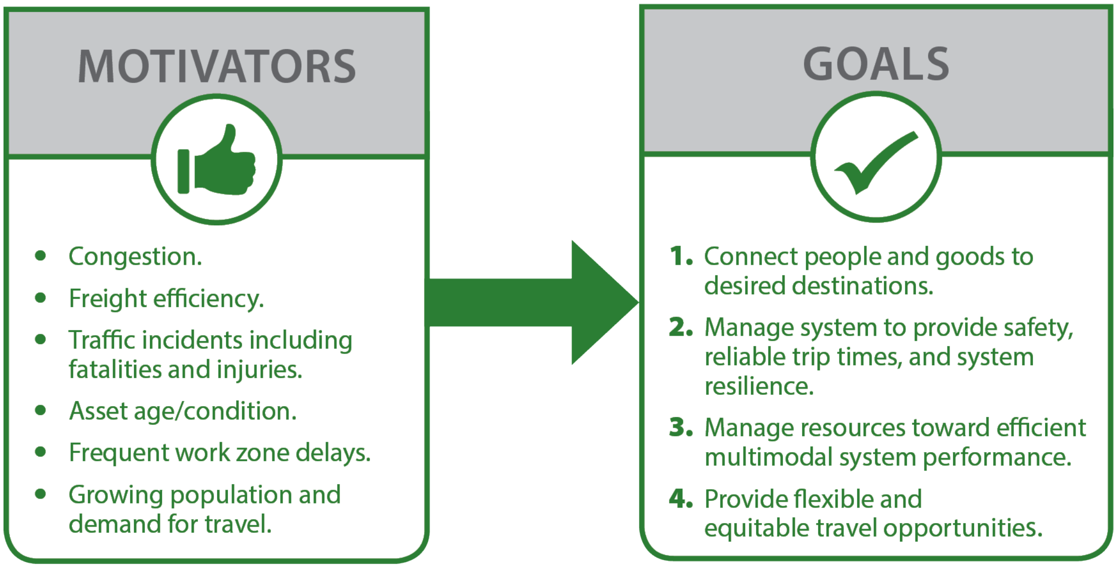
Establishing System-Level Goals

The development of system-level goals is the first step in the methodology (see figure **28**). System-level goals are derived from the list of motivators as shown in figure 29.



Source: FHWA.

Figure 28. Diagram. Scenario 2: The first step of the methodology is establishing system-level goals.



- Congestion.
- Freight efficiency.
- Traffic incidents including fatalities and injuries.
- Asset age/condition.
- Frequent work zone delays.
- Growing population and demand for travel.

1. Connect people and goods to desired destinations.
2. Manage system to provide safety, reliable trip times, and system resilience.
3. Manage resources toward efficient multimodal system performance.
4. Provide flexible and equitable travel opportunities.

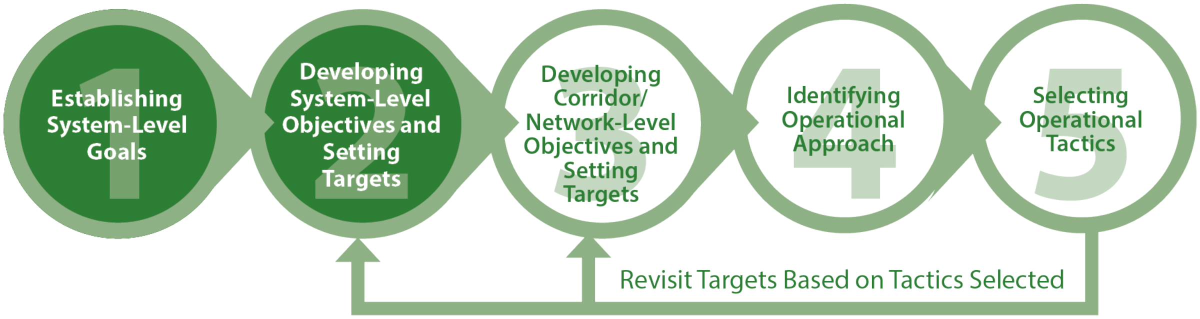
Source: FHWA.

Figure 29. Diagram. Scenario 2: Motivators for improvement in the corridor lead to goals.

Application of RDAT Tools: The SHRP2 L05 performance measures guide and SHRP2 L02 monitoring guide are relevant for this step. A travel-time reliability monitoring system could be used to help identify some of the motivators listed in figure 29—most notably for scenario 2, freight efficiency, incidents, and work zone delay.

Developing System-Level Objectives and Setting Targets

The second step of the methodology is to develop system-level objectives and set targets (figure 30).



Source: FHWA.

Figure 30. Diagram. Scenario 2: The second step of the methodology is to develop system-level objectives and set targets.

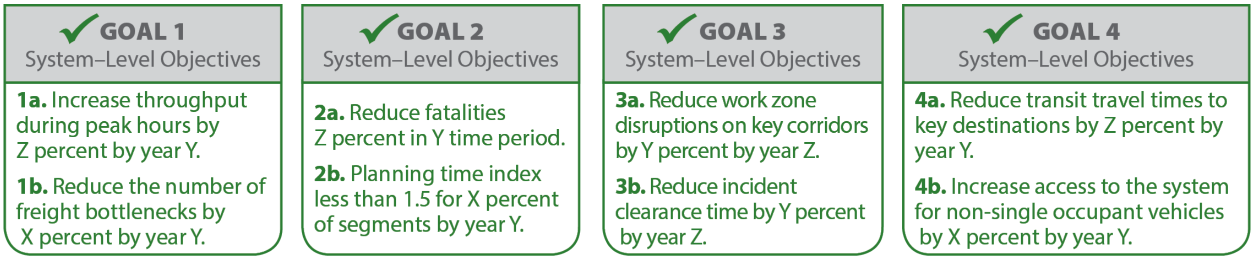
Application of RDAT Tools: At the stage of setting system-level objectives and targets, the primary usefulness of RDAT tools is in the establishment of existing and historical conditions to support the following:

- Setting a baseline: Setting the baseline allows the analyst to identify existing systematic reliability problems, which in turn can guide—at a high level—the establishment of objectives. For example, in scenario 2, travel-time distributions along freight corridors could influence objectives, given the importance of the freight network.

- Identifying sources of congestion: Knowing the sources of system-wide congestion (both recurring and non-recurring) can help agencies focus when determining system-wide objectives. As shown in
- figure 31, for scenario 2, Objective 3a relates to work zone disruptions and Objective 3b focuses on incident clearance times—two different congestion sources.

- Establishing system-level performance measures: Several objectives for scenario 2 are congruent with the measures in the SHRP2 L05 handbook, including the planning time index, incident clearance time, and work zone disruption.

- Setting thresholds: The SHRP2 L05 handbook provides guidance and examples related to setting reliability thresholds. At the statewide level, it is important to keep reliability measures disaggregated by facility type, because the reliability issues on rural facilities are much different than those on urban and suburban facilities. In addition, for scenario 2, the freight corridor may be considered for different or elevated thresholds depending on how important freight is to the region; it might be worth treating as a separate facility type.



GOAL 1
System–Level Objectives

1a. Increase throughput during peak hours by Z percent by year Y.

1b. Reduce the number of freight bottlenecks by X percent by year Y.

GOAL 2
System–Level Objectives

2a. Reduce fatalities Z percent in Y time period.

2b. Planning time index less than 1.5 for X percent of segments by year Y.

GOAL 3
System–Level Objectives

3a. Reduce work zone disruptions on key corridors by Y percent by year Z.

3b. Reduce incident clearance time by Y percent by year Z.

GOAL 4
System–Level Objectives

4a. Reduce transit travel times to key destinations by Z percent by year Y.

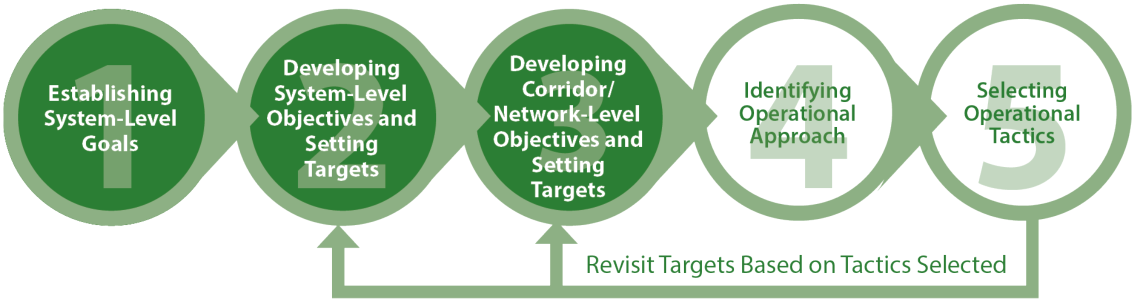
4b. Increase access to the system for non-single occupant vehicles by X percent by year Y.

Source: FHWA.

Figure 31. Diagram. Scenario 2: System-level objectives and targets for realizing system goals.

Developing Corridor-Level Objectives and Setting Targets

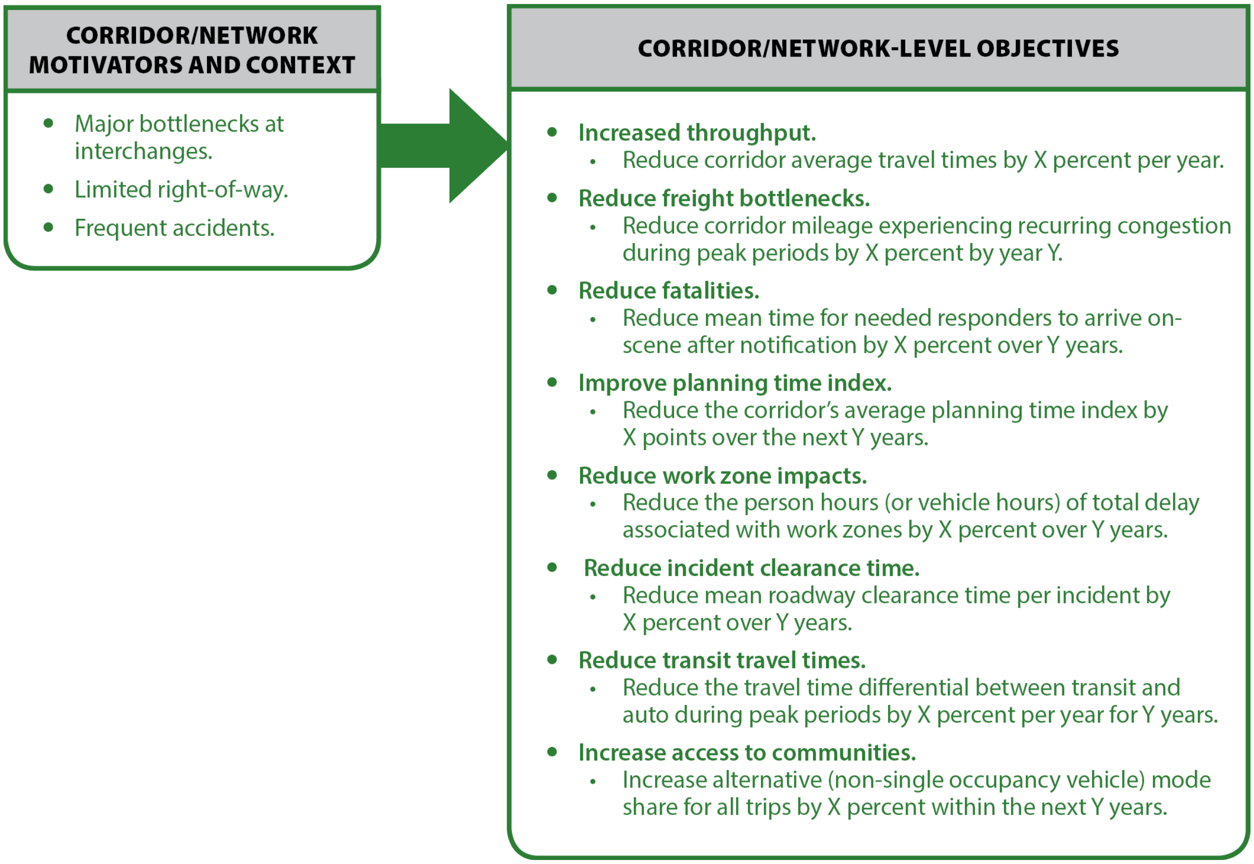
In step 3 of the methodology, objectives are developed for the specific corridor (figure 32). Network and corridor-level objectives are derivatives of system-level objectives connected to a much more specific geographic context (figure 33).



Source: FHWA.

Figure 32. Diagram. Scenario 2: The third step of the methodology is to develop corridor-level objectives and set targets.

Application of RDAT Tools: On the focus corridor for this scenario, reliability performance measures somewhat mirror the system-wide measures, including such elements as incident response times, planning time index, work zone delays and additional reliability indicators such as reduced travel times and improved incident clearance times.



CORRIDOR/NETWORK MOTIVATORS AND CONTEXT

- Major bottlenecks at interchanges.
- Limited right-of-way.
- Frequent accidents.

CORRIDOR/NETWORK-LEVEL OBJECTIVES

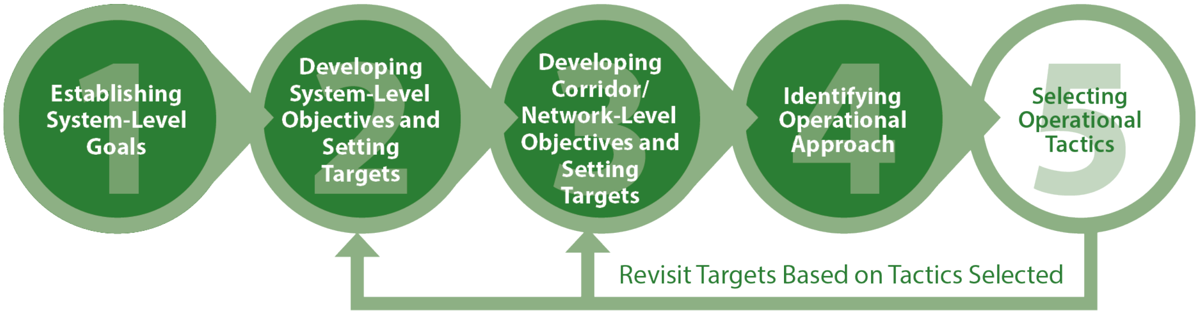
- **Increased throughput.**
  - Reduce corridor average travel times by X percent per year.
- **Reduce freight bottlenecks.**
  - Reduce corridor mileage experiencing recurring congestion during peak periods by X percent by year Y.
- **Reduce fatalities.**
  - Reduce mean time for needed responders to arrive on-scene after notification by X percent over Y years.
- **Improve planning time index.**
  - Reduce the corridor's average planning time index by X points over the next Y years.
- **Reduce work zone impacts.**
  - Reduce the person hours (or vehicle hours) of total delay associated with work zones by X percent over Y years.
- **Reduce incident clearance time.**
  - Reduce mean roadway clearance time per incident by X percent over Y years.
- **Reduce transit travel times.**
  - Reduce the travel time differential between transit and auto during peak periods by X percent per year for Y years.
- **Increase access to communities.**
  - Increase alternative (non-single occupancy vehicle) mode share for all trips by X percent within the next Y years.

Source: FHWA.

Figure 33. Diagram. Scenario 2: Corridor motivators and system-level objectives drive the development of the corridor-level objectives and targets.

Identifying an Operational Approach

Identifying an operational approach and defining supportive tactical program areas is the fourth step of the methodology (figure 34).



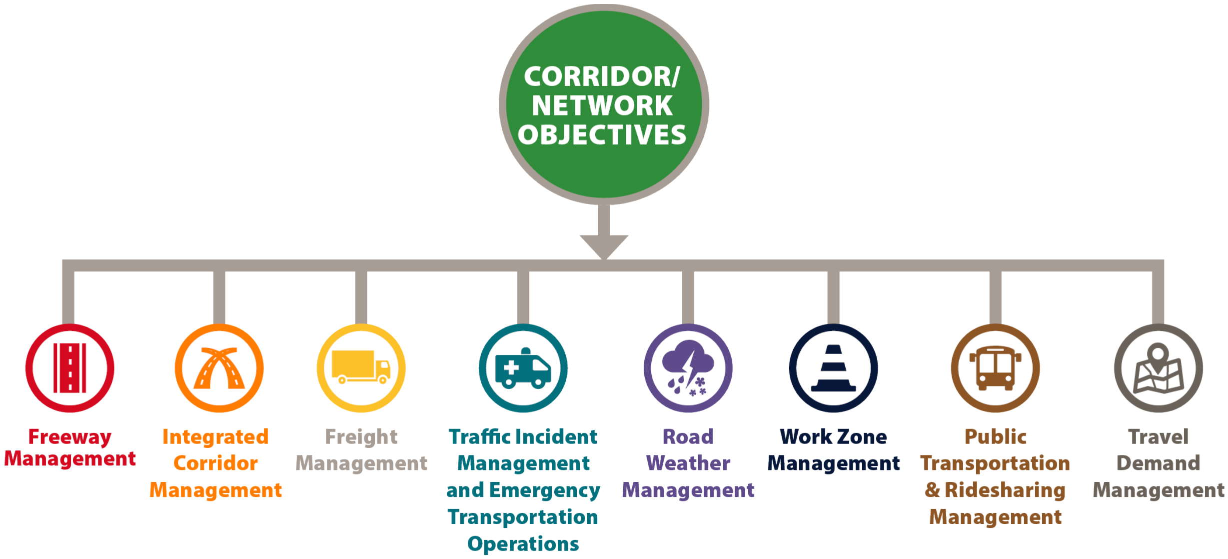
Source: FHWA.

Figure 34. Diagram. Scenario 2: System-level objectives and targets lead to the development of corridor-level objectives to support their achievement.

Application of RDAT Tools: In scenario 2, identifying reliability issues, and the congestion sources associated with them, could point the way toward reliability-related program areas such as freeway management, integrated corridor management, road weather management, traffic incident management/emergency transportation operations, work zone management, and travel demand management.

The tactical program areas identified to support each corridor-level objective (figure 35) are listed below:

- Reduce corridor average travel times by X percent per year.
    - **Freeway Management** and **Integrated Corridor Management.**
- Reduce corridor mileage experiencing recurring congestion during peak periods by X percent by year Y.
    - **Freeway Management** and **Freight Management.**
- Reduce mean time for needed responders to arrive on-scene after notification by X percent over Y years.
    - **Traffic Incident Management and Emergency Transportation Operations.**
- Reduce the corridor's average planning time index by X points over the next Y years.
    - **Road Weather Management** and **Traffic Incident Management and Emergency Transportation Operations.**
- Reduce the person hours (or vehicle hours) of total delay associated with work zones by X percent over Y years.
    - **Work Zone Management.**
- Reduce mean roadway clearance time per incident by X percent over Y years.
    - **Traffic Incident Management and Emergency Transportation Operations.**
- Reduce the travel time differential between transit and auto during peak periods by X percent per year for Y years.
    - **Public Transportation and Ridesharing Management.**
- Increase alternative (non-single occupancy vehicle) mode share for all trips by X percent within the next Y years.
    - **Public Transportation and Ridesharing Management** and **Travel Demand Management.**

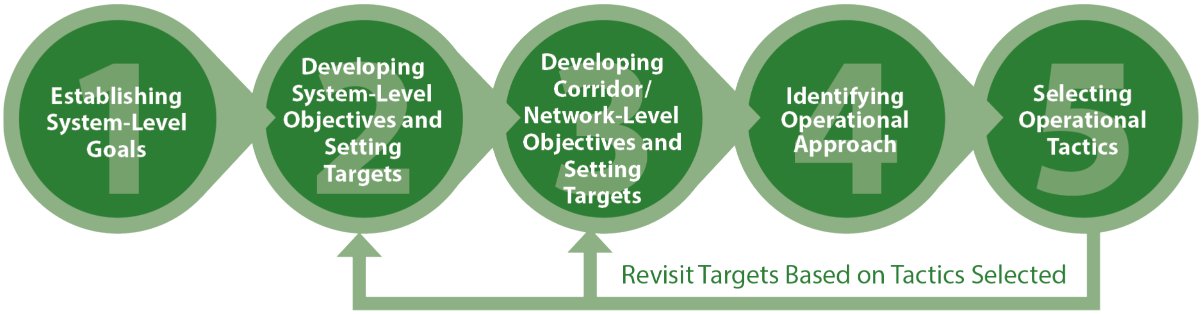


Source: FHWA.

Figure 35. Diagram. Scenario 2: The operational approach contains tactics from one or more tactical program areas to achieve the corridor-level objectives.

Selecting Operational Tactics

Selecting operational tactics requires the judgement of experts in each tactical program area to determine the corridor's fit with potential tactics (figure 36).



Source: FHWA.

Figure 36. Diagram. Scenario 2: The fifth step of the methodology is to select operational tactics to execute the operational approach.

Application of RDAT Tools: The RDAT tools require the user to map the effects of tactics to changes in tool inputs. For example, to evaluate a tactic such as peak-period shoulder use in this scenario, a user would have to define how capacity would vary throughout the relevant portions of the day. The L07 report provides guidance in this area.

Example RDAT applications for this scenario include:

- FREEVAL and SHRP2 L07 could be used to analyze tactics related to temporal changes in demand and capacity – tactics such as managed lanes, ramp metering, peak-period shoulder use, traveler information (to the extent that it causes diversion), freight priority/lanes, and dynamic ridesharing.

- These tools could also be used to evaluate tactics that address the impact of congestion sources – tactics such as interagency cooperation on emergency response and co-located dispatch units, tow truck incentives, and roving patrols (for efficient response times); and coordinated maintenance and construction activities (to minimize work zone impacts).

Below are the tactics identified to support the achievement of each corridor-level objective (figure 37):

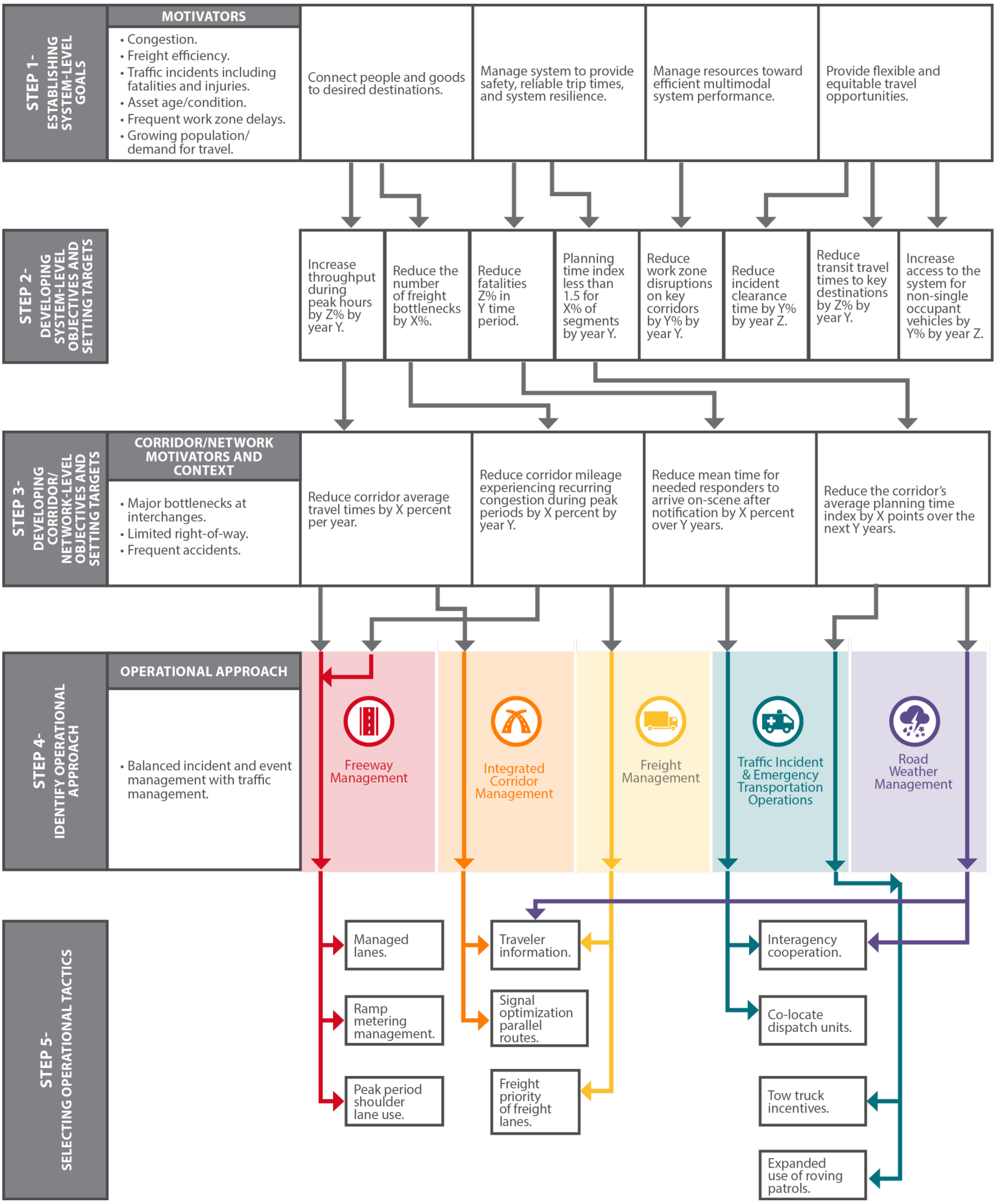
- Reduce corridor average travel times by X percent per year.
    - **Freeway Management** and **Integrated Corridor Management.**
        - Managed lanes.
        - Ramp metering/management.
        - Peak period shoulder lane use.
        - Traveler information.
        - Signal optimization of parallel routes and ramp terminals.
- Reduce corridor mileage experiencing recurring congestion during peak periods by X percent by year Y.
    - **Freeway Management** and **Freight Management.**
        - Managed lanes.
        - Ramp metering/management.
        - Peak period shoulder lane use.
        - Traveler Information.
        - Freight priority or freight lanes.
- Reduce mean time for needed responders to arrive on-scene after notification by X percent over Y years.
    - **Traffic Incident Management and Emergency Transportation Operations.**
        - Interagency cooperation.
        - Co-locate dispatch units.
- Reduce the corridor's average planning time index by X points over the next Y years.
    - **Road Weather Management** and **Traffic Incident Management and Emergency Transportation Operations.**
        - Traveler Information.
        - Interagency cooperation.
        - Tow truck incentives.
        - Expand use of roving patrols.

- Reduce the person hours (or vehicle hours) of total delay associated with work zones by X percent over Y years.
    - **Work Zone Management.**
        - Coordinate maintenance and construction activities.
        - Implement dynamic warning systems.
- Reduce mean roadway clearance time per incident by X percent over Y years.
    - **Traffic Incident Management and Emergency Transportation Operations.**
        - Interagency cooperation.
        - Expand use of roving patrols.
- Reduce the travel time differential between transit and auto during peak periods by X percent per year for Y years.
    - **Public Transportation and Ridesharing Management.**
        - Establish dynamic transit fare reductions.
        - Deploy managed lanes – high occupancy/toll lane.
- Increase alternative (non-single occupancy vehicle) mode share for all trips by X percent within the next Y years.
    - **Public Transportation and Ridesharing Management** and **Travel Demand Management.**
        - Deploy managed lanes – high occupancy/toll lane.
        - Implement dynamic ridesharing.
        - Deploy commuter financial incentives.
        - Offer guaranteed rides home.

Source: FHWA.

Figure 37. Diagram. Scenario 2: Tactics from these tactical program areas were selected for the operational approach.

On the following page, figure 38 illustrates the application of the full methodology for the statewide rural interstate corridor and shows the connections between the steps.

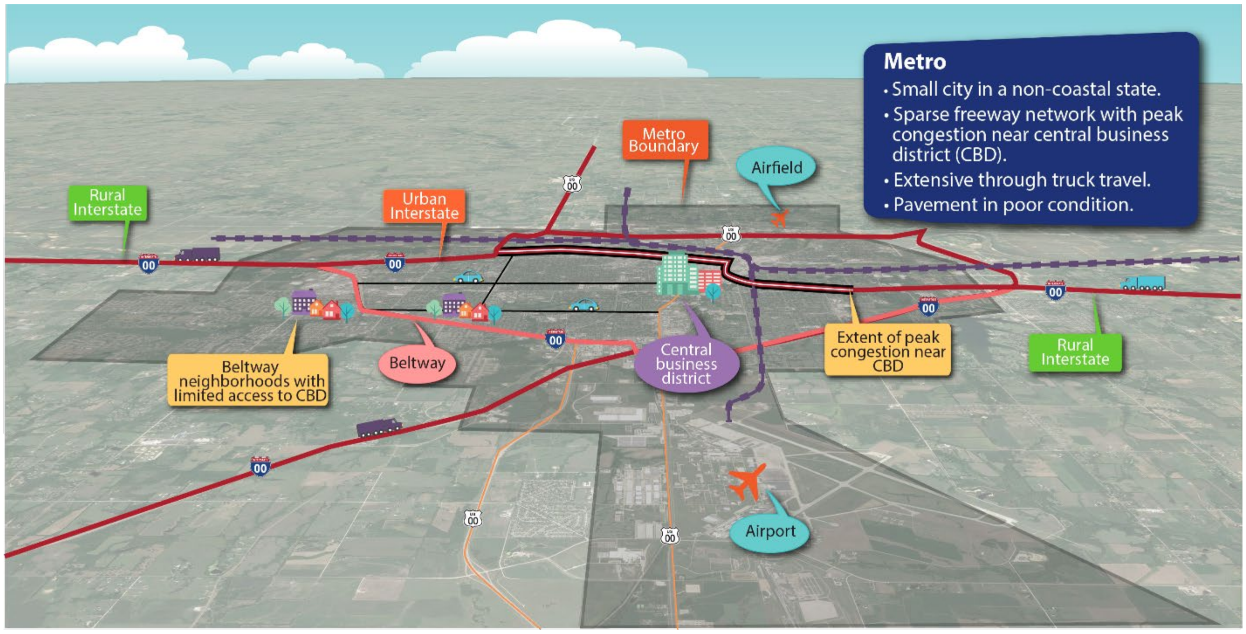


Source: FHWA.

Figure 38. Diagram. Scenario 2: Application of methodology to a freight corridor important to interstate commerce.

SCENARIO 3: APPLICATION OF METHODOLOGY TO A SMALL CITY

This section describes the third of four scenarios that will be used to illustrate the methodology. Scenario 3 is a small city with a limited freeway network and congestion during peak periods near the central business district (CBD), as shown in figure 39.



Source: FHWA.

Figure 39. Map. Scenario 3: A small city and its geographic context.

Context of the Small City

The geographic and multimodal transportation context for the small metropolitan area is described below. It should be assumed that transportation agencies within the metropolitan area have a baseline of operational capabilities on which to build.

Geographic Setting

This small- to mid-sized city is in an inland State with an urban area of roughly 75 square miles and a metropolitan area covering 6 counties.

National Highway System and Freight Context

- A major interstate highway bisects the city and an interstate beltway provides a loop around the southern part of the city.
- The interstate serves as a national east-west freight corridor.
- A major NHS arterial runs through the city, but local travel generally uses local arterials to avoid congestion on the NHS arterial.
- A municipal airport and a separate general aviation airfield serve commercial and freight travel by air.

- The city is served by a Class 1 railroad.
- A major rail intermodal facility supports the transfer of shipping containers between rail and trucks.

Population

- The city population is under 150,000 and just over 225,000 people live within the metropolitan planning area.
- The average population density is about 2,000 persons per square mile.
- Most of the area within the interstate beltway has population density greater than 3,500 persons per square mile, while development outside the beltway frequently has densities less than 1,200 persons per square mile.

Highway Characteristics and Usage

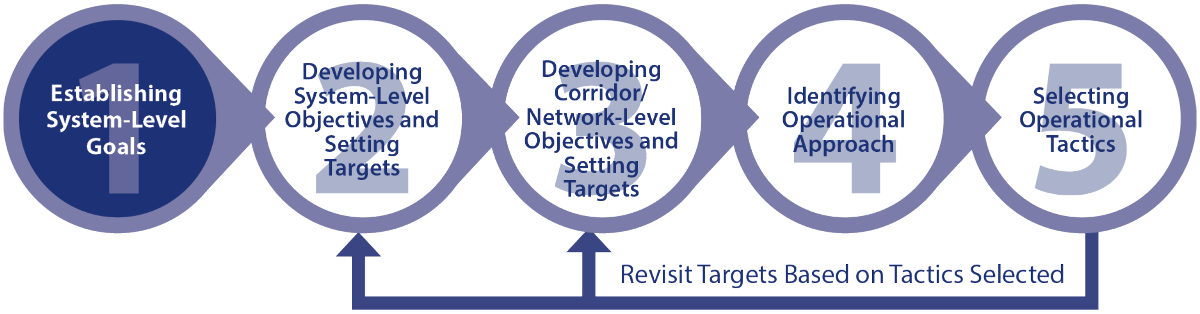
- The highway network facilitates high-speed travel around the outskirts of the primary city to residents living in all directions.
- The sparse highway network within the interstate beltway includes one high-capacity freeway route running east-west and another high-capacity primary arterial route running north-south.
- High volumes of heavy trucks pass through the CBD.
- Less than a quarter of the highway system pavement is in good condition, but the goal is to have 85 percent in good condition.
- While arterial and collector roads are in good to fair condition, local roads are in a poor state of repair.

Multimodal Network

- The local bus system provides adequate coverage within the city to the CBD, but headways are 30 minutes during peak hours and 60 minutes off-peak.
- The transit system has seen recent ridership growth, although levels are well below those set in 2008.
- The city recently committed to filling gaps in the pedestrian and bicycle network. Addressing gaps in the sidewalk network are a high priority, while bike amenities are an emerging opportunity.

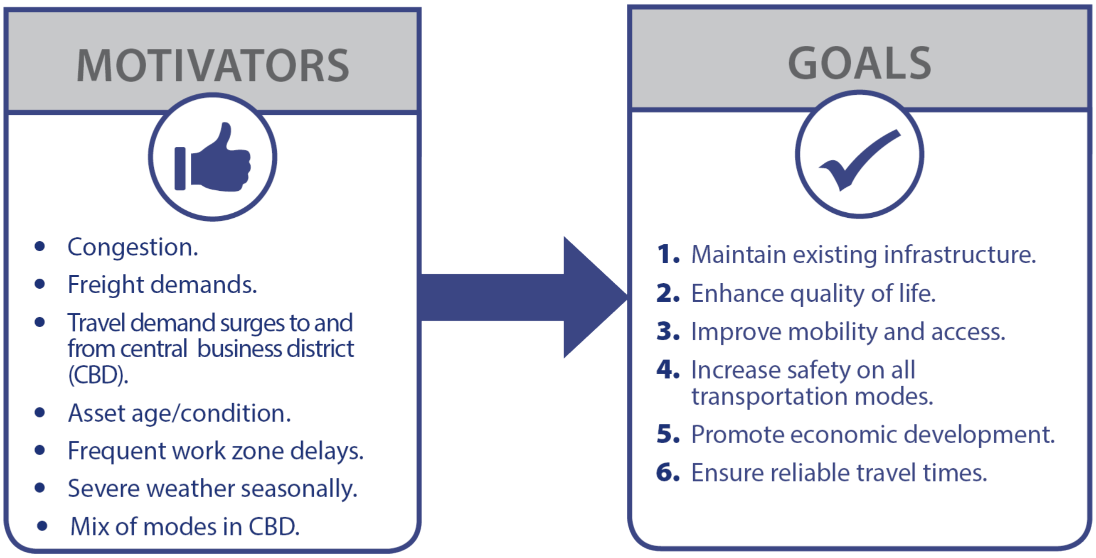
Establishing System-Level Goals

The development of system-level goals is the first step in the methodology (figure 40). System-level goals were developed in response to motivators, as identified for this scenario in figure 41.



Source: FHWA.

Figure 40. Diagram. Scenario 3: The first step of the methodology is establishing system-level goals.



- Congestion.
- Freight demands.
- Travel demand surges to and from central business district (CBD).
- Asset age/condition.
- Frequent work zone delays.
- Severe weather seasonally.
- Mix of modes in CBD.

1. Maintain existing infrastructure.
2. Enhance quality of life.
3. Improve mobility and access.
4. Increase safety on all transportation modes.
5. Promote economic development.
6. Ensure reliable travel times.

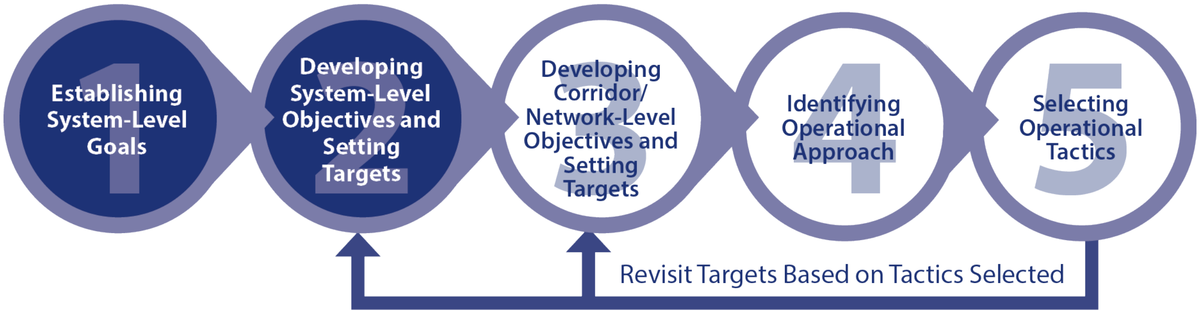
Source: FHWA.

Figure 41. Diagram. Scenario 3: Motivators for improvement in the metropolitan region lead to goals.

Application of RDAT Tools: The SHRP2 L05 performance measures guide and the TTRMS described in the SHRP2 L02 monitoring guide are significant for this step. A TTRMS could be used to help identify some of the motivators listed in figure 41—most notably in this scenario, congestion, travel-demand surges to the CBD, work-zone delays, and severe weather.

Developing System-Level Objectives and Setting Targets

The second step of the methodology is to develop system-level objectives and set targets (figure 42).



Source: FHWA.

Figure 42. Diagram. Scenario 3: The third step of the methodology is to develop network-level objectives and set targets.

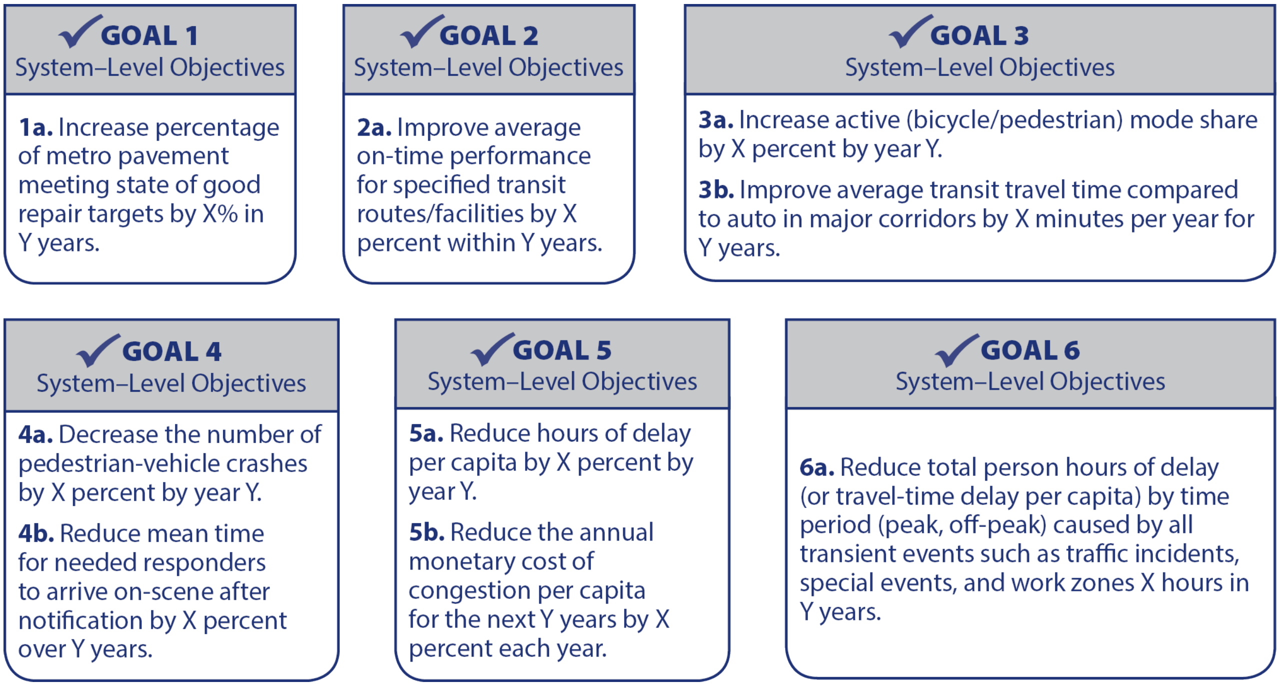
Application of RDAT Tools: At the stage of setting system-level objectives and targets, the primary usefulness of RDAT tools is in establishing existing and historical conditions to support the following activities:

- Setting a baseline: Setting the baseline allows the analyst to identify existing systematic reliability problems that can guide the development of objectives and targets. For example, in this scenario, it might be noticed that travel-time distributions skew high, which might lead to a further examination of congestion sources.

- Identifying sources of congestion: In the case of scenario 3, Objective 6a ended up relating to “all transient events,” but it could also have been the case that a congestion-source analysis identified a strong pattern in one or more particular sources (figure 43). One example might be outsized delays related to incidents, which would prompt objectives related to incident response time. For this scenario, Objective 4b is related to response time; this situation illustrates how a reliability approach—and the RDAT tool suite—cuts across issues such as safety and recurrent delay.

- Establishing system-level performance measures: This scenario focuses largely on CBD surface streets, and although the SHRP2 L05 methods are generally focused on freeways, the general principles could be applied to develop aggregated measures for surface streets as well.

- Setting thresholds: The SHRP2 L05 handbook provides guidance and examples related to setting reliability thresholds. Although not shown for this scenario, the handbook discusses thresholds by facility type—an important consideration for system-level analysis.



✓ GOAL 1
System–Level Objectives

1a. Increase percentage of metro pavement meeting state of good repair targets by X% in Y years.

✓ GOAL 2
System–Level Objectives

2a. Improve average on-time performance for specified transit routes/facilities by X percent within Y years.

✓ GOAL 3
System–Level Objectives

3a. Increase active (bicycle/pedestrian) mode share by X percent by year Y.

3b. Improve average transit travel time compared to auto in major corridors by X minutes per year for Y years.

✓ GOAL 4
System–Level Objectives

4a. Decrease the number of pedestrian-vehicle crashes by X percent by year Y.

4b. Reduce mean time for needed responders to arrive on-scene after notification by X percent over Y years.

✓ GOAL 5
System–Level Objectives

5a. Reduce hours of delay per capita by X percent by year Y.

5b. Reduce the annual monetary cost of congestion per capita for the next Y years by X percent each year.

✓ GOAL 6
System–Level Objectives

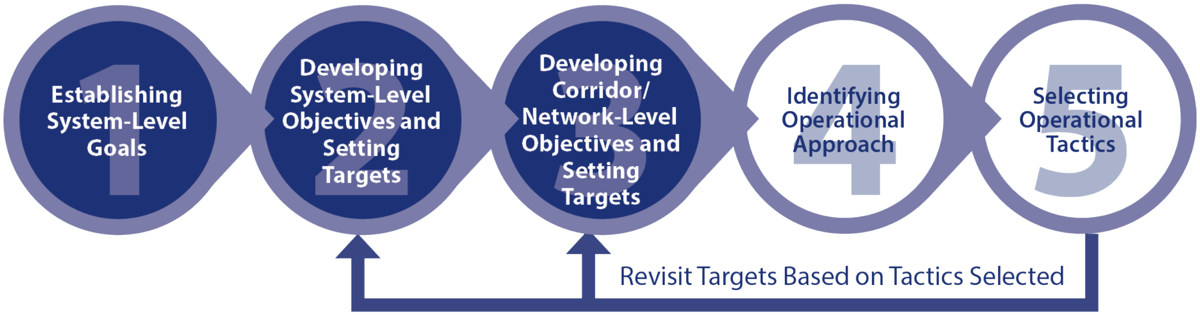
6a. Reduce total person hours of delay (or travel-time delay per capita) by time period (peak, off-peak) caused by all transient events such as traffic incidents, special events, and work zones X hours in Y years.

Source: FHWA.

Figure 43. Diagram. Scenario 3: System-level objectives and targets that lead to the development of network-level objectives to support the achievement of the system-level objectives.

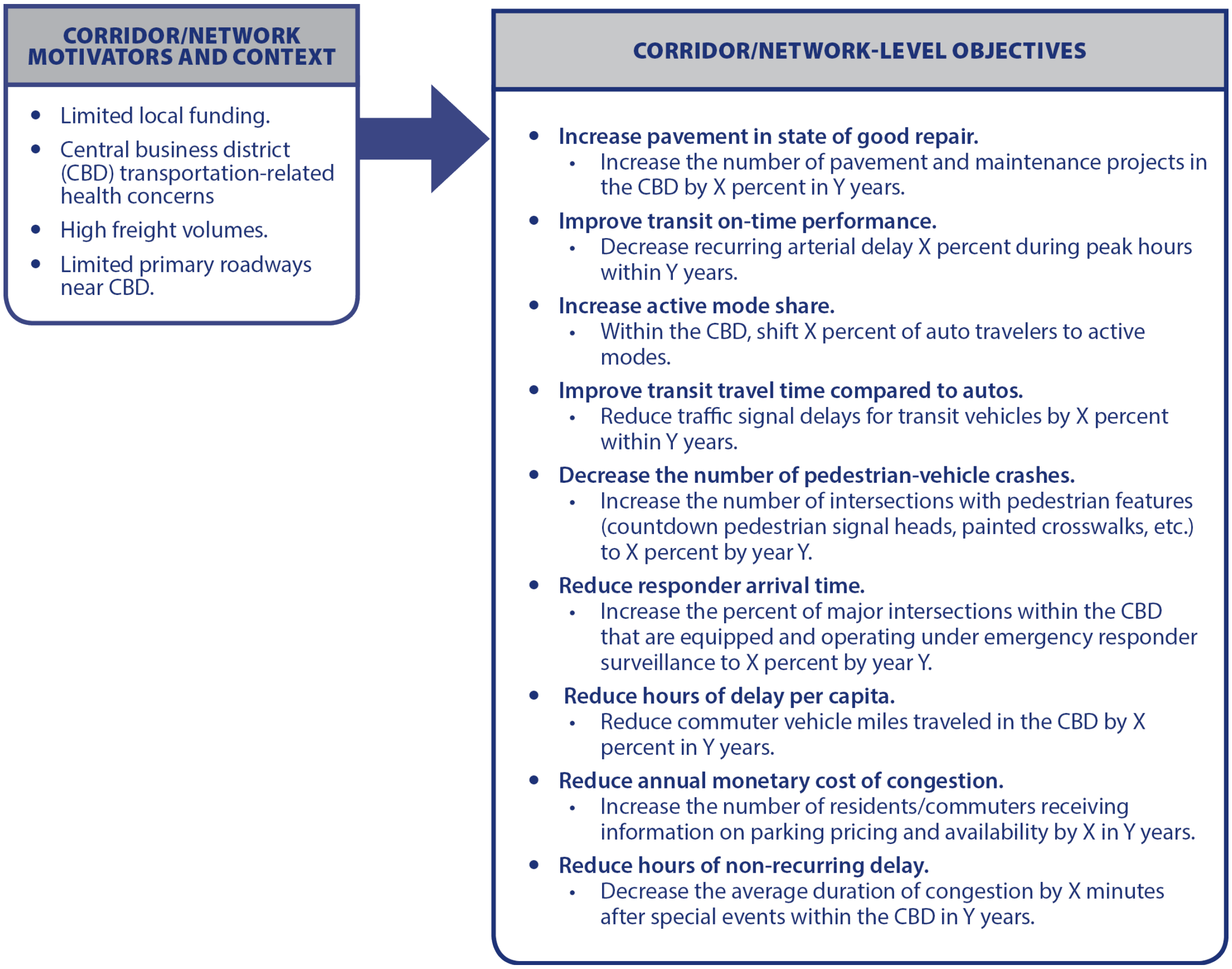
Developing Network-Level Objectives and Setting Targets

In step 3 of the methodology, objectives are developed for the specific corridor or network (figure 44). Network- and corridor-level objectives are derivatives of system-level objectives and are connected to a much more specific geographic context (figure 45). Each system-level objective in this example was linked to a single network or corridor-level objective, although there could be many network or corridor-level objectives that also support the system-level objectives defined.



Source: FHWA.

Figure 44. Diagram. Scenario 3: The third step of the methodology is to develop network-level objectives and set targets.



CORRIDOR/NETWORK MOTIVATORS AND CONTEXT

- Limited local funding.
- Central business district (CBD) transportation-related health concerns
- High freight volumes.
- Limited primary roadways near CBD.

CORRIDOR/NETWORK-LEVEL OBJECTIVES

- **Increase pavement in state of good repair.**
  - Increase the number of pavement and maintenance projects in the CBD by X percent in Y years.
- **Improve transit on-time performance.**
  - Decrease recurring arterial delay X percent during peak hours within Y years.
- **Increase active mode share.**
  - Within the CBD, shift X percent of auto travelers to active modes.
- **Improve transit travel time compared to autos.**
  - Reduce traffic signal delays for transit vehicles by X percent within Y years.
- **Decrease the number of pedestrian-vehicle crashes.**
  - Increase the number of intersections with pedestrian features (countdown pedestrian signal heads, painted crosswalks, etc.) to X percent by year Y.
- **Reduce responder arrival time.**
  - Increase the percent of major intersections within the CBD that are equipped and operating under emergency responder surveillance to X percent by year Y.
- **Reduce hours of delay per capita.**
  - Reduce commuter vehicle miles traveled in the CBD by X percent in Y years.
- **Reduce annual monetary cost of congestion.**
  - Increase the number of residents/commuters receiving information on parking pricing and availability by X in Y years.
- **Reduce hours of non-recurring delay.**
  - Decrease the average duration of congestion by X minutes after special events within the CBD in Y years.

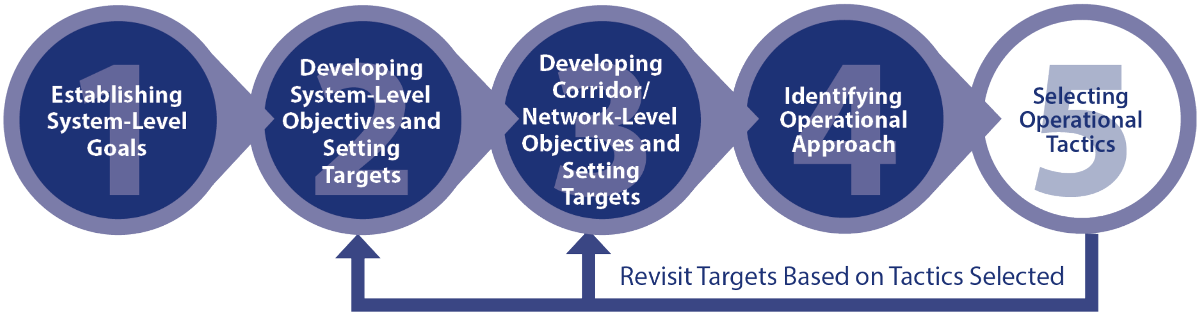
Source: FHWA.

Figure 45. Diagram. Scenario 3: Network motivators and system-level objectives drive the development of the network-level objectives and targets.

Application of RDAT Tools: The applications described in the Step 2 narrative—setting a baseline, identifying sources of congestion, establishing performance measures, and setting thresholds—also apply to Step 3, and the same RDAT tools are relevant.

Identifying an Operational Approach

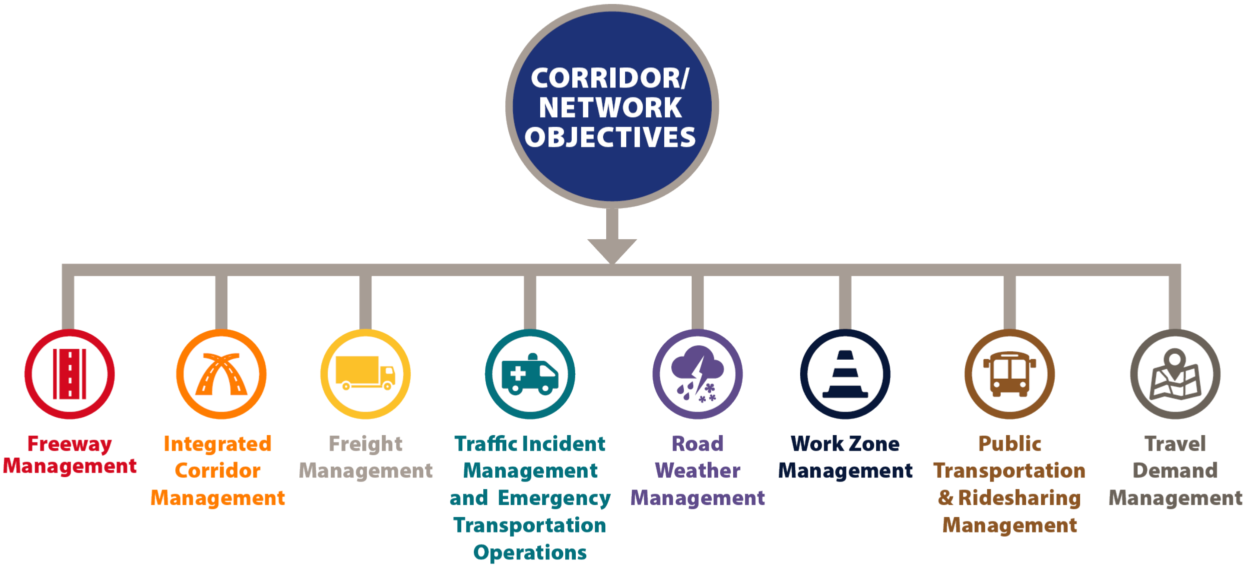
Identifying an operational approach with supportive tactical program areas is Step 4 of the methodology (figure 46).



Source: FHWA.

Figure 46. Diagram. Scenario 3: The fourth step of the methodology is to identify an operational approach for achieving the network-level objectives.

In Step 4, a universe of tactical program areas is assessed against network-level objectives. For this scenario, only one or two of the most practical technical program areas were selected from this universe to form the next-level decision in identifying tactics. Once the example tactical program areas were assigned for all network-level objectives, the network-level objectives were depicted as a tree sprouting off all included tactical program areas (figure 47).



Source: FHWA.

Figure 47. Diagram. Scenario 3: The operational approach contains tactics from one or more tactical program areas.

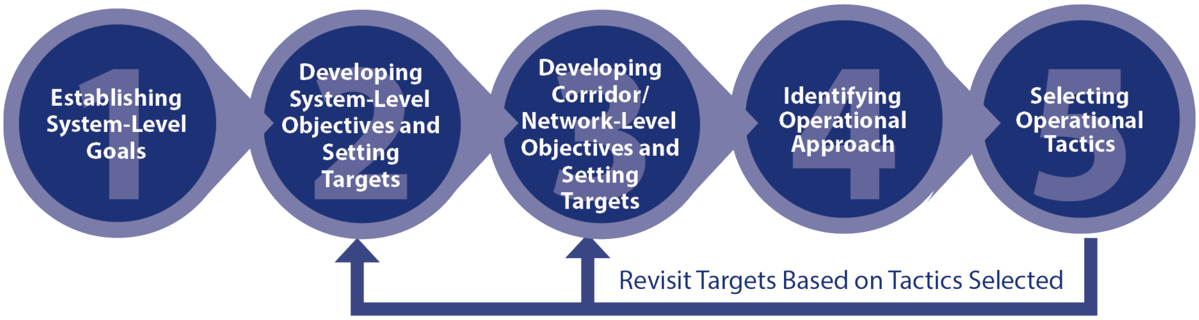
Application of RDAT Tools: In this scenario, identifying reliability issues, and the congestion sources associated with them, could point the way toward program areas such as arterial management, travel demand management, traffic incident management/emergency transportation operations, and special event management.

The tactical program areas identified to support each network-level objective are listed below:

- Increase the number of pavement and maintenance projects in the CBD by X percent in Y years.
    - **Asset Management** and **Work Zone Management.**
- Decrease recurring arterial delay X percent during peak hours within Y years.
    - **Arterial Management** and **Travel Demand Management.**
- Within the CBD, shift X percent of auto travelers to active modes.
    - **Arterial Management** and **Travel Demand Management.**
- Reduce traffic signal delays for transit vehicles by X percent within Y years.
    - **Arterial Management** and **Public Transportation and Ridesharing Management.**
- Increase the number of intersections with pedestrian features (pedestrian countdown signal heads, painted crosswalks, etc.) to X percent by year Y.
    - **Arterial Management.**
- Increase the percent of major intersection within the CBD that are equipped and operating under emergency responder surveillance to X percent by year Y.
    - **Arterial Management** and **Traffic Incident Management and Emergency Transportation Operations.**
- Reduce commuter vehicle miles traveled in the CBD by X percent in Y years.
    - **Travel Demand Management** and **Public Transportation and Ridesharing Management.**
- Increase the number of residents/commuters receiving information on parking pricing and availability by X within Y years.
    - **Parking Management.**
- Decrease the average duration of congestion by X minutes after special events within the CBD in Y years.
    - **Planned Special Event Management**, **Public Transportation and Ridesharing Management** and **Travel Demand Management.**

Selecting Operational Tactics

The selection of tactics in Step 5 requires expert judgment of leaders within each tactical program area to determine the network's fit with potential tactics (figure 48).



Source: FHWA.

Figure 48. Diagram. Scenario 3: The fifth step of the methodology is to select operational tactics to execute the operational approach.

Application of RDAT Tools: This scenario's tactics are mostly related to surface streets in the CBD, so STREETVAL would be most applicable. Example RDAT applications for this scenario include the following:

- STREETVAL could be used to analyze tactics that influence traffic demand fluctuations on CBD streets, such as commuter financial incentives and dynamic ridesharing.
- STREETVAL could also be used to analyze tactics that influence CBD incident durations, most notably those related to decreasing emergency response times.
- STREETVAL could also be used to examine the effects of increased work zones (due to the increased number of pavement and maintenance projects) and work zone management in the CBD, by adding work zones to affected segments and adjusting demand on parallel reliever routes.

Below are the tactics identified to support the achievement of each network-level objective (figure 49):

- Increase the number of pavement and maintenance projects in the CBD by X percent in Y years.
  - **Asset Management** and **Work Zone Management.**
    - Coordinate maintenance and construction activities.
    - Signal optimization of parallel routes and ramp terminals.

- Decrease recurring arterial delay X percent during peak hours within Y years.
  - **Arterial Management** and **Travel Demand Management.**
    - Deploy enhanced traffic signal operations.
    - Improve traffic control schemes.
    - Deploy commuter financial incentives.
    - Offer guaranteed rides home.

- Within the CBD, shift X percent of auto travelers to active modes.
  - **Arterial Management** and **Travel Demand Management.**
    - Provide leading pedestrian intervals/bike signal heads.
    - Re-time traffic signals on bike routes to provide bicycle progression.
    - Deploy commuter financial incentives.
    - Offer guaranteed ride home.
    - Fund employer pedestrian/bicycle amenities (e.g., bike racks, showers).

- Reduce traffic signal delays for transit vehicles by X percent within Y years.
  - **Arterial Management** and **Public Transportation and Ridesharing Management.**
    - Build far-side transit stations.
    - Re-time traffic signals on transit spine to provide progression.
    - Implement transit signal priority.
    - Use queue jump lanes at signalized intersections.

- Increase the number of intersections with pedestrian features (pedestrian countdown signal heads, painted crosswalks, etc.) to X percent by year Y.
  - **Arterial Management.**
    - Design for complete streets.

- Increase the percent of major intersection within the CBD that are equipped and operating under emergency responder surveillance to X percent by year Y.
  - **Arterial Management** and **Traffic Incident Management and Emergency Transportation Operations.**
    - Implement network surveillance with cameras or detectors.
    - Integrate CAD.
    - Co-locate dispatch units.

- Reduce commuter vehicle miles traveled in the CBD by X percent in Y years.
  - **Travel Demand Management** and **Public Transportation and Ridesharing Management.**
    - Deploy commuter financial incentives.
    - Offer guaranteed rides home.
    - Establish dynamic transit fare reductions.
    - Implement dynamic ridesharing.

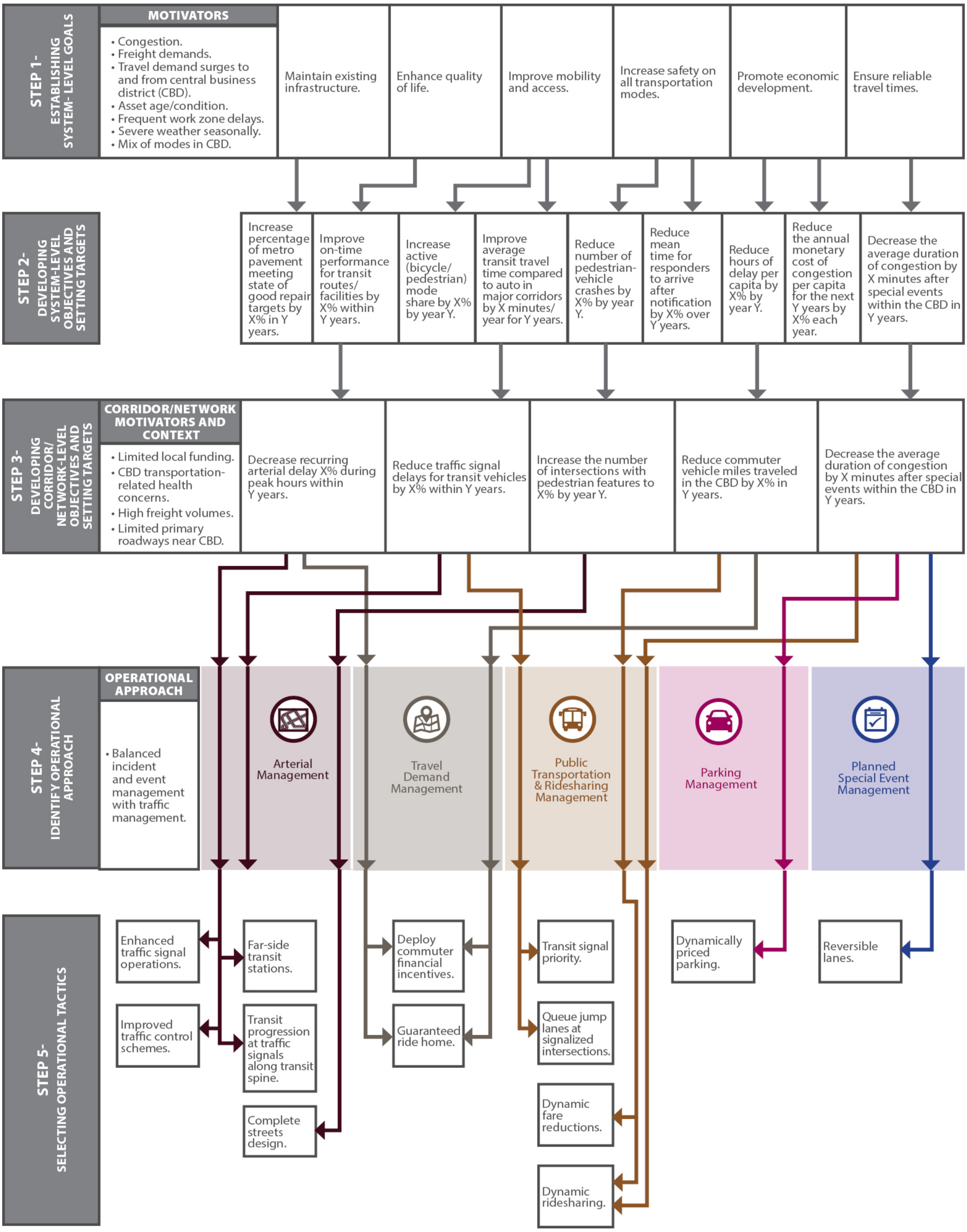
- Increase the number of residents/commuters receiving information on parking pricing and availability by X in Y years.
  - **Parking Management.**
    - Implement dynamic parking wayfinding, reservations, capacity.
    - Provide incentives to use underutilized parking facilities.

- Decrease the average duration of congestion by X minutes after special events within the CBD in Y years.
  - **Planned Special Event Management**, **Public Transportation and Ridesharing Management** and **Parking Management**.
    - Implement reversible lanes.
    - Implement dynamic ridesharing.
    - Deploy dynamically priced parking.

Source: FHWA.

Figure 49. Diagram. Scenario 3: Tactics from these tactical program areas were selected for the operational approach.

On the following page, figure 50 illustrates the application of the full methodology for this small city scenario and shows connections between each step.

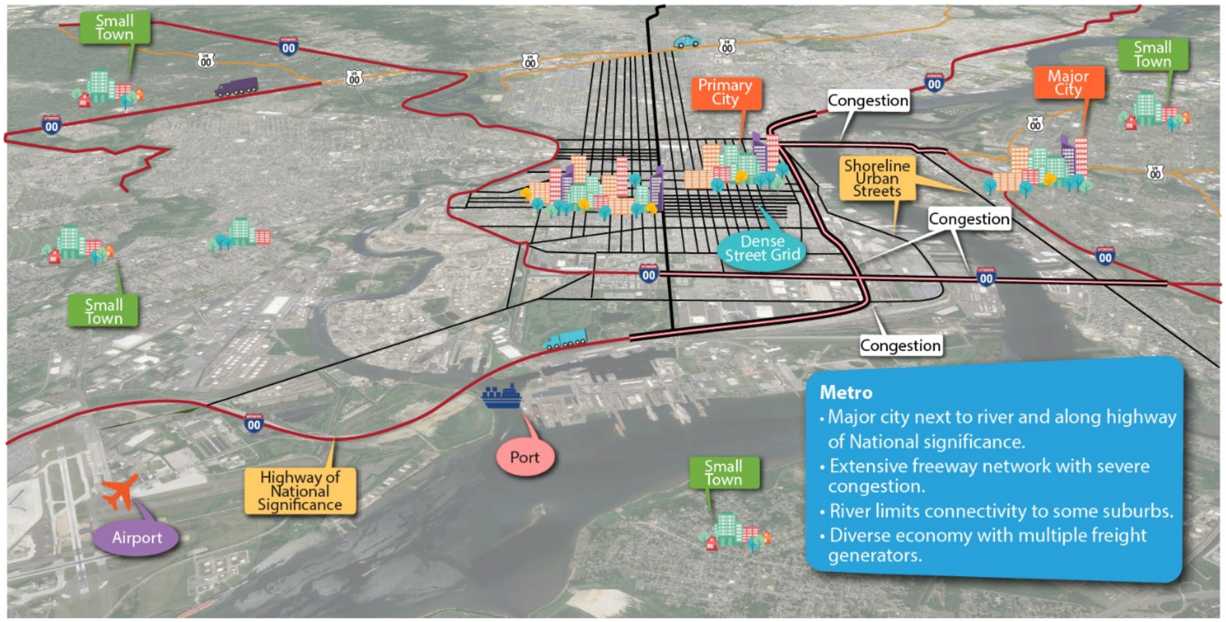


Source: FHWA.

Figure 50. Diagram. Scenario 3: Application of the methodology to a small city.

SCENARIO 4: APPLICATION OF METHODOLOGY TO A LARGE URBAN SUBAREA

This section describes the last of four scenarios that will be used to illustrate the methodology. This is a major city next to a river, as shown in figure 51.



Metro
- Major city next to river and along highway of National significance.
- Extensive freeway network with severe congestion.
- River limits connectivity to some suburbs.
- Diverse economy with multiple freight generators.

Source: FHWA.

Figure 51. Map. Scenario 4: A large urban subarea and its geographic context.

Context of the Large Urban Subarea

The geographic and multimodal transportation context for the large urban subarea is described below. It should be assumed that transportation agencies within the urban subarea have a baseline of operational capabilities on which to build.

Geographic Setting

- The metropolitan region covers more than 5,000 square miles and consists of a primary city with several nearby cities and towns. Approximately 2,000 square miles in the metropolitan region are urbanized.
- The primary city covers approximately 150 square miles and borders a major river, which separates it from a major city in an adjoining State.
- The focus subarea is the CBD in the primary city.

National Highway System and Freight Context

- The metropolitan region and primary city are located along a north-south interstate of national significance.

- The primary city also serves as the terminus of a major east-west interstate that connects the city to manufacturing and agricultural States in the middle of the country.
- The metropolitan region and the primary city receives freight via the east-west interstate and port facilities both within the primary city and in outlying communities.

Population

- The metropolitan regional population is greater than 6 million with an average density of approximately 1,200 people per square mile.
- The primary city population is more than 1.5 million with a population density of more than 10,000 people per square mile.
- Other major cities in the metropolitan region have population densities ranging from 5,000 to 7,500 people per square mile.

Highway Characteristics and Usage

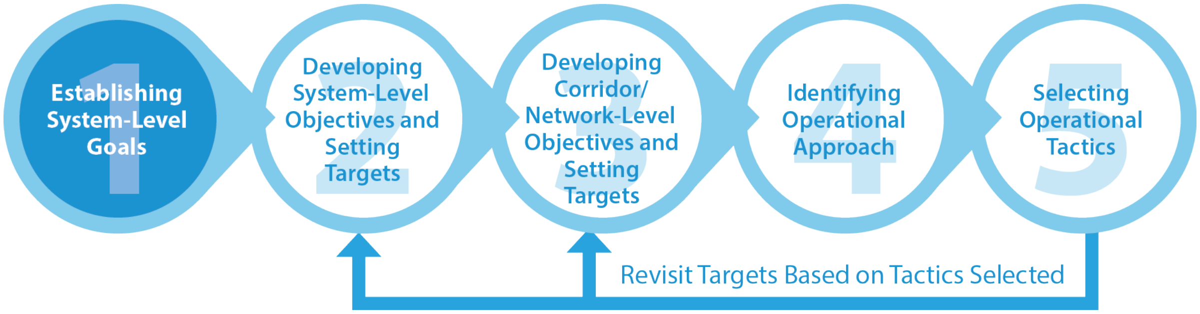
- An interstate highway runs directly adjacent to the urban core and forms one edge of a beltway around the primary city.
- The east-west interstate brings travel from outlying suburbs to beltway freeways along the opposite edge of the primary city.
- The river limits connectivity between the primary city and some other major cities in the metro area, underscoring the significance of bridge connections on primary roadways.
- The metropolitan region's transportation network also supports a confluence of intermodal freight near the CBD.

Multimodal Network

- The transportation network offers a variety of modal choices for passengers and freight, including automobiles, trucks, heavy rail, freight rail, buses, shared ride services, bicycling, walking, and air- and water-based travel.
- Transit service is widely available within the primary city.
- While almost 80 percent of current travel in the metropolitan region is by personal automobile, most personal travel around the primary city is conducted by automobile (65 percent) and transit (15 percent).
- There is strong utilization of high-occupancy vehicles along the highway network near the CBD.
- Pedestrian and bicycle travel also account for a measurable mode share within the primary city.

ESTABLISHING SYSTEM-LEVEL GOALS

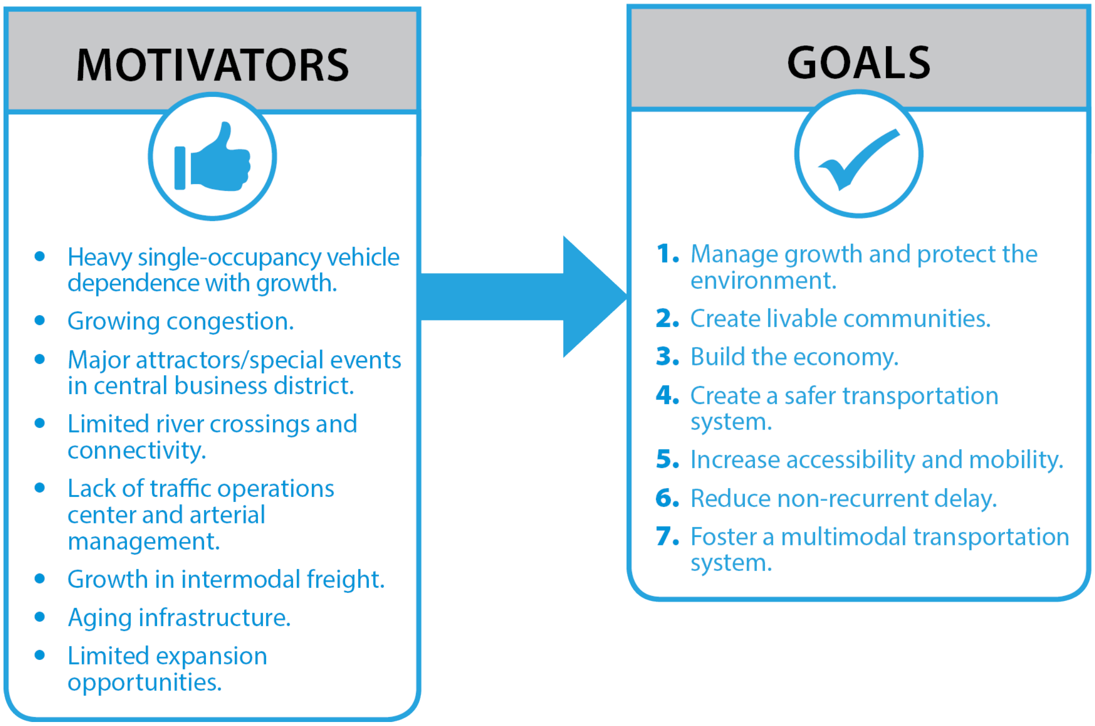
The development of system-level goals is the first step in the methodology (figure 52). The large urban subarea has developed system-level goals in response to the motivations defined in figure 53.



Source: FHWA.

Figure 52. Diagram. Scenario 4: The first step of the methodology is establishing system-level goals.

Application of RDAT Tools: A travel-time reliability monitoring system could be used to help identify some of the motivators in figure 53—most notably in the case of this scenario, growing congestion, special events, and arterial management.



MOTIVATORS

- Heavy single-occupancy vehicle dependence with growth.
- Growing congestion.
- Major attractors/special events in central business district.
- Limited river crossings and connectivity.
- Lack of traffic operations center and arterial management.
- Growth in intermodal freight.
- Aging infrastructure.
- Limited expansion opportunities.

GOALS

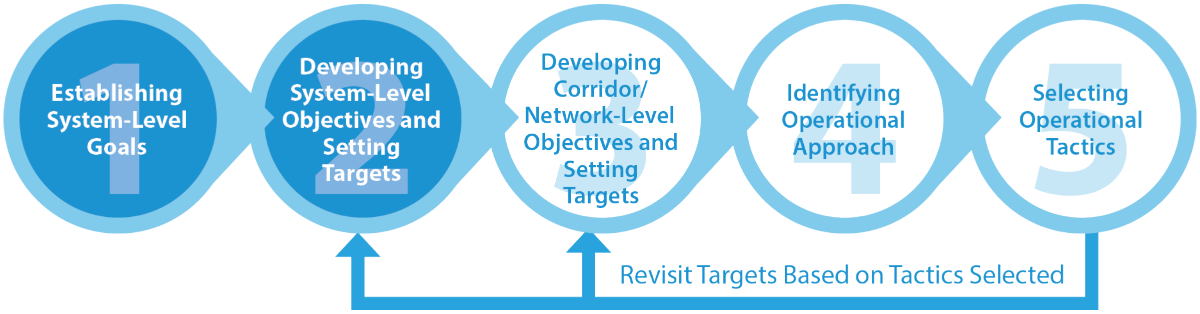
1. Manage growth and protect the environment.
2. Create livable communities.
3. Build the economy.
4. Create a safer transportation system.
5. Increase accessibility and mobility.
6. Reduce non-recurrent delay.
7. Foster a multimodal transportation system.

Source: FHWA.

Figure 53. Diagram. Scenario 4: Motivators for improvement in the subarea lead to goals.

Developing System-Level Objectives and Setting Targets

The second step of the methodology is the development of system-level objectives and performance targets. Setting objectives also requires an understanding of the context of the system and community within which the goal has been established. For example, transportation is about connectivity, but for urban communities connectivity may be about providing system options.



Source: FHWA.

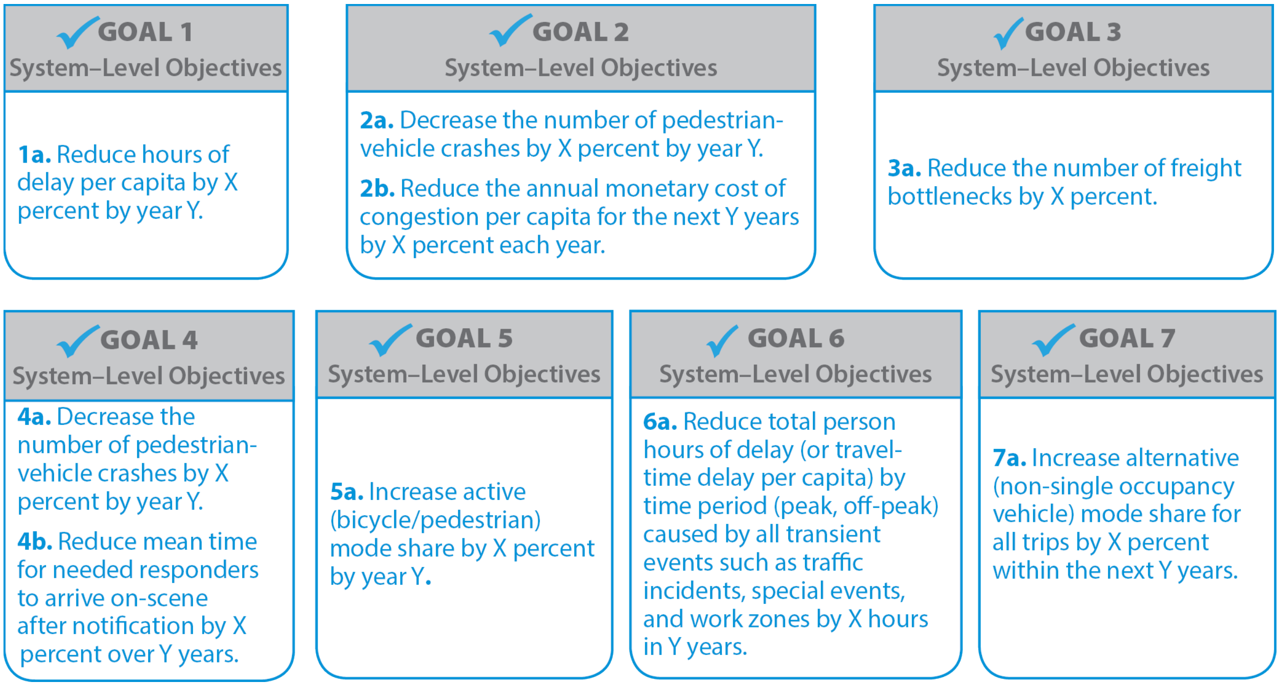
Figure 54. Diagram. Scenario 4: The second step of the methodology is to develop system-level objectives and set targets.

Application of RDAT Tools: At the stage of setting system-level objectives and targets (figure 54), the primary usefulness of RDAT tools is in the establishment of existing and historical conditions to support the following:

- Setting a baseline: Setting the baseline allows the analyst to identify existing systematic reliability issues, which in turn can guide, at a high level, the establishment of objectives. For example, in this scenario, one might notice that travel-time distributions indicate a significant non-recurring component, which might lead to further examination of congestion sources, which could then influence objectives.

- Identifying sources of congestion: Knowing the sources of system-wide congestion (both recurring and non-recurring) can help agencies focus when determining system-wide objectives. In this scenario, Objective 4b, shown in figure 55, is related to mean incident response time, and certainly could have been prompted by outsized incident-related delays partially attributable to inadequate response times.

- Establishing system-level performance measures: In addition to more typical reliability considerations, this scenario also includes Objective 3a (figure 55) related to freight bottlenecks, which can also be analyzed in a reliability framework.



GOAL 1 System–Level Objectives

1a. Reduce hours of delay per capita by X percent by year Y.

GOAL 2 System–Level Objectives

2a. Decrease the number of pedestrian-vehicle crashes by X percent by year Y.

2b. Reduce the annual monetary cost of congestion per capita for the next Y years by X percent each year.

GOAL 3 System–Level Objectives

3a. Reduce the number of freight bottlenecks by X percent.

GOAL 4 System–Level Objectives

4a. Decrease the number of pedestrian-vehicle crashes by X percent by year Y.

4b. Reduce mean time for needed responders to arrive on-scene after notification by X percent over Y years.

GOAL 5 System–Level Objectives

5a. Increase active (bicycle/pedestrian) mode share by X percent by year Y.

GOAL 6 System–Level Objectives

6a. Reduce total person hours of delay (or travel-time delay per capita) by time period (peak, off-peak) caused by all transient events such as traffic incidents, special events, and work zones by X hours in Y years.

GOAL 7 System–Level Objectives

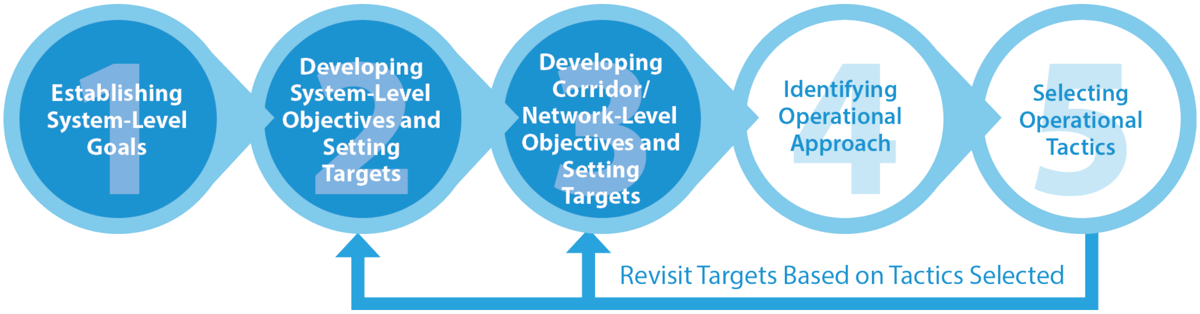
7a. Increase alternative (non-single occupancy vehicle) mode share for all trips by X percent within the next Y years.

Source: FHWA.

Figure 55. Diagram. Scenario 4: System-level objectives and targets for realizing system goals.

Developing Network-Level Objectives and Setting Targets

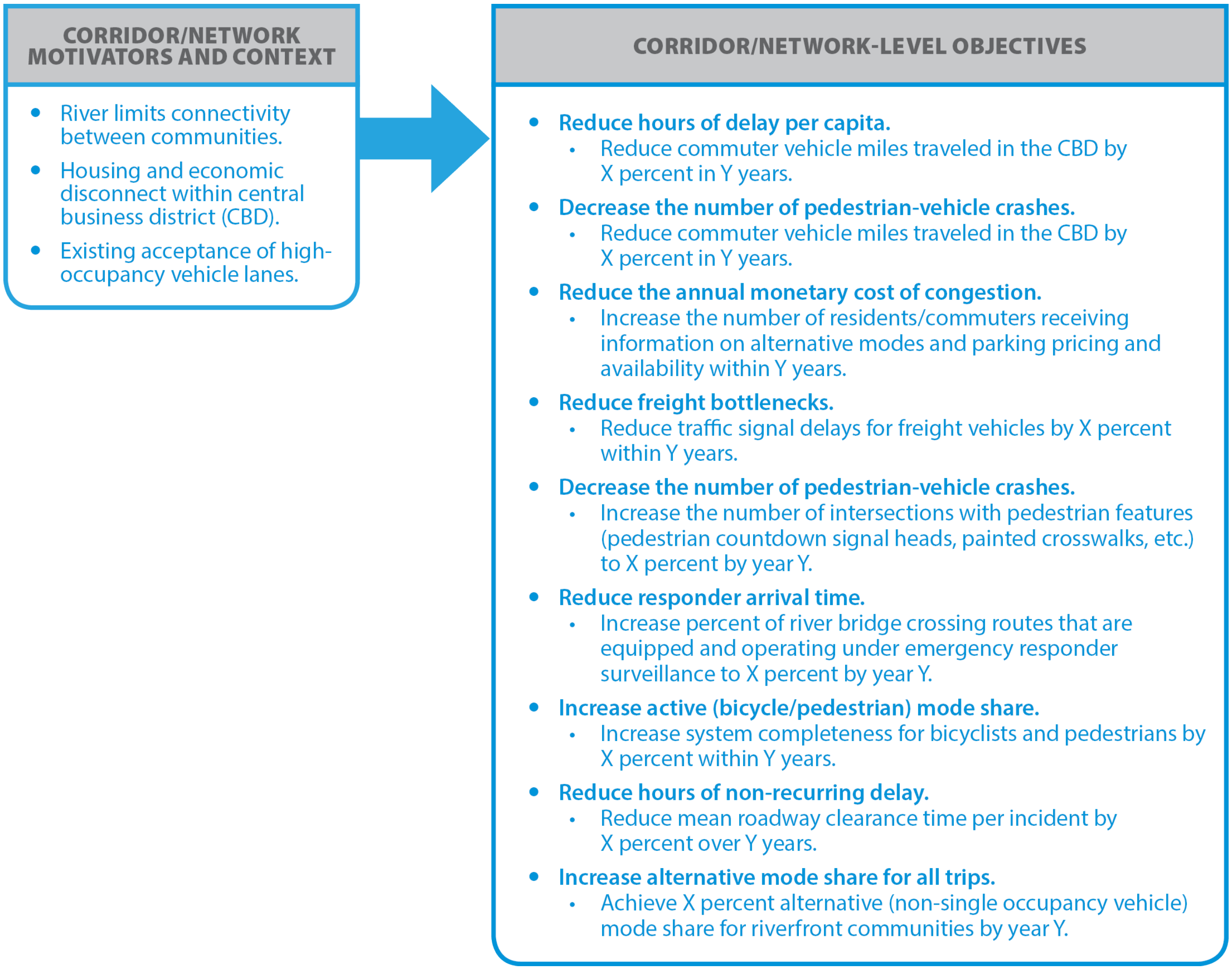
In Step 3 of the methodology, objectives are developed for the specific corridor or network (figure 56). Network and corridor-level objectives are derived from system-level objectives and are connected to a much more specific geographic context (figure 57).



Source: FHWA.

Figure 56. Diagram. Scenario 4: The third step of the methodology is to develop network-level objectives and set targets.

Application of RDAT Tools: At the network level, the usefulness of RDAT tools is similar to their usefulness at the system level. In fact, as mentioned in the Step 2 narrative, system-level performance measures must be built up or aggregated from the network or segment level. The applications described in the Step 2 narrative—setting a baseline, identifying sources of congestion, establishing performance measures, and setting thresholds—also apply to Step 3, and the same RDAT tools are relevant.



CORRIDOR/NETWORK MOTIVATORS AND CONTEXT

- River limits connectivity between communities.
- Housing and economic disconnect within central business district (CBD).
- Existing acceptance of high-occupancy vehicle lanes.

CORRIDOR/NETWORK-LEVEL OBJECTIVES

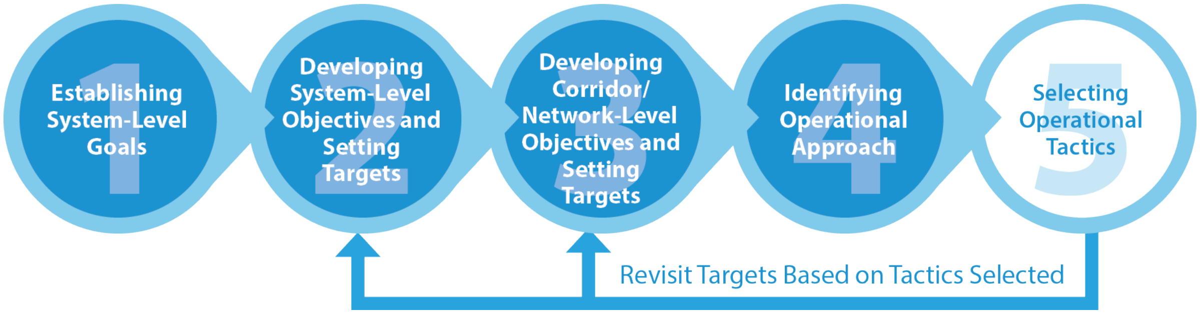
- **Reduce hours of delay per capita.**
  - Reduce commuter vehicle miles traveled in the CBD by X percent in Y years.
- **Decrease the number of pedestrian-vehicle crashes.**
  - Reduce commuter vehicle miles traveled in the CBD by X percent in Y years.
- **Reduce the annual monetary cost of congestion.**
  - Increase the number of residents/commuters receiving information on alternative modes and parking pricing and availability within Y years.
- **Reduce freight bottlenecks.**
  - Reduce traffic signal delays for freight vehicles by X percent within Y years.
- **Decrease the number of pedestrian-vehicle crashes.**
  - Increase the number of intersections with pedestrian features (pedestrian countdown signal heads, painted crosswalks, etc.) to X percent by year Y.
- **Reduce responder arrival time.**
  - Increase percent of river bridge crossing routes that are equipped and operating under emergency responder surveillance to X percent by year Y.
- **Increase active (bicycle/pedestrian) mode share.**
  - Increase system completeness for bicyclists and pedestrians by X percent within Y years.
- **Reduce hours of non-recurring delay.**
  - Reduce mean roadway clearance time per incident by X percent over Y years.
- **Increase alternative mode share for all trips.**
  - Achieve X percent alternative (non-single occupancy vehicle) mode share for riverfront communities by year Y.

Source: FHWA.

Figure 57. Diagram. Scenario 4: Network motivators and system-level objectives drive the development of the network-level objectives and targets.

Identifying an Operational Approach

Identifying an operational approach and defining supportive tactical program areas is Step 4 of the methodology (figure 58). A universe of tactical program areas is available to support this step. The approach is assessed against network-level objectives. For this scenario, only the most practical technical program areas were selected from this universe to form the next-level decision in identifying tactics.



Source: FHWA.

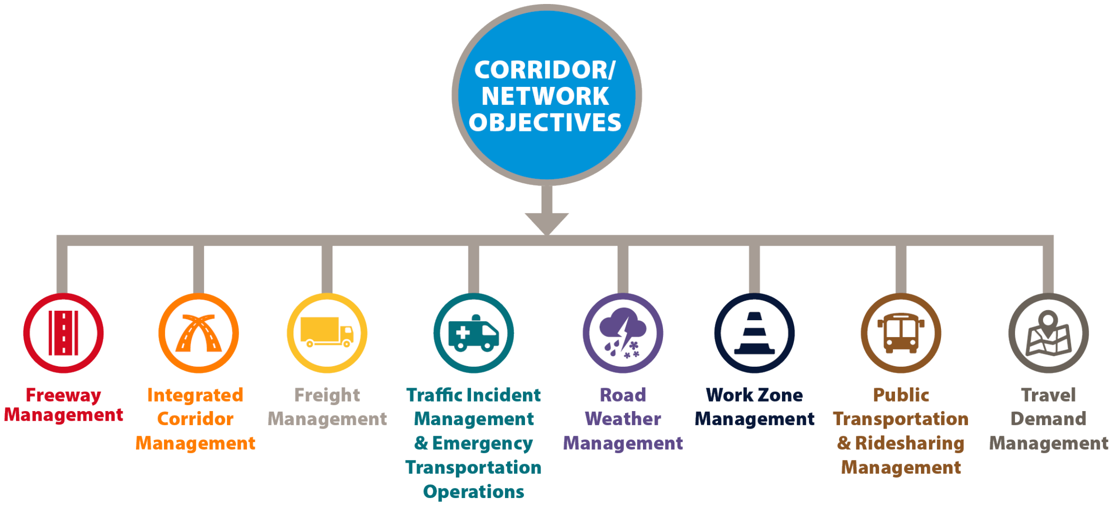
Figure 58. Diagram. Scenario 4: The fourth step of the methodology is to identify an operational approach for achieving the network-level objectives.

Application of RDAT Tools: In this scenario, identifying reliability issues, and the congestion sources associated with them, could point the way toward program areas such as travel demand management, freeway management, freight management, traffic incident/emergency transportation operations, and special event management, and arterial management.

The tactical program areas identified to support each network-level objective, shown in figure 59, are listed below:

- Reduce commuter vehicle miles traveled in the CBD by X percent in Y years.
  - **Public Transportation and Ridesharing Management** and **Travel Demand Management.**
- Increase the number of residents/commuters receiving information on alternative modes and parking pricing and availability within Y years.
  - **Public Transportation and Ridesharing Management** and **Parking Management.**
- Reduce traffic signal delays on freight vehicles by X percent within Y years.
  - **Arterial Management** and **Freight Management.**
- Increase the number of intersections with pedestrian features (pedestrian countdown signal heads, painted crosswalks, etc.) to X percent by year Y.
  - **Arterial Management.**
- Increase percent of river bridge crossing routes that are equipped and operating under emergency responder surveillance to X percent by year Y.
  - **Freeway Management** and **Traffic Incident Management and Emergency Transportation Operations.**
- Reduce commuter vehicle miles traveled in the CBD by X percent in Y years.
  - **Travel Demand Management** and **Public Transportation and Ridesharing Management.**
- Increase system completeness for bicyclists and pedestrians by X percent within Y years.
  - **Arterial Management.**
- Reduce mean roadway clearance time per incident by X percent over Y years.
  - **Traffic Incident Management and Emergency Transportation Operations.**
- Achieve X percent alternative (non-SOV) mode share for riverfront communities by year Y.

- **Public Transportation and Ridesharing Management** and **Travel Demand Management.**



Source: FHWA.

Figure 59. Diagram. Scenario 4: The operational approach contains tactics from one or more tactical program areas.

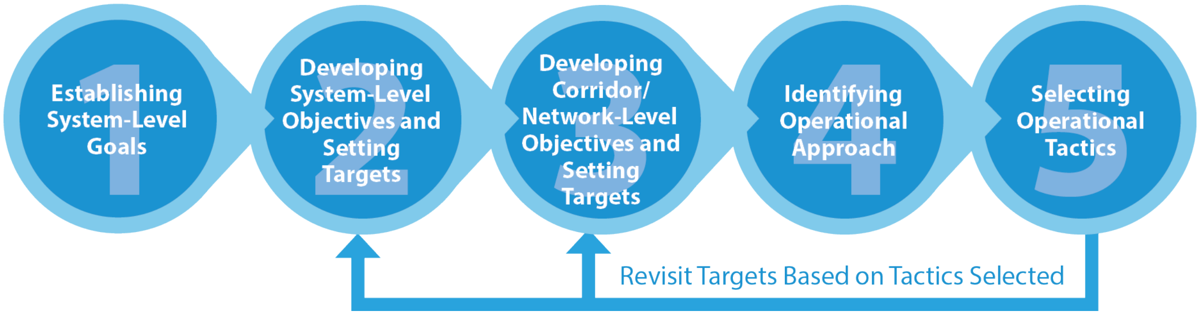
Selecting Operational Tactics

Step 5 (figure 60) requires the expert judgment of leaders within each tactical program area (figure 61) to determine the network's fit with potential tactics.

Application of RDAT Tools: This scenario's tactics are related to a mixture of freeways and surface streets in and near the CBD. Example RDAT applications for this scenario follow:

- FREEVAL/SHRP2 L07 and STREETVAL could be used to analyze tactics that influence traffic demand fluctuations on CBD freeways and streets, such as commuter financial incentives, dynamic ridesharing, dynamic transit fare reductions, dynamically priced parking, and other mode-shift tactics.

- These tools could also be used to analyze tactics that influence CBD incident durations, most notably those related to decreasing emergency response times, use of roving patrols, and tow truck incentives—especially as related to river bridges.



Source: FHWA.

Figure 60. Diagram. Scenario 4: The fifth step of the methodology is to select operational tactics to execute the operational approach.

Source: FHWA.

Figure 61. Diagram. Scenario 4: Tactics from these tactical program areas were selected for the operational approach.

Below are the tactics identified to support the achievement of each network-level objective:

- Reduce commuter vehicle miles traveled in the CBD by X percent in Y years.
    - **Public Transportation and Ridesharing Management**, **Travel Demand Management**, and **Parking Management**.
        - Implement dynamic ridesharing.
        - Implement transit signal priority.
        - Establish dynamic transit fare reductions.
        - Deploy commuter financial incentives.
        - Deploy dynamically priced parking.

- Reduce commuter vehicle miles traveled in the CBD by X percent in Y years.
    - **Public Transportation and Ridesharing Management**, **Travel Demand Management**, and **Parking Management.**
        - Implement dynamic ridesharing.
        - Implement transit signal priority.
        - Establish dynamic transit fare reductions.
        - Deploy commuter financial incentives.

    - Deploy dynamically priced parking.

- Increase the number of residents/commuters receiving information on alternative modes and parking pricing and availability within Y years.
  - **Public Transportation and Ridesharing Management** and **Parking Management.**
    - Establish dynamic transit fare reductions.
    - Deploy dynamically priced parking.

- Reduce traffic signal delays on freight vehicles by X percent within Y years.
  - **Arterial Management** and **Freight Management**.
    - Implement truck traffic signal priority.
    - Implement freight loading zone policies (e.g., delivery times, designated zones, electronic parking payment systems).

- Increase the number of intersections with pedestrian features (pedestrian countdown signal heads, painted crosswalks, etc.) to X percent by year Y.
  - **Arterial Management.**
    - Provide enhanced bicycle and pedestrian crossings.
    - Design for complete streets.

- Increase the percent of river bridge crossing routes that are equipped and operating under emergency responder surveillance to X percent by year Y.
  - **Freeway Management** and **Traffic Incident Management and Emergency Transportation Operations**.
    - Implement network surveillance with cameras or detectors.
    - Integrate CAD.
    - Co-locate dispatch units.

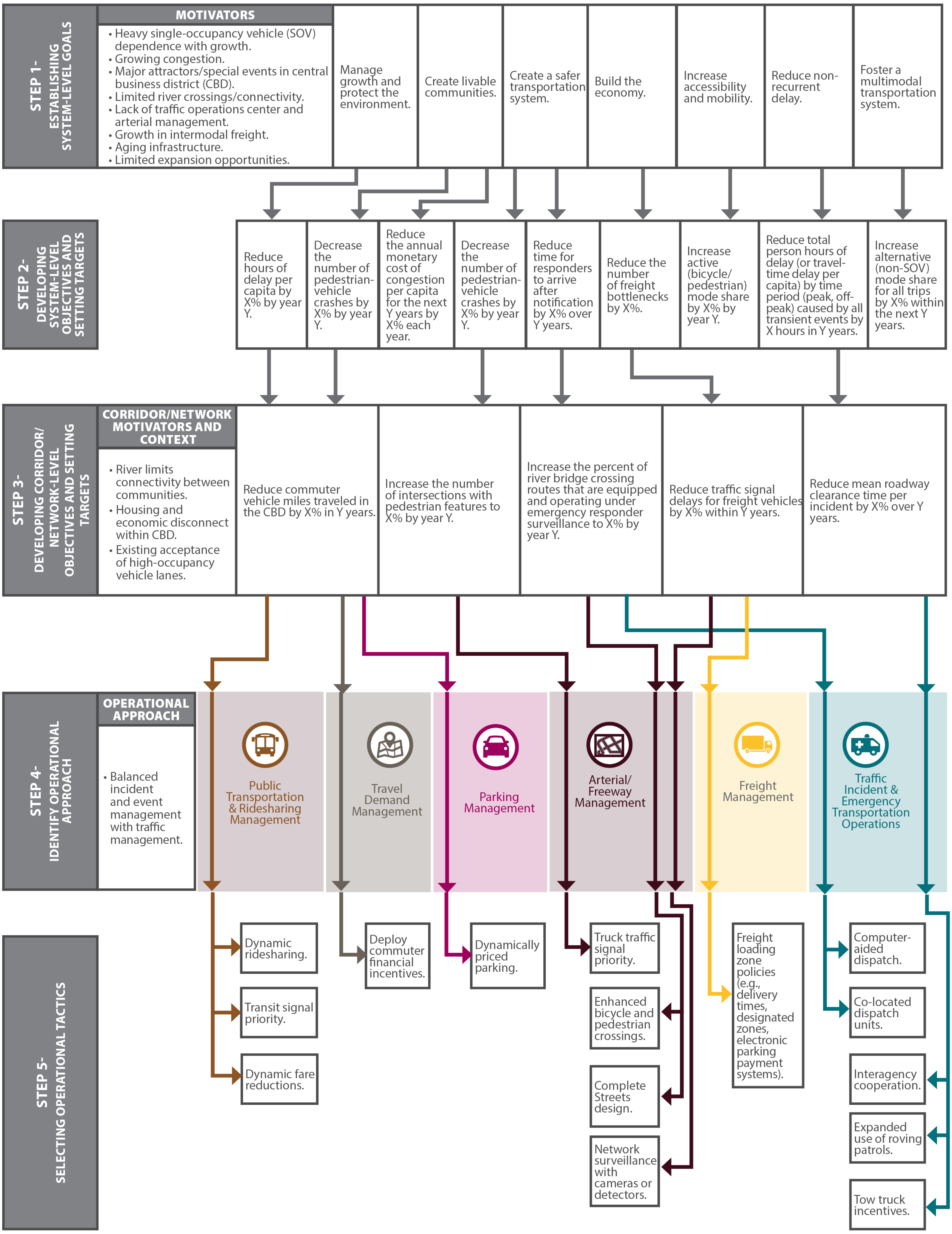
- Reduce commuter vehicle miles traveled in the CBD by X percent in Y years.
  - **Public Transportation and Ridesharing Management**, **Travel Demand Management**, and **Parking Management.**
    - Implement dynamic ridesharing.
    - Implement transit signal priority.
    - Establish dynamic transit fare reductions.
    - Deploy commuter financial incentives.
    - Deploy dynamically priced parking.
- Increase system completeness for bicyclists and pedestrians by X percent within Y years.
  - **Arterial Management.**
    - Provide enhanced bicycle and pedestrian crossings.
    - Design for complete streets.

- Reduce mean roadway clearance time per incident by X percent over Y years.
  - **Traffic Incident Management and Emergency Transportation Operations.**

        - Interagency cooperation.
        - Expand use of roving patrols.
        - Use tow truck incentives.

- Achieve X percent alternative (non-single occupancy vehicle) mode share for riverfront communities by year Y.
    - **Public Transportation and Ridesharing Management**, **Travel Demand Management**, and **Parking Management.**
        - Implement dynamic ridesharing.
        - Implement transit signal priority.
        - Establish dynamic transit fare reductions.
        - Deploy commuter financial incentives.
        - Deploy dynamically priced parking.

On the following page, figure 62 illustrates the application of the full methodology for the large urban subarea and shows connections between the steps.



Source: FHWA.

Figure 62. Diagram. Scenario 4: Application of methodology to large urban subarea.

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