Measuring Transportation Network Performance

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Measuring Transportation Network Performance

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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FOREWORD

By Lori L. Sundstrom
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This guidebook provides methods for integrating performance measures from individual transportation modes and multiple jurisdictions and for developing new measures, if needed, to monitor transportation network performance. These network performance measures can be used to improve system management, planning, and investment decisions and can be applied to various scenarios. The guidebook should be of immediate use to practitioners in state, regional, or local governments; specially designated authorities; or those in the private sector who are responsible for measuring, operating, and investing in the performance of multimodal and/or multijurisdictional transportation networks.

Transportation systems typically span multiple jurisdictions, serve common markets, and often provide overlapping services within regions and corridors. Most research for developing transportation system performance management highlights the tools, frameworks, and guidelines necessary for performance program creation and implementation; research has not sufficiently examined ways of integrating system-level programs in order to measure the performance of multimodal and/or multijurisdictional transportation networks.

Transportation system users may navigate across transportation systems owned, operated, and maintained by numerous public agencies and private organizations without regard to the controlling entity; users may tend to perceive this collection of systems as a "seamless" transportation network. Data and indicators that can be used to measure performance across multiple modes and multiple jurisdictions are increasingly necessary to enable various agencies and organizations to plan for and manage a multimodal and/or multijurisdictional transportation network and to improve the likelihood that a collection of systems can function, or continue to function, effectively as a network.

Under NCHRP Project 08-67, Cambridge Systematics, Inc., (1) conducted an in-depth analysis of the potential for integrating or developing measures for gauging the performance of multimodal and multijurisdictional transportation networks and (2) developed a handbook for use as a reference by transportation agencies when implementing network performance measures across modes and/or jurisdictions.

To meet the project objectives, the research team (1) documented the state of practice for network performance measures in state DOTs, regional transportation authorities, metropolitan planning organizations, corridor coalitions, and local governments; (2) described methods and conditions that support the development of network performance measures; (3) developed in-depth case studies that demonstrate the successful application of network performance measures; (4) developed potential cross-jurisdictional and cross-modal performance measures that can be applied to generic network scenarios, identifying data sources, needs, and issues for each scenario while weighing the feasibility of implementation based on factors such as policy or institutional bias and cost implications; and (5) created a guidebook to be used as a reference by transportation agencies when implementing network performance measures.

CONTENTS

Note: In some instances, illustrations and tables in this report have been converted from color to grayscale for printing. The electronic version of the report (posted on the Web at www.trb.org) retains the color versions.

CHAPTER 1

Introduction

Performance measurement has become increasingly common at transportation agencies as they strive to improve their understanding of the outcomes of investments in the transportation system and as citizens increasingly require accountability for actions. As performance measurement has become more common, there is increased recognition that individual agencies cannot address the transportation systems they are responsible for in a vacuum, but must coordinate and interact with other agencies to address the network performance implications of their decisions.

Network performance measurement is an attempt to evaluate the transportation system as a whole, considering all modes of transportation, all potential strategies (e.g., capital versus operational investments), and all jurisdictions (e.g., state, regional, and local). Network performance measurement involves breaking down the silos between different investment approaches and attempting to consider tradeoffs and efficiencies across systems. Agencies have become interested in network performance both because of a recognition that investments made on one mode or jurisdiction may affect the performance of other modes or jurisdictions and because limited resources are creating a need to invest transportation resources as efficiently as possible.

Purpose of the Guidebook

This guidebook provides an introduction to network performance measurement oriented toward transportation planning practitioners. It will help agencies begin to understand

- The potential uses and benefits of considering network performance measurement and
- How agencies can begin to adopt and implement network performance measures.

Though many transportation agencies understand the interrelationship of various components of the transportation system, relatively few have attempted to work outside of existing silos to consider tradeoffs and efficiencies in investments. Most transportation funding comes with strings attached and program managers are naturally reluctant to invest in other programs or agencies, given needs that typically outstrip available resources.

Network performance measures can provide critical information to help decisionmakers understand better how their choices impact fundamental outcomes for the transportation system as a whole and for their customers. Without clear and useful information, breaking through existing barriers will always be a challenge.

Organization of the Guidebook

The guidebook provides an introduction to network performance measurement and examples of how network performance measurement can be applied to specific scenarios. Chapter 2 describes network performance and how it can be applied to address congestion and other transportation challenges. This section will likely be of interest to all because it defines network performance and describes how to apply it. Chapters 3 through 7 provide windows into the implementation of network performance measures through a set of scenarios. These sections apply the framework described in Chapter 2, and readers will likely be interested in only the scenarios relevant to their situations. The scenarios are introduced in Chapter 2. Finally, Chapter 8 summarizes the findings of the analysis and provides a set of recommended steps for beginning to address network performance measurement.

CHAPTER 2

Understanding Network Performance Measurement

> System performance depends critically on how the parts fit and work together, not merely on how well each performs independently; it depends on interactions rather than on actions. Furthermore, a system's performance depends on how it relates to its environment—the larger system of which it is a part—and to other systems in that environment (Ackoff, 1980, p. 7).

Traditionally, transportation planning and project development practice has focused on the impacts of discrete types of investment strategies in relation to specific transportation goals, with goals most often tied to a modal or even functional aspect of the transportation system, funding source, or particular transportation function. This silo-based approach to planning and project development has carried over into performance measurement, with measures that assess individual investment options and do not provide a true systems-level perspective. Federal funding programs, organizational barriers, and other factors mean that performance management techniques are often applied within silos. Furthermore, although several transportation organizations have begun to develop more comprehensive performance measures that better reflect their diverse planning goals and objectives, measuring performance for the transportation network and using measures across various stages of the transportation planning process remains a challenging endeavor.

Several recent trends in systems planning and performance measurement have begun to increase the amount of attention paid to network- or systems-level performance measurement. Though the list is not comprehensive, some of the most important examples include

- **Congestion management.** The growth of the congestion management process (CMP) has resulted in agencies considering a broader range of strategies to tackle congestion, including, in particular, multimodal investments.
- **Linking planning and operations.** Increased attention has been paid to bringing operations into the mainstream planning and project development process. Though planning and operations have traditionally been addressed separately, there is increased realization that data collected for operations purposes also can support the planning process and that the planning process must address operational needs and evaluate operational solutions (e.g., incident management and intelligent transportation systems [ITS]) alongside traditional capacity solutions). This integration is considered both as part of the CMP and as part of state metropolitan planning more broadly. The FHWA has authored guidebooks to address linking planning and operations at both state and metropolitan levels.
- **Corridor coalitions.** Growth of corridor coalitions has spurred an increase in addressing transportation system needs across long-distance corridors using a wide range of strategies (e.g., capacity additions and operational improvements) and modes (e.g., highway, rail, and transit). These coalitions are increasing the recognition of freight movements and their impact on the system, especially over long-distance corridors.

These efforts have attempted to address the multiple impacts of transportation projects (i.e., transportation, economic, environmental, and community) and an understanding that traditional new-capacity projects are no longer feasible in many areas and have to be fully justified when they are considered.

Network Performance Measurement Framework

Components of Network Performance

Define the Network

From the traveling public's perspective, transportation systems are not bounded by the jurisdictional boundaries or functional mandates that tend to drive current planning and project development processes. These transportation system boundaries are a result of transportation planning and funding mechanisms needed to develop, operate, and maintain transportation infrastructure within the context of a larger regulatory and political framework. As such, a way is needed to communicate performance of transportation investments that makes sense to the system user. Network performance measures are intended to span these boundaries in order to produce a more meaningful picture of transportation performance and, as a result, communicate to transportation stakeholders why particular investment strategies are chosen for funding and how well they are meeting expectations.

Transportation agencies already are beginning to work together across jurisdictions and scales of government (e.g., state, regional, and local) to improve performance measurement. Because differences exist between various agencies' organizational and functional mandates, it can be challenging to develop a common set of **multijurisdictional** performance measures to assess the impact of the system in relation to mutual goals and transportation objectives. With multiple jurisdictions working together, the number of potential actors compounds issues (e.g., what performance data is to be collected, which data matters, and how data can be used to inform decision making). Yet collaboration of multiple actors can ultimately yield more meaningful and comprehensive measurements. Use of performance information can be increased and improved through collaboration and dialogue between jurisdictions and across scales of government (interagency) or between individual units within an agency (intra-agency).

Agencies also are increasingly setting goals to improve **multimodal** mobility and accessibility. Agency performance measures already are commonly used to assess various individual modes, but most often in isolation of one another. There are challenges to measuring multiple modes across a network, or the connectivity of modes within or between systems, with the most common being technical issues associated with predicting multimodal effects of projects and plans using tools limited by network scope and detail. As interagency and intra-agency partnerships increase and tools improve, agencies can develop and use multimodal measures to assess a broader array of investment strategies, improve decision-making processes, and determine if the transportation network as a whole is improving mobility and accessibility for all system users. A related issue is that the measures are typically associated with investment options that fall within a particular silo. For example, many agencies report some measure of overall congestion. However, they typically do so only in the context of roadway investments, rather than including multimodal investments.

Similarly, many agencies are setting goals to provide needed transportation capacity through more cost-effective projects, rather than traditional roadway widenings. Systems operations projects, in particular, are a growing component of planned investments. These types of investments function differently by providing additional capacity through more efficient traffic operations and smoother traffic flow, without requiring new roadway infrastructure. They are **multistrategy** in that there are multiple approaches to achieve an agency's goals. Similar to challenges associated with multimodal measures, comparing the benefits of smaller-scale investments, such as system operations projects, to larger roadway projects is hindered by limitations of commonly used technical tools, which have been developed over decades to assess the impacts of added roadway capacity. The same can be said for other types of smaller-scale investment strategies intended to improve traffic flow and transportation efficiencies (e.g., travel demand management measures).

In addition to the jurisdictional, functional, and modal factors highlighted above, network performance measures also can be applied to span the various stages of the planning process, including project identification, evaluation, selection/programming, and development (environmental review and construction). Often, these stages of the planning process are managed by different agencies or groups within particular agencies, and the methods for performance evaluation at various stages can be very different. For example, a newly identified project may be evaluated in terms of a congestion reduction metric, programmed for funding based on a cost-benefit metric that may include other benefits, and administered through the project development processes based on a project deliverability/readiness metric. This **multistage** aspect is a critical dimension of network performance measurement, because it links planning to implementation.

Framework for Implementing Network Performance

This handbook provides a framework and a set of scenarios to help transportation agencies define approaches and specific performance measures to address network performance. Figure 2.1 presents the basic framework, building on the dimensions identified above. The left half of the diagram indicates the dimensions and the right half describes the basic process for considering network performance.

The remainder of this section describes this process for addressing network performance.

Define the Network

It is important to define the network part of network performance early in the process. Put simply, the network is the combination of (1) the relevant agencies or jurisdictions—state, regional, and local—that have existing or proposed infrastructure within the geographic area under consideration

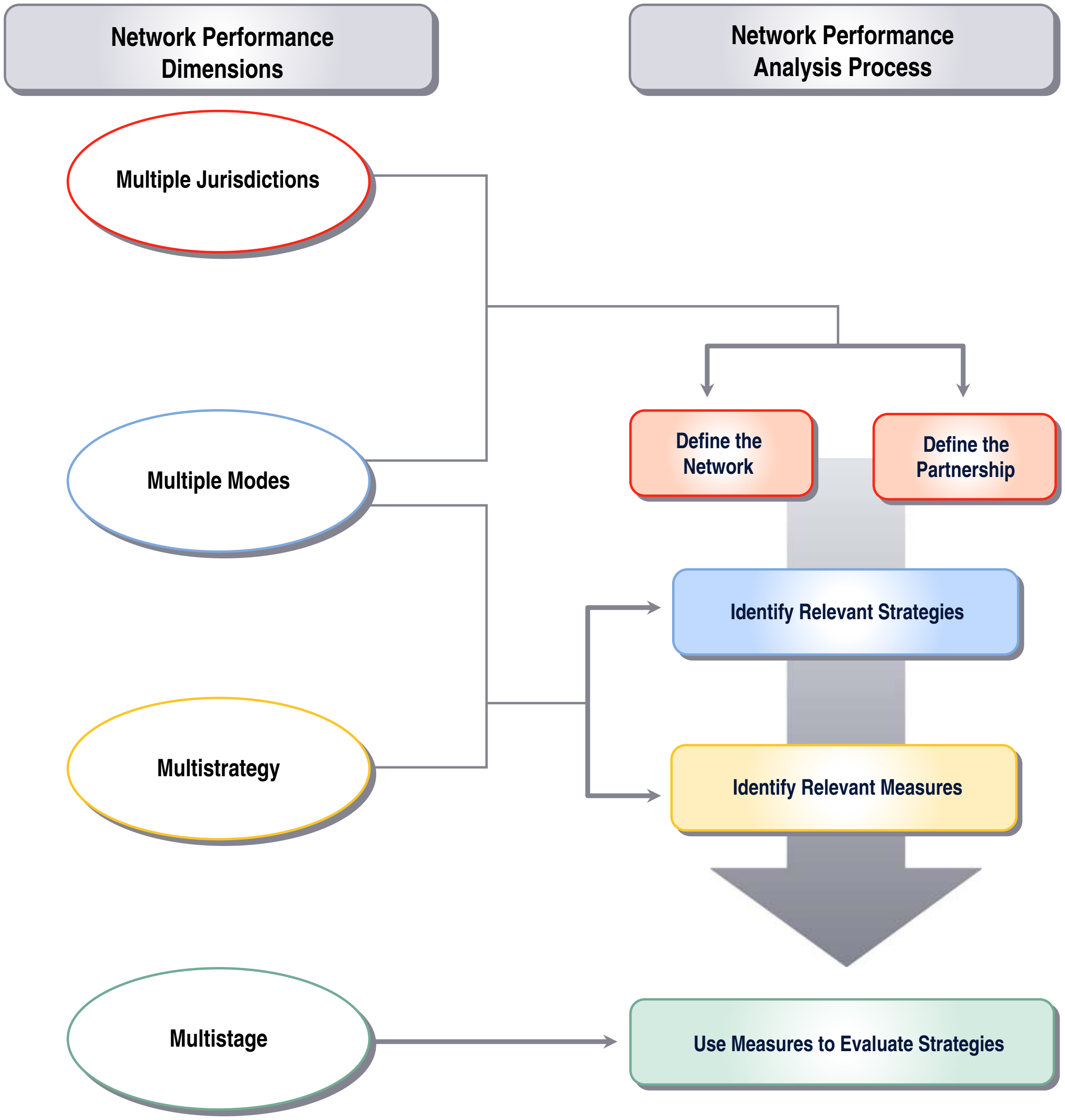


Figure 2.1. Network performance measurement framework concept.

and (2) the relevant transportation modes. As an agency or set of agencies begins to address a congestion problem (or a safety, renewal, or environmental problem), considering the full set of relevant agencies and modes to include in the network will improve their understanding of the specific problem and the potential range of solutions.

Defining the network will depend, in part, on the scale of the problem under consideration. For example, a focus on commuting challenges to a specific destination might consider all modes and all types of travel, while a focus on intercity congestion issues might not examine local transit but definitely include intercity rail.

Define the Partnership—Organizing Principle of the Handbook

Along with defining the network, it is important to define the partnership. Who is involved and has a voice or control over decisions? Though several important dimensions of network performance have been defined, the **partnership** dimension is used to organize this handbook. *Partnerships* refer to the forum used by a set of agencies measuring network performance (as well as tackling other issues). Partnerships are primary because nothing else can happen without them. Until a set of agencies agrees on an approach and a forum to make decisions, network performance measurement cannot take place. The specific partnership arrangement will respond to the conditions and questions that the individual agencies have. Three basic types are relevant:

1. **Single region.** The most common existing partnership model for considering network performance is the metropolitan planning organization (MPO) or other regional agency. MPOs provide a deliberative forum for making regional decisions. These bodies can consider the entire transportation network and tradeoffs among modes and strategies. In some states, there is a similar collaborative approach, at least across modes, but MPOs are more common. The MPO is federally defined with requirements for inclusion.
2. **Peer-to-peer.** With the growth of metropolitan areas and the increased recognition of multiregional and multistate issues, such as long-distance freight movements, a new form of partnership is emerging to address these issues. These partnerships are between agencies (two or more MPOs, or two or more states) that are peers. Network performance measures can be useful for supporting two different types of peer-to-peer partnerships:
   – State-to-state partnerships are increasingly common through various corridor coalitions that have been established for individual projects (e.g., the I-10 Corridor Coalition) or on an ongoing basis (e.g., the I-95 Corridor Coalition). In addition, sets of states often develop multistate compacts to address individual transportation challenges.
   – MPO-to-MPO partnerships for performance measurement are less common, but the growth of metropolitan areas has increased the need to address transportation issues across MPO boundaries. In several states, individual MPOs are defined by county boundaries, and the true area of commuting spans these boundaries. In addition, megaregions are increasingly spanning multiple multicounty MPOs.
3. **Intra-agency partnerships.** Because partnerships are the organizing principle of this handbook, individual agency attempts to consider the network-level implications of transportation decisions have not been the focus. However, even within a given agency, there are often different groups with responsibilities for different pieces of the system or different types of investment. For example, a state may want to evaluate tradeoffs across capacity expansion and operations investments to address congestion. The measures and considerations identified in this handbook may be useful for these circumstances as well.

Define Network-Level Performance Measures

What are network performance measures and how are they used to measure transportation network performance? Though no specific definition of transportation network performance measures exists, the measures encompass certain criteria and qualities. Network performance measures

- Address the regional, state, or multistate impacts of individual decisions;
- Are derived from a process that involves multiple actors working in collaboration;
- May span multiple jurisdictions, modes, investment strategies, and stages of the plan and project development process;
- Are connected with broader outcomes and systemwide performance objectives;
- Measure the performance of a transportation network, not only individual facilities; and
- Are supported by data and tools that provide a fair comparison of different types of investment strategies.

Define Network Performance Strategies

One of the key dimensions of network performance is the consideration of multiple types of strategies. The significant cost of and lack of physical space for new transportation capacity (whether highway or transit) have increased the interest in system operations solutions. Like modal silos, performance measurement has often been conducted separately for different types of strategies. Again, defining the appropriate strategies will depend on the scale of the effort under consideration and the modes and jurisdictions involved in defining the network and partnership.

Apply Network Performance Measures

Applying the network performance measures will depend on context. Examples of application may include the following:

- Corridor-level performance measures. Measure investment strategies across an entire corridor that spans jurisdictions (e.g., congestion measures, crash reduction, and environmental impact);

- System-level performance measures. Measure the cumulative effect of investment strategies at the systems level (e.g., air quality measures for conformity analysis);
- A project selection process that compares benefits and impact across multiple modes and investment strategies; and
- Project development activities that ensure investment priorities are established using one set of metrics throughout the project development process.

Introduction to the Scenarios

Table 2.1 describes the five scenarios that can help an agency or group of agencies apply network-level performance measures.

The scenarios reflect one or more case studies conducted for this project. For most of the scenarios, a primary case study is identified in the table, but information from other case studies is also presented. The complete set of case studies conducted for the project is available in Appendix B. Select literature that was the foundation of this effort is discussed in Appendix A.

Table 2.1. Handbook scenarios.

Chapter	Scenario Name	Scenario Description	Primary Case Studies
3	Regional Scenario – Defining Community Goals Across Jurisdictions	State and regional policy, program, project, and operational decisions can have significant implications for local communities. Conversely, local transportation projects and operational strategies can have impacts that are felt far beyond the borders of the municipal boundaries. Statewide and regional entities are working collaboratively with local governments and transportation providers to assess the impacts of these decisions on a systems level and fully understand and plan for the implications.	Capital District Transportation Commission planning process
4	Regional Scenario – Multimodal and Multistrategy Investment Prioritization	Decreasing resources and an interest in funding projects with the most favorable benefit–cost ratio has increased the interest in analyzing all projects across a system for planning and programming purposes. These efforts typically include many entities with varying responsibilities for the transportation network.	Bay Area Metropolitan Planning Commission *Transportation 2035 Plan: Change in Motion*
5	Peer-to-Peer Scenario – Multistate Partnership for System Operations	Many key corridors throughout the country cross state boundaries, creating a complex web of players who are responsible for the planning and operations of what for users is a single transportation network. Infrastructure improvements that directly address a problem for one mode may have important impacts (both negative and positive) for other modes. Without the data to analyze these improvements across state lines and among agencies, and without the forum to vet and discuss the implications, the most effective investment decisions may be lost.	Mid-Atlantic Rail Operations Study, I-95 Vehicle Probe Study
6	Peer-to-Peer Scenario – Megaregional Partnership to Address Growth	As metropolitan regions expand, they become increasingly linked via economic interdependence and common transportation corridors and networks. These new "megaregions" share common issues, including economic growth, environmental concerns, and mobility. As the regions expand, there is an increased need for planning and operations considerations among existing jurisdictions and agencies, including both those that cross state boundaries and those that fall within one state.	San Joaquin Valley Partnership Regional Blueprint
7	Intra-agency Scenario – Linking Planning and Operations at a State DOT	Several agencies have addressed network performance within the context of a single agency. State DOTs are increasingly recognizing the need to link their planning and operations investments both to better address issues such as reliability and to share investments in data collection and tool development.	Oregon Transportation Plan update, Washington State Gray Notebook

The scenario chapters are organized in the same way to aid in connecting the information presented in this section to the specific scenario. The organization is as follows:

- **Scenario.** A short description of the basic motivation for and components of the scenario.
- **Case Studies.** A summary of the primary case study used to illustrate the scenario and identification of additional case studies.
- **Building blocks.** The scenarios describe specific applications of network performance, but a common set of building blocks also has been identified. These building blocks include the following:
  - **Establish Partnership Agreements.** This building block addresses the first step in the network performance process: setting up a partnership among agencies or different departments within an agency. These partnerships set the stage for using network performance to address a specific challenge.
  - **Define Performance Measurement Framework.** Early in the process, it is important to establish a common set of goals and objectives between agencies and identify modes and strategies to be considered. This building block addresses the steps in the network performance measurement process to define the network and identify strategies.
  - **Develop Measurement and Data Collection Methodologies.** Network performance analysis requires data and analysis tools to be able to capture strategies that cross jurisdictions or can apply to multiple modes. In some cases, data may already exist and need to be integrated, but in others new data may need to be collected. Performance measures also need to be defined. This building block addresses two steps of the network performance process: developing performance measures and using measures to address network performance.

CHAPTER 3

Regional Scenario—Defining Community Goals Across Jurisdictions

Scenario

In urbanized areas, MPOs provide a well-established forum for identifying community goals across multiple jurisdictions. In many MPOs, goals and objectives traditionally consider the limited set of investments that MPOs have direct control or influence over—primarily highway and transit capacity investments. A network performance approach can help to incorporate other major considerations, such as highway and transit operations, nonmotorized programs, land use policy decisions, and other nontraditional concerns. This scenario describes how MPOs can use network performance measurement to help define regional goals and the full range of strategies necessary to meet them.

The coordination of multiple agencies within a region can help in determining and driving network performance. However, multiagency coordination of performance data and measures can be challenging. Moreover, it is often difficult to share common network measures across systems if the different agencies have divergent goals. The typically uncoordinated interplay between local and regional transportation and land use planning compounds these issues.

Rather than developing data collection and performance measures individually, agencies can collaborate and harmonize measures and strategies across jurisdictions in order to reach broader regional goals and outcomes. MPOs can play an important role in facilitating this collaboration across local involvement and public engagement in the planning stages. State support from transportation agencies and strong working relationships between state, regional, and local governments also are important in fostering the development of a systemwide perspective that can help to improve network performance.

Case Studies

The primary case study for this scenario is the Capital District Transportation Committee (CDTC), the MPO for the Albany, New York, region. The Albany urbanized area, also known as the Capital District, consists of major highways, including I-87 and I-91, and key corridors, including NY Routes 7, 9, and 155.

CDTC uses core performance measures relating to aggregate system performance and supplemental performance measures relating to specific elements of the systems. CDTC has, for many years, included system reliability, land use compatibility, and a wide range of environmental impacts in its planning process. CDTC and its members also have been active in providing significant support for community planning, transit service design, intermodal development, ITS deployment, demand management, and public participation.

CDTC uses performance measures to evaluate strategic goals and outcomes as well as operational and individual facility-level measures. It works with the public and many local governments in the long-range planning process to develop goals and strategies, and then works with local jurisdictions to implement the strategies through programs and projects.

Additional examples of multilevel agency coordination have been taken from the San Diego Association of Governments (SANDAG), Sacramento Area Council of Governments (SACOG), and Minnesota Department of Transportation (MnDOT).

Building Blocks

Establish Partnership Agreements

The fundamental building block for this scenario is the establishment of partnership agreements with the several agencies that have responsibility for transportation infrastructure within the region.

Collaboration Across Levels of Government

Though all MPOs include participation by local governments and state and regional agencies within the region, individual agencies often either are not active in the MPO process or do not collaborate to define regional goals. CDTC uses a collaborative approach to understand the region's transportation network and move toward regional goals, such as livability.

CDTC collaborates with the New York DOT, regional planning and transit organizations, and local jurisdictions to establish goals and to define and implement strategies. Examples include the following:

- CDTC has defined congestion management performance measures and tradeoff analysis through a Regional Operations Committee.
- CDTC contracts with the Capital District Regional Planning Commission (CDRPC) and funds that agency's work in demographic data and forecasts and in regional land use policy discussions.
- CDTC includes land use measures in its CMP, including dislocation of existing residences and businesses and community quality-of-life measures.
- CDTC works with local municipalities to implement joint planning studies. Because MPOs have no land use authority, CDTC established a program that funnels almost one-third of its funding to communities for projects that integrate land use and transportation planning. The program links regional plans with local projects and provides a tool to reach consensus on how the transportation network should perform.

> Since the early 1990s, MnDOT and the Metropolitan Council (the MPO for the Twin Cities region) have worked to build a multiagency partnership around transit called "Team Transit" to improve transit operations and increase transit usage. Other agencies involved have included the Center for Transportation Studies at the University of Minnesota, the Minnesota State Patrol, representatives from the Twin Cities, and other municipalities served by transit. Team Transit focuses on maximizing the number of people moving throughout the Twin Cities, rather than the number of vehicles.

Extended Outreach to Local Governments and Communities

Effective partnerships with local governments and communities often require a level of outreach that goes beyond typical MPO planning efforts. For example, a major multi-strategy program CDTC undertakes is the Community and Transportation Linkage Planning Program.[1] This unique planning process engages regional economic entities, environmental groups, business leaders, university administration, chambers of commerce, neighborhood associations, and regional community organizations.

In the planning process, CDTC widely engages the public to help link strategies and measures to goals. CDTC staff believes that all performance measures should be first approved through public process. For example, public opinion polls have shown that people are willing to tolerate traffic congestion levels, if there are improvements to transit, walking, biking, safety, and landscaping. This interest in and understanding of public opinion helps CDTC choose appropriate measures that will facilitate aligning of network performance with community goals. For example, CDTC conducted public opinion surveys about congestion and realized that reliability measures are more important and meaningful to the public than are other congestion measures, such as level of service (LOS), speed, and volume.

Define Performance Measurement Framework

MPOs typically already have in place the basic components of a performance measurement framework that can be expanded to address network performance. Most MPOs define regional goals and objectives as part of their regional transportation plan (RTP). This section describes how network performance can help MPOs in addressing a broader array of considerations in their planning processes.

Assess Network Performance in the Context of Long-Range Goals

Long-range goals provide a key mechanism for developing and communicating regional priorities. Integrating network performance requires crafting goals that emphasize the performance of the network. CDTC focuses on the most important links in the system for achieving efficiency, rather than on individual system components/facilities. The agency has created a land use transportation compatibility index based on traffic intrusions in residential areas and the compatibility between arterial and local access.

[1]More information on CDTC's Community and Transportation Linkage Planning Program can be found at http://www.cdtcmpo.org/linkage.htm.

SANDAG publishes an annual performance monitoring report for its Regional Comprehensive Plan each year. The section on urban form and transportation includes indicators on smart growth, transit, commute mode shares, travel times, and volumes on key corridors (including evaluation of corridor improvements on these measures), annual hours of traffic delay per traveler, and the percentage of the CMP network that is deficient. Measures are derived from state, regional, and local data and are used by SANDAG and its member governments to help choose strategies to meet regional goals and improve the overall transportation system.

Use Multiple Strategies to Achieve Goals

A network performance focus on regional goals means considering multiple strategies. CDTC identifies transportation strategies that are aligned with regional goals, including

- **Reliability.** CDTC analyses of congestion reveal that adding capacity to major corridors may push bottlenecks further up a roadway. Strategies to improve network reliability also are considered, including intelligent transportation systems (ITS) and traffic management systems, managed lanes, and highway monitoring programs.
- **Land use.** In 2001, a CDTC- and Capital District Transit Authority (CDTA)-led Land Use and Transportation Concepts Plan for New York Route 5 led to a bus rapid transit (BRT) concept that is now included in expanded form in the region's long-range plan.
- **Corridor approach.** CDTC's Integrated Transportation Corridor Effort provides a stakeholder-driven approach to developing and evaluating major regional corridors. The 2008 Hudson River Crossing study considered mobility, operational efficiency, and community in a study of the bridge systems along the Hudson River using travel model and microsimulation tools and suggested that the network of bridges did not need widening to meet the needs of the region's travelers.

SACOG's Bicycle and Pedestrian Funding Program awards local grants for bicycle and pedestrian improvements using performance measures, such as changes in miles of bikeways and sidewalks and impact of bicycle and pedestrian investments on air quality and public health. SACOG recently integrated a Regional Bicycle, Pedestrian, and Trails Master Plan into its Metropolitan Transportation Plan. SACOG's goals include doubling the percentage of bike/walk trips and reducing bicycle and pedestrian fatalities by 20% by 2020.

SANDAG's Integrated Performance Management (IPM) system provides a multimodal approach to system management that recognizes the interdependence of travel modes. Ongoing monitoring helps assess consistency with regional policies. ITS is a critical element of the IPM systems network used to monitor performance. ITS helps to interconnect the region's local transportation management centers and integrates data from the modal management systems. Completion of this network will enable the modal agencies to cohesively manage the overall performance of the local and regional transportation systems.

Develop Measurement and Data Collection Methodologies

Considering network performance requires developing data sources and measures that can help transportation agencies conduct system-level evaluations.

Identify and Evaluate Nontraditional Performance Measures

Network performance requires moving the CMP beyond simple measures of congestion and delay. CDTC and its planning partners have developed "aggregate" performance measures targeted at improving overall network performance (Table 3.1). Besides the traditional MPO focus on accessibility, safety, and congestion (especially delay and LOS), CDTC includes measures of

- **System reliability.** Traditional MPO congestion management planning tends to address recurring congestion, using simple averages of travel-time delay and volume/capacity (v/c) measures. These measures do not consider variations in the experiences of travelers. For example, a network approach might consider both average travel time and travel-time variability. CDTC's CMP uses the planning time index to capture network performance. The index uses expressway speed and volume by lane in 15-minute increments in key corridors.

Table 3.1. CDTC core performance measures.

Area	Core Performance Measures
Access	• Percentage of p.m. peak-hour trips transit accessible • Percentage of p.m. peak-hour trips with transit advantage • Percentage of p.m. peak-hour trips accessible by bicycle and walking
Accessibility	• Travel time between representative locations
Congestion	• p.m. peak-hour recurring excess person-hours of delay • Excess person-hours of peak-hour delay per person-miles traveled • Excess person-hours of peak-hour delay per person
Flexibility	• Reserve capacity on the urban expressway and arterial system (p.m. peak-hour vehicle miles of capacity)
Safety	• Estimated annual societal cost of transportation accidents ($M)
Energy	• p.m. peak-hour fuel consumption (thousands of gallons)
Economic Cost	• Annual vehicle ownership and operating costs for autos and trucks ($M) • Other monetary costs of transport: highway and transit facilities and service, parking facilities, environmental damage ($M)
Air Quality	• p.m. peak-hour daily hydrocarbon (HC) emissions (kg) • p.m. peak-hour daily nitrogen oxide (NO_x) emissions (kg)
Land Use	• Land use transportation compatibility index (residential use traffic conflict: miles at LOS "E" or "F" and arterial land access conflict: miles at LOS "E" or "F") • Dislocation of existing residences and businesses • Amount of open space • Community quality-of-life factors that reflect community quality of life in the central cities, inner suburbs, outer suburbs, small cities and villages, and rural areas
Environmental	• Number of major environmental issues to be resolved to implement existing commitments
Economic	• How does the transportation system support the economic health of the region?

Source: CDTC Congestion Management Process, 2007. http://www.cdtcmpo.org/rtp2030/materials/cm-doc.pdf.

Planning Time Index

Ratio of driving time on a "worse than average delay day" (95th percentile) to a "free-flow day":

- PTI >1.0: trip would take longer time;
- PTI =1.0: trip would take no extra time; and
- PTI <1.0: speed would be >55 mph even on the "worst" day

- **Community compatibility.** CDTC is concerned with how transportation system and land use decisions affect the *New Visions* goal of becoming a "Quality Region" with a strong sense of place. Since the 1990s, CDTC has employed qualitative measures of community compatibility and quality of life in its transportation planning process, assigning Levels A through F for community impact in addition to quantitative analysis.
- **Greenhouse gas emissions.** CDTC incorporates analysis of greenhouse gas (GHG) emissions into its planning process through "full cost analysis," including the potential effects of climate change in the region in a project's cost. An analysis of global warming costs is applied to major system decisions, such as the evaluation of transportation improvement plan (TIP) projects when applicable. CDTC also has gone beyond state requirements and produced GHG emissions specific to year, operating speed, and functional class. This has allowed CDTC to mark progress toward reaching regional environmental goals.

The Minnesota I-394 Integrated Corridor Management coalition is using measures to help reduce variations in travel time and improve reliability, including a buffer index, maximum travel times experienced by travelers throughout the corridor, the range of travel times (and variability) experienced by travelers, and the percentage of "late" bus routes throughout the corridor. The coalition includes MnDOT, several municipal governments, and Metro Transit. The groups will develop a data hub used to connect multiple systems.

Minnesota's Twin Cities region conducted an extensive study of the effectiveness of the region's 430 ramp meters in 2000, including a shutdown of the system. The study revealed that meters improve throughput by about 14%, yield 2.6 million hours of systemwide delay savings, reduce the number of crashes by about 4 each day, and save 1,160 tons of emissions. Ramp metering results in a net benefit of $32 million to $37 million per year to the region's traveling public. Providing rigorous analysis of operations and ITS investments helps justify expenditures on these strategies.

Metadata Collection and Data Sharing

Developing common databases and travel models across jurisdictions or modes can be a significant challenge of multilevel agency coordination. The CDTC has addressed this issue on several fronts, including (1) using the Management Information System for Transportation (MIST) database that records expressway speed and volume by lane every 15 minutes[2] and (2) monitoring travel speed and delay on arterial corridors using global positioning system (GPS) technology. New databases and performance measures are being used to revise the critical congestion corridors articulated in the CMP documents, which contain all long-range performance measures, including congestion measures. For example, nonrecurring delay indicators are being used to redefine the definition of critical congestion. The Regional Operations Committee is using these performance measures to help CDTC evaluate the performance of its ITS, incident management systems, and operations systems.

CDTC maintains significant transportation system performance data, including biennial data for nonstate federal-aid system facilities, quadrennial sample data for local roads, supplemental data for all Albany county and city roads, and data for transit system infrastructure age, facilities, ITS, signal systems, sidewalk inventories, Thruway, and operations and maintenance systems. CDTC's data collection includes automatic traffic recorder counts; intersection traffic counts; vehicle, truck, and pedestrian trip generation; vehicle classification counts; bicycle and pedestrian shared-path volumes; transit ridership and park-and-ride lot usage; various safety data, including crash location and frequency; and other data as necessary. CDTC maintains these data for access by state government, local municipalities, public and nonprofit agencies and groups, consultants, and other interested parties.

[2]http://www.cdtcmpo.org/rtp2030/materials/wb-doc.pdf

Through CDTC's TIP, the agency funds the Capital District Transportation Management Center, run by the New York State Police and New York State DOT (NYSDOT). The Center is a source of data on traffic volumes, speed, and incidents, which are incorporated into the CMP. Values for many of CDTC's performance monitoring measures are estimated using the regional travel model. With the excess delay measurements methods, postprocessors will be used with STEP model data to generate values for excess delay, congested corridors, and bicycle and pedestrian accessibility (The Metropolitan Congestion Management Process, May 2007).

CDTC coordinates with NYSDOT, New York State Department of Environmental Conservation, and others to update natural and cultural resource maps for environmental planning and uses geographic information system (GIS) applications, such as the regional bike-hike trail maps, bike and pedestrian data mapping and analysis, and crash data mapping and analysis for the Linkage studies. CDTC also works with CDRPC to process GIS data and incorporate parcel-level data and high-resolution orthophotography for the entire region.

SANDAG uses data collected by California DOT (Caltrans) as part of the Freeway Performance Monitoring System (PeMS) to measure freeway speeds, delays, and reliability for the regional freeway system. PeMS transmits data from automated detection devices every 30 seconds. SANDAG uses these data to identify and prioritize transportation corridor improvements and to monitor the regional comprehensive plan, rather than relying solely on travel times derived from models.

SACOG's multimodal, multijurisdictional "smart corridor" initiative is a collaborative effort of the County of Sacramento, the Regional Transit District, Caltrans, the State Highway Patrol, and American River Fire District. The Sacramento Transportation Area Network (STARNET) will coordinate the interagency ITS network, including providing web-based software that operators can access from any computer to see a map of the whole region showing the current status of all agencies' field devices, transit vehicles, and current incidents and events, thus providing a common and comprehensive view of current conditions.

CHAPTER 4

Regional Scenario—Multimodal and Multistrategy Investment Prioritization

Scenario

In large urban areas, MPOs have a wide range of strategies to choose from when addressing congestion. Whereas the previous scenario addressed how MPOs can facilitate the analysis of network performance to better understand regional goals, this scenario examines how MPOs can use network performance measures to prioritize and select individual investments. Prioritizing projects for implementation must address road and transit improvements for both major facilities (e.g., highways and rail systems) and minor facilities (e.g., arterials and buses) and both capacity and operational improvements. Many MPOs have approached these challenges by following traditional splits of funding to major agencies (e.g., DOT, the transit agency, and local agencies). In an era of decreasing resources and an interest in funding investments with the most favorable benefit-cost ratio, there is an increased interest in analyzing projects across a network.

The investment prioritization scenario examines the process of using network performance measures to prioritize projects and make funding decisions, taking into account how individual investments contribute to the performance of the network. Collaborative relationships between MPOs and various key agencies within a region guide the process, providing critical feedback and data to support the calculation of network performance measures.

The primary focus of this scenario is on programming, though the overarching goal is to identify an approach that supports the region's vision.

Case Studies

The primary case study comes from the Metropolitan Transportation Commission (MTC), the MPO for the San Francisco Bay Area. The MTC region includes the nine counties that touch the San Francisco Bay, home to 100 municipalities and more than 7 million people in 7,000 square miles. Within this region are eight primary public transit systems; 20,000 miles of local streets and roads; 1,400 miles of highway; six public ports; and three major commercial airports.[3]

In 2006, MTC began updating its RTP. The *Draft Transportation 2035 Plan: Change in Motion* serves as the roadmap for investing the $226 billion in funding projected to be available over the next 25 years. MTC set ambitious goals to consider and incorporate current and impending issues that affect and are affected by the transportation network, including climate change, foreign oil dependency, air quality, economic growth, and social equity in the region. By calling the plan "Change in Motion," they take on the challenge as a region to "anticipate change, instigate change, and, most of all, succeed in putting change in motion."[4]

To achieve these goals, MTC and its partners created a performance-based planning process that provided valuable feedback on how individual investments would impact the region's defined vision, goals, and performance objectives.

Additional information is drawn from case studies of the Florida DOT, SACOG, Washington State DOT, Maryland DOT, Transportation Metropolitan Atlanta Performance (MAP) Initiative, and the Minnesota Twin Cities Metropolitan Council.

Building Blocks

Establish Partnership Agreements

The basic partnership agreement for this scenario was defined within the standard MPO planning process.

Partnership agreements should

- Guide the investment prioritization and programming process by providing (1) critical feedback on regional goals and performance objectives and (2) data to support calculation of network performance measures,

[3]http://www.mtc.ca.gov/about_mtc/about.htm

[4]http://www.mtc.ca.gov/planning/2035_plan/DRAFT/Intro.pdf. At the time of this writing, the draft plan was available for public review and comment.

- Oversee the performance-based project evaluation, and
- Provide input on investment tradeoffs for project prioritization and programming.

As part of the development of the Transportation 2035 Plan, MTC formed a Partnership Ad Hoc Committee consisting of representatives from state, regional, and local transportation agencies, as well as the Bay Area Air Quality Management District, the Association of Bay Area Governments, and the Bay Conservation and Development Commission. All of the processes for developing the Transportation 2035 Plan and the results of these processes were developed and reviewed in consultation with the Partnership Ad Hoc Committee.

SACOG has initiated several successful collaborative efforts. The region has several ITS cooperative initiatives facilitated via the Sacramento Region ITS Partnership, an advisory committee made up of local and state transportation personnel. There is also a multimodal, multijurisdictional "smart corridor" collaborative effort of the County of Sacramento, the Sacramento Regional Transit District, Caltrans, the California Highway Patrol, and the American River Fire District.

The Georgia Regional Transportation Authority spearheads the cooperative effort of the Authority and its partner agencies, the Federal Highway Administration, Atlanta Regional Commission, Georgia DOT, Georgia Department of Natural Resources, and Metropolitan Atlanta Rapid Transit Authority (MARTA) to complete the annual Transportation Metropolitan Atlanta Performance (MAP) report. A steering committee composed of the representatives of the regional transportation agencies and others guides the development of this annual transportation performance measurement effort. The MAP report provides a regional performance snapshot of progress toward improving mobility, transit accessibility, air quality, safety, and the overall performance of the Atlanta transportation network. Performance targets are established based on review and discussion by the steering committee. The collaborative process of the region's agencies extends beyond performance measurement. The process has also helped to identify data collection issues, improve data quality control procedures, and identify data gaps and needs.

Define Performance Measurement Framework

A performance measurement framework helps to establish how investments will be prioritized. This section discusses how MPOs can define a vision for the transportation system and the related goals and objectives that reflect that vision.

Define the Vision

The development of a performance measurement framework for investment prioritization begins with establishing a vision for the region. Though the tendency is to focus first on available funding and how to "slice the investment pie," a performance-based approach defines a vision for what a region's transportation system *ought* to look like in the future. The vision should incorporate key changes and trends on the horizon (e.g., climate change, volatile oil prices, an aging population, rising construction costs, and the uncertainty of federal transportation funding).

The anchors of MTC's Transportation 2035 vision are the three "E" principles of sustainability: a prosperous and globally competitive **economy,** a healthy and safe **environment,** and **equity** wherein all Bay Area residents share in the benefits of a well-maintained, efficient, and connected regional transportation system.[5] Guided by the three Es, the plan establishes a vision for the future of transportation in the San Francisco Bay Area, which includes

- Providing mobility and accessibility for all residents;
- Using a multimodal approach to system maintenance;
- Considering market-based pricing for the region's carpool lanes, bridges, and roadways;
- Focusing on creating complete communities with close access to jobs, shopping, and services connected by transit;
- Making use of technological advances, including clean fuels and vehicles, sophisticated traffic operations systems, accessible traveler information, and improved transit operations;
- Providing improved ability to travel to work, school, shopping, services, or recreation without needing a personal automobile;
- Developing an approach to addressing climate change that is a national model;
- Reducing the impact of transportation investments on natural habitats; and
- Improving the quality of life for Bay Area residents.

[5]http://www.mtc.ca.gov/planning/2035_plan

WSDOT is well known for applying performance management tools to nearly every aspect of agency business. When traditional metrics such as level of service (LOS) thresholds yielded billions of dollars in improvements needed over a 20-year time frame, WSDOT began using throughput measures of efficiency such as speed thresholds to better identify highway deficiencies. Maximum throughput measures are now used to select projects for inclusion in the Highway System Plan. In addition to identifying and prioritizing improvements for congested corridors, performance measures have also been used to support funding increases for operations and management strategies such as incident response and demand management programs. Performance measures have also helped to reveal trends or emerging problems requiring corrective action by the agency, such as detecting increased travel times on high-occupancy vehicle (HOV) lanes resulting from more frequent use, identifying major sources of nonrecurring congestion, and focusing commute trip reduction programs on the most congested corridors in the region.

Establish Goals and Performance Objectives

The vision frames the development of goals and performance objectives for the region to set the direction for the future, measure progress, evaluate transportation projects and programs needed to maintain the system, improve system efficiency, and strategically expand the system. Performance objectives should reflect the improved conditions described in the vision and be developed based on partner agencies' plans and policies.

Table 4.1 summarizes the goals and performance objectives established by MTC in the Transportation 2035 Plan. The collaborative process of the region's agencies includes identifying data collection issues, improving data quality control procedures, and identifying data gaps and needs.

Develop Measurement and Data Collection Methodologies

Early definition of data needs and analysis approaches can help ensure that measures selected for evaluation can be calculated and communicated effectively. Data are needed to conduct financially unconstrained "what if" analyses, assess the impact of individual investments based on qualitative and quantitative network performance measures, and use network performance measures for project selection and investment decisions.

Conduct a Financially Unconstrained What If Analysis

Typically, MPOs begin planning and programming efforts within set funding limits, often by program or mode. A network performance approach can benefit from an analysis of unconstrained What If scenarios to determine whether the region's goals and objectives are achievable and what it might take in terms of investment and policy to get there.

MTC evaluated three hypothetical infrastructure investment packages to determine what would be required to reach the performance objectives of the Transportation 2035 Plan:

1. A program of freeway operations strategies;
2. A regional high-occupancy toll (HOT) lane network with bus enhancements; and
3. Extensive rail and ferry expansion.

The budgets for these projects were not constrained and ranged from $600 million to $64.2 billion in capital costs.

Two sensitivity tests also were conducted to capture the impact of demand-based strategies. A pricing sensitivity test measured how a set of user-based pricing strategies would impact travel behavior. A land use sensitivity test looked at an alternative land use forecast that shifted employment and residential growth to existing centers and areas with existing or planned transit. Like the investment alternatives, the sensitivity tests were meant to test bold approaches, not specific policy alternatives.

Relative to the performance objectives, the What If scenarios demonstrated the following:

- **Reduce congestion.** This was the only objective for which an investment package had a marked impact.
- **Reduce vehicle miles traveled (VMT).** None of the scenarios or strategies brought the projected VMT down to the target level.
- **Reduce particulate emissions.** The land use and pricing strategies have more impact than the infrastructure investments, but none of them achieve the objective target levels.
- **Reduce carbon dioxide emissions.** The land use and pricing strategies have more impact than the infrastructure investments, but none of them achieve the objective target levels.
- **Improve affordability of transportation and housing for low- and moderately low-income households.** The pricing and land use strategies have bigger impacts than do infrastructure investments. Focused growth policies decrease the

Table 4.1. MTC's Transportation 2035 performance objectives.

Es	Goals	Performance Objectives
Economy	Maintenance and safety	**Improve maintenance** Local streets and roads: Maintain pavement condition index of 75 or better. State highways: Distressed land-miles no more than 10% of system. Transit: Average asset age no more than 50% of useful life and average distance between service calls of 8,000 miles. *Sources: State and local strategic plans*
		Reduce injuries and fatalities Motor-vehicle fatalities: 15% from today. Bike and pedestrian injuries and fatalities: 25% each from 2000 levels. *Source: California State Strategic Highway Safety Plan*
	Reliability Freight	**Reduce delays** 20% per capita from today. *Source: California's Strategic Growth Plan*
Environment	Clean air	**Reduce vehicle miles traveled and emissions** Vehicle miles traveled: 10% per capita from today. Fine particulate matter ($PM_{2.5}$): 10% from today. Course particulate matter (PM_{10}): 455 from today. Carbon dioxide (CO_2): 40% below 1990 levels. *Sources: State regulations and laws*
Equity	Access	**Improve affordability** 10% reduction from today in share of earnings spent on housing and transportation costs by low- and moderately low-income households. *Source: Adapted from the Center for Housing Policy*

Source: http://www.mtc.ca.gov/planning/2035_plan/Supplementary/T2035Plan-Perf_AssessmentReport.pdf, p. 3.

cost of transportation, but pricing increases cost because many people will continue to use vehicles for some trips.

Overall, the freeway operations package was the most cost-effective; however, when the pricing and land use strategies are added, the gap between the freeway and the transit packages closes significantly. This set of network performance measurement calculations provided a baseline and context for MTC to begin looking at the performance of individual investments.

For the 2004 Oregon Transportation Plan update, Oregon DOT evaluated a set of policy and investment scenarios to help set the policy direction for the department. These scenarios examined business as usual, focusing state investment on system operations and making significant new investments in capacity. The DOT also tested funding scenarios that include continuation of current revenue sources, flat revenue, and pricing. Each scenario was evaluated against a set of performance scenarios linked to Oregon DOT's objectives. The analysis helped focus the DOT on the benefits of increasing funding for operations and the need to address potential future funding shortfalls.

Use a Mix of Quantitative and Qualitative Measures

An investment assessment based on quantitative *and* qualitative performance measures captures the effect of individual projects in the context of regional performance objectives. The purpose is to identify project outliers (i.e., those investments that would most strongly support the performance objectives and those that would most strongly undermine the objectives). The analysis procedures are not precise enough to distinguish among investments with very close benefit–cost ratios. This exercise provides valuable feedback on how indi-

Table 4.2. MTC's quantitative project evaluation measures.

T-2035 Performance Objective	Performance Measures
Reduce congestion Reduce emissions Reduce collisions and fatalities	Benefit-Cost Ratio (monetized), reflecting • Recurrent delay (vehicle hours) • Nonrecurring delay (vehicle hours) • Transit travel time[1] • Particulate matter emissions ($PM_{2.5}$ and PM_{10}) • Carbon dioxide emissions • Fatal and injury collisions • Direct user costs (vehicle operating and, in some cases, auto ownership costs) • Public and private cost savings from performing on-time maintenance[2]
Reduce vehicle miles driven	Reduction in vehicle miles traveled (VMT) and cost per VMT reduced
Reduce emissions	Reduction in carbon dioxide emissions and cost per ton reduced
Improve affordability	Cost per low-income household served by transit (trial measure)[3]

1. For HOV and HOT projects only

2. For maintenance programs only

3. For transit projects only

Source: http://www.mtc.ca.gov/planning/2035_plan/Supplementary/T2035Plan-Perf_AssessmentReport.pdf, pg. 24.

vidual projects would affect the region's defined vision, goals, and performance objectives.

MTC limited their quantitative assessment to higher cost projects only (i.e., those with areawide effects and costs higher than $50 million), because these typically account for the largest percentage of discretionary investment decisions. The primary performance measure was a combined benefit-cost ratio (B/C) that monetized benefits from reductions in collisions, delay (recurrent and nonrecurring), and emissions (Table 4.2). The B/C for each project was assigned a range, regardless of mode type or area of the region: high (B/C of 10 or higher); medium-high (B/C between 5 and 9); mid-range (B/C between 1 and 4); and low (B/C less than 1).

A qualitative assessment also was conducted to evaluate how individual investments support the Transportation 2035 goals. This assessment complemented the quantitative evaluation by considering other factors that cannot be measured directly, such as whether projects serve key freight corridors, support focused growth, or improve access for certain categories of users.

In an effort to improve the efficiency of the qualitative evaluation, the investments were first grouped into project types, such as capacity expansion, interchanges, maintenance, technology, HOT lanes, bike/pedestrian, transit efficiency and expansion, transit-oriented development, and others. Qualitative evaluation criteria were developed to assess support of Transportation 2035 goals (Table 4.3). A ranking of "strongly support," "support," or "neutral toward" was assigned to each project type based on how well it met the criteria associated with each goal.

Link Network Performance Measures to Project Prioritization and Programming

Synthesizing the project performance results for programming decisions represents a significant challenge to many MPOs. MTC's process used a matrix approach that included both quantitative and qualitative measures (Figure 4.1). Projects with high benefit–cost ratios that support multiple goals were included in the Transportation 2035 Plan. Projects with low benefit–cost ratios that address few goals were not,

> Florida DOT's Strategic Intermodal System (SIS) was established in 2003 to enhance Florida's economic competitiveness by focusing limited resources on those transportation facilities critical to Florida's economy and quality of life. The planning process for the SIS includes system designation based on adopted criteria and thresholds; needs assessment to identify unprogrammed SIS needs based on adopted statewide modal plans; project prioritization to develop a Phased Cost Feasible Plan with 10- and 20-year components; and a finance strategy that incorporates the investment policy and forecasts of anticipated revenues, innovative financing, and joint funding by public and private partners.

Table 4.3. MTC's qualitative project evaluation measures.

Transportation 2035 Goals	Qualitative Criteria for Determining Support
Maintenance	• Advances maintenance of the existing transportation system
Congestion relief (reliability and efficient freight travel) Includes roadway safety	• Improves freight mobility • Improves transit mobility, effectiveness, or efficiency • Improves local mobility or circulation • Completes a critical transportation gap (geographic or temporal) • Institutes or enables a new user-based pricing system • Implements technology-based operations or traveler information • Improves roadway safety
Emissions reduction	• Provides an alternative to driving alone • Improves transit mobility, effectiveness, or efficiency • Establishes marketing, education, and incentive programs that encourage mode shift away from driving alone or during peaks
Focused growth	• Locates within a proposed or planned priority development area • Connects to priority development areas
Access and safety (nonmotorized)	• Provides a transit alternative to driving on a future priced facility • Provides an alternative to driving alone • Improves access for those who are young, old, or have disabilities • Improves safety for pedestrians and cyclists • Reduces transportation or housing costs for low-income households

Source: http://www.mtc.ca.gov/planning/2035_plan/Supplementary/T2035Plan-Perf_AssessmentReport.pdf, p. 30.

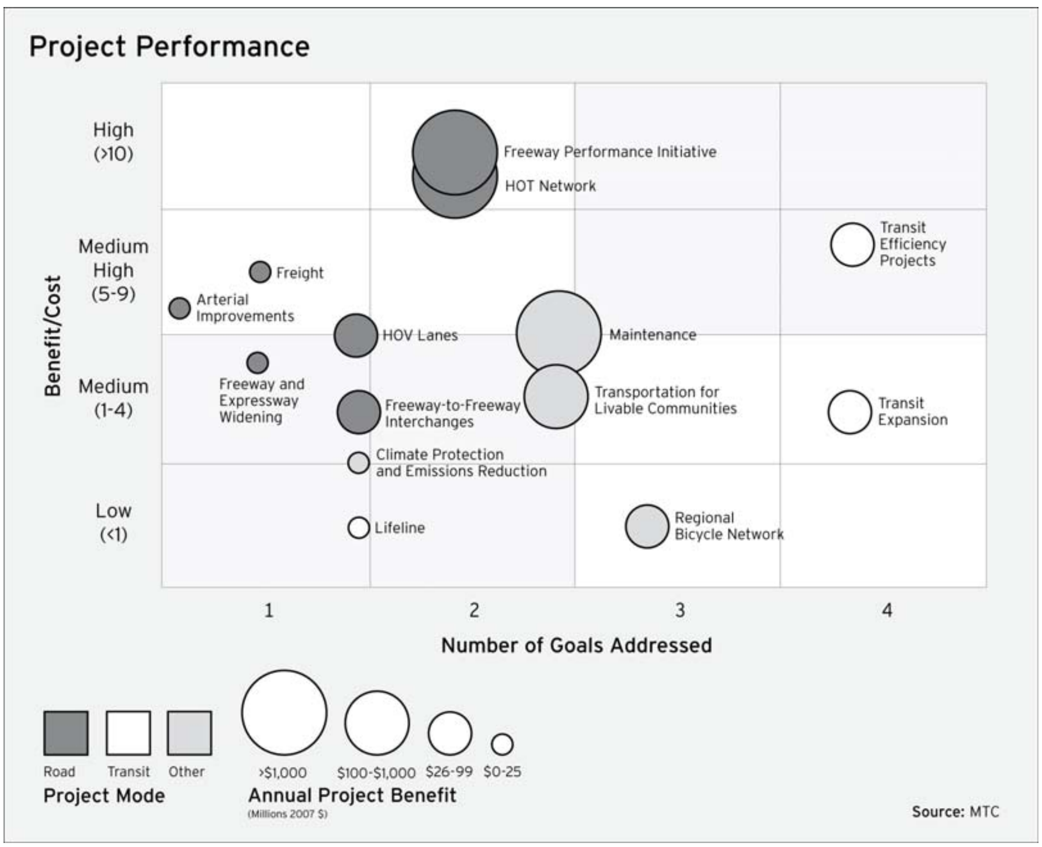


Figure 4.1. MTC's synthesized results for project-level performance.

unless they were of high local priority or addressed special transportation needs. Once project selection was complete, MTC conducted an overall program performance assessment to evaluate how well the proposed projects in the Draft Transportation 2035 Plan met the region's performance goals and objectives.

The outcome of MTC's planning efforts helps identify strategies that provide regional benefits while recognizing that infrastructure investments by themselves produce only modest benefits. The planned investments point the Bay Area in the direction of meeting the stated objectives, but a considerable gap remains between the targets and the outcome. Regional objectives cannot be met without additional land use, pricing, and technology strategies that provide additional benefits.

The Maryland Transportation Trust Fund is unique in that it allows complete flexibility across modes in project prioritization and selection. Projects are selected based on their support of the goals and objectives set in Maryland's Transportation Plan, level of service, safety, maintenance issues, economic development potential, availability of funding, and input received from public and local officials. By facilitating a bottom-up approach of project recommendations, Maryland DOT involves the perspective of all levels of government while supporting the importance of mode-neutral funding.

CHAPTER 5

Peer-to-Peer Scenario—Multistate Partnership for System Operations

Scenario

Many key corridors throughout the country cross state boundaries, creating a complex web of players who are responsible for planning and operating what users see as a single transportation network. Infrastructure improvements that directly address a problem for one mode or jurisdiction may have important impacts (both negative and positive) for other modes and jurisdictions. Without the data to analyze these improvements across state lines and among agencies, and without the forum to vet and discuss the implications, the most effective investment decisions or operations policies may be lost. For example, jurisdictions addressing operations concerns of a portion of the network in isolation from others may be prohibited from benefits of coordinated action, economy of scale, and shared knowledge and resources that occur when multiple entities cooperate to implement globally optimum solutions.

The motivating elements to establish effective network performance measures in this scenario are major regional transportation networks (i.e., rail, highway, or transit) that span state boundaries. This scenario also may include private companies and independent transportation authorities that operate autonomously. The burden to maintain and optimize highly integrated transportation networks represents large financial commitments. States and private companies recognize the benefits and cost savings from coordinated effort and are typically willing players in such efforts, provided that the effort is directed by objective goals and performance measures and is perceived as an equitable investment with financial benefits to all states and their citizens.

Case Studies

The primary case study is the Mid-Atlantic Rail Operations Study (MAROps), a rail freight cooperative initiative carried out through the I–95 Corridor Coalition. The network included freight rail systems operated by CSX and Norfolk Southern (NS) (including operations on the Amtrak Northeast Corridor) in five mid-Atlantic states (i.e., New Jersey, Pennsylvania, Delaware, Maryland, and Virginia). The motivating factor for the cooperative effort was the need to increase capacity in a limited funding environment. Network performance measures were needed to effectively identify projects with the greatest system impact and then quantify the network benefits of the candidate projects for the entire region.

The partners acknowledged that in order to spend limited improvement dollars most effectively, a multistate perspective was needed to identify the projects that would improve goods movement conditions throughout the region. Although the focus of MAROps is on the rail system that operates within the mid-Atlantic region, by improving rail service there are inevitable impacts on the region's highways, particularly for freight movement, and these are estimated as part of the MAROps effort.

Additional case studies include the following:

- The I–95 Vehicle Probe Project, a collective procurement of a traffic monitoring system by several mid-Atlantic states to provide seamless and consistent travel-time and speed-performance data to support planning and operations over a multistate area; and
- A similar effort by the TRANSCOM/TRANSMIT system in the northeast areas of New York, New Jersey, and Connecticut to provide highway operations performance information based on data from an automated toll tag system.

Building Blocks

Establish Partnership Agreements

The multistate scenario involves cooperation among autonomous, sovereign states with no fiscally or legally binding relationships. Though MPOs have a natural, federally sanctioned forum for cooperation on network performance, multistate collaboration requires building new institutions that allow for collective decision making. Peer-to-peer collaboration at the state level is further complicated by individual state laws governing procurement policy; state-specific regulations must be carefully managed in order for all participants to benefit from multistate agreements, contracts, and pooled procurements.

Establish Broad Partnership Agreements Between States

Key to the enablement of a multistate initiative is the formation or utilization of an independent organization to pursue common objectives. Lead agency and other types of simple cooperative partnership agreements useful in other scenarios are less effective in coordinating state interests. Simple partnership agreements that do not employ a neutral third-party coordinating body may lead to implied hierarchical relationships among states that can be disruptive to collaborative efforts.

The I–95 Corridor Coalition is an independent organization that provides a partnership of state departments of transportation, regional and local transportation agencies, toll authorities, and related organizations from Maine to Florida (including the District of Columbia). The coalition has strong board leadership from state champions who recognize the need for multistate collaboration. The coalition staff is dedicated to the benefit of the entire multistate corridor and is not encumbered with possible conflicting state agency loyalties. Such an organization serves as the foundation for an effective multistate forum.

> The Transportation Operations Coordinating Committee (TRANSCOM) is an independent organization that provides a forum and framework for participants to coordinate on incident management and trip planning for highways and transit for 16 transportation and public safety agencies in the New York/New Jersey/Connecticut metropolitan region. It was created in 1986 to provide a cooperative, coordinated approach to regional transportation management. TRANSCOM seeks to improve mobility and safety through interagency communication and the enhanced utilization of their existing traffic and transportation management systems (www.xcm.org).

Develop Specialized Agreements for Individual Initiatives

In addition to the broad partnership framework established by the I–95 Corridor Coalition, individual coalition projects often require specialized agreements tailored to the study. For the MAROps effort, the specific agreement was between the five mid-Atlantic states and three Class I railroads—Amtrak, CSX, and NS—that operated within the mid-Atlantic. Historically, relationships among the railroads and between the railroads and the states have sometimes been strained.

Though the forum established for MAROps primarily focused on considering the mid-Atlantic rail system as an overall network that needed to be evaluated and improved as such, a side benefit came from improved relationships among the states and railroads. The MAROps project helped the railroads understand the benefits of partnering with individual states or groups of states and also of working more closely together.

Since the initiation of the MAROps study, both NS and CSX have developed significant individual rail corridor initiatives in cooperation with states, including the NS Heartland Corridor (connecting the Port of Norfolk to the Midwestern distribution centers), the NS Crescent Corridor (connecting New Orleans along I–81 to Northern New Jersey), and the CSX National Gateway (connecting the ports of Baltimore, Maryland; Wilmington, North Carolina; and Charlotte, North Carolina, to Midwestern distribution centers).

Define Performance Measurement Framework

For a multistate entity, a performance framework helps establish focused and clearly articulated goals and objectives among states and other partners.

Identify the Benefits of a Multistate Approach

Before considering any project, all of the partners must agree on the project parameters. In the case of the I–95 Corridor Coalition, this required being flexible and including participants relevant to the specific study. The MAROps study included active participation by the five mid-Atlantic states and three Class I Railroads, in recognition of the regional impact of existing rail bottlenecks. A multistate initiative held the potential to optimize the return of limited capital improvement dollars using a system approach. MAROps both identified significant rail bottlenecks and provided a forum for improved coordination among the freight railroads in the region and between the freight railroads and the states.

The I–95 Vehicle Probe study supports both individual state operation of Transportation Management Centers (TMCs) and provides travel information services for long-distance, inter-jurisdictional diversions characteristic of major incidents that have a multistate impact.

Select Network Measures That Reflect Multistate Performance Objectives

The second phase of the MAROps study (completed in 2009) built on the partnership agreement by evaluating the expected benefits of packages of investments to address the rail bottlenecks identified in the original study. Using a performance approach helped strengthen the basis for the set of investments identified. A framework was developed that identified the potential beneficiaries of rail system investments and the likely key performance concepts that would best capture benefits for that beneficiary (Table 5.1). Developing the framework ensured that the benefits of, and therefore funding for, potential investments would be connected to the agencies and groups that benefit from a particular investment.

The I–95 Vehicle Probe Project recognized the failure of previous approaches for delivering ubiquitous traffic monitoring and set forth an objective of providing a comprehensive multistate traffic monitoring system based on cutting-edge probe technology. Through use of a pooled procurement, the coalition acquired a traffic data service based on vehicle probe technology for both freeways and major signalized arterials on a significant portion of the corridor. The information from the project has already been integrated into a follow-on effort to provide travel times on a website for common origin-destination pairs within the corridor.

The TRANSCOM/TRANSMIT objective was to secure traffic flow performance data across a multistate area. Highway operations in this tristate area require consistent and accurate highway information for appropriate management. This resulted in the central vision to use the data from the automated toll tag system being deployed in the region for traffic information. TRANSCOM was also targeted as the mechanism to coordinate operations and planning issues of the multistate highway network infrastructure.

Develop Measurement and Data Collection Methodologies

Using shared assets or common systems (either infrastructure, technological, or otherwise) is an effective strategy to maximize the investment in pooled resources.

The I–95 Vehicle Probe Project exemplifies the strategy of maximizing benefit from a multistate pooled procurement.

Table 5.1. MAROps performance measure concepts by beneficiary.

States, Metro Areas, National	Freight Railroads	Passenger Railroads	Rail Passengers	Shippers	Ports
• Economic impacts • System efficiency • Environmental impacts • Maintenance costs • Safety	• Market share • Throughput • System reliability • Environmental impacts • Operations/ maintenance costs • Safety	• Ridership • Throughput • System reliability • Environmental impacts • Operations/ maintenance costs • Safety	• Travel costs • Travel time • Service access	• Business cost • Service access • Service reliability • Transit time	• Market access • Business cost • Throughput • Safety

Strategies used in this case study are transferable to other multistate initiatives, including the following:

- A multistate procurement involved procurement specialists from member states early in the project, yielding a methodology that provided the greatest flexibility.
- A working group of representatives of participating states and academia directed the project, allowing the coalition access to significant experience from states that performed demonstration projects.
- The request for proposals (RFP) specified full data sharing between states, allowing all states to access and view data for any state. For example, Pennsylvania has access to flow data from New Jersey.
- A data rights and ownership policy allowed for liberal use of the data by the coalition and member agencies for both internal and external applications, while allowing the vendor to resell the data to commercial clients. For example, www.i95travelinfo.net provides travel times between major cities.
- The traffic data are continuously validated by an independent agent across jurisdictions. This provides an objective assessment of data quality and value for agency applications and helps manage information about the program status and value. Validation results help determine payment to the commercial data provider.

MAROps used economic models to estimate benefits to all beneficiaries with a focus on fitting within emerging federal programs such as projects of national significance. Economic models revealed significant benefit for all states and parties and thus provided justification for continued political support throughout the program. Recognizing the funding challenges of any capital improvement project, the MAROps strategy was to position the program to maximize the potential for funding through emerging federal initiatives, providing further benefit for MAROps' participating members.

TRANSCOM/TRANSMIT used the investment of a common asset of the participating states to acquire consistent and accurate highway information. The program used data from toll tags as a common technology backbone for an effective traffic monitoring system spanning state lines.

CHAPTER 6

Peer-to-Peer Scenario—Megaregional Partnership to Address Growth

Scenario

As metropolitan regions expand, they are becoming increasingly linked via economic interdependence and common transportation networks. These megaregions share common issues (including economic growth, environmental concerns, and mobility) and have an increased need to look beyond jurisdictional boundaries when planning and operating the transportation system. Megaregional planning also presents an opportunity to pool funds for more efficient use.

There are many challenges to successfully conducting megaregional planning. Federal funding is not provided to megaregions, and local land use plans and decisions often conflict. MPOs in megaregions have traditionally operated within well-defined roles and clearly delineated geographic areas. Those MPOs that have adopted performance measures typically do not coordinate with other neighboring MPOs.

Yet, MPOs across the United States are increasingly faced with the challenges and opportunities of collaborating with their neighboring MPOs. At least nine large megaregions in the United States have been defined by various regional planners and academics, yet these are not officially recognized by the U.S. Census Bureau. Further, many MPOs originally formed as single-county regions are growing into one another.

Peer-to-peer megaregional planning partnerships occur primarily during early planning. This is mainly because these kinds of partnerships are fairly new and there is little experience on which to base megaregional implementation structures.

Case Studies

The primary case study is the San Joaquin Valley (SJV) Blueprint Process and related California Partnership established for the same region. The SJV stretches from the Tehachapi Mountains in the south to the San Joaquin Delta in the north, nearly 300 miles. The SJV is between the large metropolitan areas of San Francisco and Los Angeles. The major transportation facilities include Interstate 5, State Route 99, the Union Pacific Railroad (UP), the Burlington Northern Santa Fe Railroad (BNSF), and air travel corridors. Numerous highways and rail lines, including State Routes 58, 46, 152, 198, and 120, also cross the Valley. Though each county has its own transit facilities, there is no unified transit system for the entire region.

Eight MPOs, each representing a single county, are participating in the SJV Blueprint Process. The region's population is expected to double from 3.4 million to 7 million by 2050. The forecasted growth—combined with current mobility, environmental, quality-of-life, and economic development challenges—has motivated regional planning partnerships.

The Blueprint Process is a multiyear planning effort that engages the general public, civic groups, business interests, the agricultural community, environmental groups, and government officials. The Blueprint Process is developing a regional vision but recognizes that decision-making power and implementation remain within the region's local jurisdictions.

This megaregional partnership includes a state-mandated partnership (California Partnership), a regionwide planning process (Blueprint), and active participation of all governments in the region. The unique nature of the partnerships, the project funding source, the coordinated planning components, the high level of participation, and the data sharing are all key reasons for the success in developing a megaregional partnership. The process is just beginning to be implemented, so final outcomes are unknown.

Other case study examples were drawn from the Central Florida MPO Alliance, the West Central Florida MPO, and the San Francisco–Sacramento interregional planning efforts.

Building Blocks

Establish Partnership Agreements

Formal Partnership Commitments Between MPOs

Because megaregional partnerships involve multiple agencies, partnership agreements are vital to their success. Many MPOs exchange information or attend presentations of their neighbors, and a few have begun to formalize partnership agreements across their boundaries. The SJV Blueprint Process is an "unprecedented example of local jurisdictions demonstrating increased regional identity and a unified purpose in addressing the region's challenges."[6] Eight Councils of Government (COGs) in the valley agreed to take part in the Blueprint Process.

The SJV Blueprint Process has been well served by established working relationships among the partners. The eight counties are all within a regional air quality basin and have a history of working together on air quality issues.

Coordinated regional planning also can identify needs for regionwide programs. The Corridor Enhancement Plan for California State Route 99 (an expressway that spans the valley) is a multicounty initiative that arose from the California Partnership and Blueprint Process.

Collaboratively Leverage Funding for Planning, Programs, and Projects

The eight COGs within the SJV used state funding, receiving a $4 million grant from the state, with an additional $500,000 in matching funds from the Valley's Air Pollution Control District. The Blueprint Process also has drawn on the work of the California Partnership (a public–private partnership established by executive order of the California Governor with a focus on improving regional economic vitality and quality of life) to help support coordinated data collection and integration of regional needs.

Assistance from Outside Organizations

In a multi-MPO partnership, the support of various groups, including nonprofit organizations, can help maintain working relationships and keep agencies focused on regional issues. For the SJV Blueprint Process, supportive agencies include the following:

- The Great Valley Center (GVC), a nonprofit community development organization, is the regional facilitator for the Blueprint Process. The GVC also is the headquarters for the California Partnership.
- The Blueprint Regional Advisory Committee supports the entire effort, acting as champion of the final Blueprint vision, advocating implementation with local jurisdictions, and promoting regional strategies at state and federal levels.
- The SJV Blueprint Professional Planners Group consists of land use planners from each county who provided a framework to develop the guiding principles for community outreach and scenario planning.
- A partnership called the Blueprint Learning Network helps coordinate shared data and learning experiences about the megaregional planning effort.
- The San Joaquin Valley Regional Policy Council, consisting of two elected officials from each MPO, made the final Blueprint scenario recommendation.

> The Central Florida MPO Alliance was formed in 1997 by METROPLAN ORLANDO and the Volusia County MPO with a collaborative focus on regional transportation issues. The alliance consists of six MPOs and two Florida DOT Districts, governed by a joint resolution of the participating member MPOs and the Florida DOT. The alliance developed a Central Florida Long-Range Transportation Plan that unifies regional goals and coordinates individual MPO plans. The plan synthesizes existing MPO plans, rather than developing a separate regional vision. Under a new Florida DOT program, the alliance (and other regions with interlocal agreements between MPOs) is eligible to receive state funding (up to a 50% share) for facilities that serve regional, state, or national functions. (www.metroplanorlando.com/siste/parterships/cfmpo.asp)

Define Performance Measurement Framework

Interregional Adoption of Common Goals, Objectives, and Vision

The megaregional scenario addresses the challenges of growth while recognizing the limitations existing agencies face in tackling problems that stretch beyond their borders. Addressing growth across MPO boundaries requires an understanding of how a megaregion is growing and changing and a common set of goals or a vision for addressing this growth.

The SJV Blueprint Process integrates transportation, housing, land use, economic development, and environmental data to produce growth scenarios for 2050. The starting point for the Blueprint Process was a "status quo" scenario projection of how all eight counties would grow based on current trends. Alternative scenarios were developed based on land use, transportation, conservation, and housing plans. These scenarios addressed questions such as

- How and where should we grow?
- How will we travel around the region?
- How will growth affect our environment and our overall quality of life?

[6] http://www.fresnocog.org/files/Blueprint%20Summary%20-%20Brochure.pdf

These scenarios were used to produce a regional vision, goals, and objectives. The final Blueprint product will include growth strategies for each county and the entire Valley. The COGs in the Blueprint initiative plan to track progress toward valleywide goals and make any "midcourse corrections" necessary to stay on track.

> The Central Florida MPO Alliance worked with myregion.org, a Central Florida nonprofit, to create a regional vision through studies and outreach efforts, including the *How Shall We Grow?* Regional Vision Project. Myregion.org is developing a position paper to identify what Central Florida must do to build a world-class multimodal transportation system. The top issues include a regional funding mechanism; education of the community and stakeholders, and the need for an integrated regional vision incorporating all modes of transportation. (www.myregion.org/Home/tabid/36/Default.aspx)

Allow for Flexibility and Bottom-Up Planning

Though a common vision is important to megaregional network performance, it is equally necessary to avoid applying measures or strategies using a top-down approach. At this level of application, a network performance approach must provide flexibility to the various agencies involved, or they are unlikely to participate.

For the SJV Blueprint Process, each of the counties developed its own goals and strategies, though there are significant overlaps. For example,

- Merced County's strategies include an intermodal transportation system, light-rail transit, and high-occupancy vehicle (HOV) lanes;
- Kern County examined multiple scenarios, including (1) a "Major Change" scenario focused on mixed development, walkable centers, and transit and (2) a "Moderate Change" scenario focused on transportation choices and cost-effective use of infrastructure; and
- Fresno County's strategies include connecting centers, congestion relief, transportation choices for people and goods, and access to key economic assets.

In addition, the Blueprint Process included public meetings and scenario planning sessions that involved a broad array of stakeholders. With the help of GVC, each COG engaged local communities in a visioning process that was incorporated into a valleywide vision. Engaging the public at this level is an enormous undertaking, but the bottom-up approach encourages local decisionmakers to embrace and promote the regional vision.

Maintaining this bottom-up approach of the Blueprint Process presents challenges, especially for local decision-making authority. Though local jurisdictions are often wary of regional plans that may impact local decision making, the bottom-up approach has facilitated a collaborative process. As the Blueprint Process is implemented, changes to the strategies and decisions from the Blueprint planning process could lead local jurisdictions to view the plan as top-down. Outcomes of the regional Blueprint Process and the California Partnership cannot supersede local land use authority.

Developing Measurement and Data Collection Methodologies

Adopt a Base Set of Metrics, but Allow for Flexibility

Where multiple agencies are involved, it can be challenging to have the appropriate data and tools available to evaluate the performance measure framework across agency boundaries. For the SJV Blueprint Process, a common set of measures was reviewed and adopted by each COG, allowing for flexibility to use additional measures based on each COG's unique planning needs and county goals. Table 6.1 lists the common set of measures used by all eight COGs.

All performance measures used by counties during the Blueprint Process were selected based on data availability and forecasting capabilities. Additional measures would strain the modeling capacity of some of the COGs. Intracounty differences also make applying a single set of measures impractical.

Ensure Appropriate Technical Support

Megaregional network performance analysis benefits from partners with significant technical analysis and modeling expertise. For the SJV Blueprint Process, the COGs worked with the University of California at Davis (UC Davis) to model land use scenarios and generate performance measures.

The counties built on regional model coordination for previous air quality planning efforts to develop the necessary data sharing and modeling techniques for analysis of the megaregion. Part of the Blueprint Process funding was used for geographic information systems (GIS), land use modeling, and visualization technology to forecast urbanization in 2050. The land use model, UPlan, developed by UC Davis, provided technical and data support to the COGs and local governments.

Table 6.1. San Joaquin Valley Blueprint measures.

Category and Measures	Tool(s)
Transportation Measures	
Person-hours and vehicle-hours of travel (per day)	Traffic model and mode split model
Person-hours and vehicle-hours of delay (per day)	Traffic model and mode split model
Reliability of travel times	Traffic model
Mass Transit	
Mode split	Mode split model
Proportion of transit usage	Mode split model
Transit suitability	GIS
Air Quality	
Reduction of emissions	Traffic model, EMFAC (or other)
Reduction in VMT per household	Traffic model
Reduction in truck-related emissions*	Mode choice
Housing/Jobs/Balance	
Change in jobs/housing ratio	UPlan or other
Community balance	GIS
Agriculture Land Conservation	
Reduction in land conversion	GIS, UPlan
Environmental Conservation	
Reduction of impacts to environmental resources	GIS, UPlan

Source: http://www.sjvalleyblueprint.com/process.htm
* Cannot currently be estimated. EMFAC = EMission FACtors model; GIS = geographic information system.

California's Bay Area and Sacramento are working together in an interregional planning context to use funding to address freight movements. The regions are beginning to work together to coordinate land use and transportation models to help evaluate multiregional issues.

The West Central Florida Chairs Coordinating Committee includes six MPOs, two Florida DOT Districts, and several Regional Planning Councils. The committee meets quarterly to provide a consistent approach to long-range planning, congestion management, land use planning, public involvement, air quality management, and regional modeling. The committee supports a regional travel demand model developed by member agencies and a regional GIS for sharing transportation information across agencies. (www.regionaltransportation.org)

CHAPTER 7

Intra-Agency Scenario—Linking Planning and Operations at a State DOT

Scenario

The previous scenarios focused on interagency partnerships. However, even within agencies, consideration of network performance can help expand and integrate the solutions that transportation agencies apply to the challenges they face. Most DOTs and MPOs are organized by function (e.g., planning, project development, or operations) or by mode (e.g., highway or rail) or both.

This scenario focuses on linking planning and operations within a state DOT, though it may apply to other integration efforts as well. In many DOTs, there are well-established roles for planning and operations but often limited or no formal (or even informal) links between them.

Planning typically coordinates transportation planning statewide, including identifying agency goals and objectives, evaluating and prioritizing projects and strategies, and evaluating the agency's success in addressing transportation challenges.

DOTs are increasingly recognizing the value of system management and operations as both a fundamental responsibility and a strategy to tackle congestion. Operations responsibilities include some or all of maintenance, traffic, safety, and intelligent transportation systems (i.e., roadway monitoring, incident management, traveler information, and operation of traffic management centers).

Though significant progress has been made in improving management and operations, planning and operations functions have not typically coordinated on issues that they share in common, such as congestion. Improving the linkages between these two functions can improve system performance by helping to coordinate transportation investments and improve data collection strategies and data sharing.

Case Studies

Recently significant attention has been paid to linking planning and operations functions at DOTs and MPOs. FHWA has conducted several recent best practice studies of these efforts and released separate guidebooks directed toward MPOs and DOTs.

The case studies most directly relevant to this scenario come from the Oregon and Washington State DOT efforts using system-level performance measures. The Oregon Transportation Plan (OTP) is a statewide effort that looks at transportation system needs across all transportation modes. The OTP includes an assessment of the impacts of transportation system operations investments relative to capacity investments and includes a rigorous performance analysis of several plan scenarios.

The Washington State Department of Transportation (WSDOT) provides a unique example of an agency that has applied management tools to nearly every aspect of agency business. The agency publishes a comprehensive quarterly performance report called the Gray Notebook that guides decision making in congestion management, including capital planning, demand management, and operations. The WSDOT approach provides reliable data that can be applied across agency business (planning and operations) and creates consistency, allowing for overall buy-in and agreement by both legislators and the public.

In addition, this section draws examples from recent and ongoing research to supplement the case studies that were conducted for this effort. The research for this guidebook focused primarily on interagency partnerships, not individual agencies.

Building Blocks

Establish Partnership Agreements

In a typical state DOT, the roles of and responsibilities for planning and operations fall within separate and distinct departments. Coordination between these departments can improve how the agency tackles congestion. Though a partnership agreement *within* a single agency may seem unnecessary, some formal or informal agreement helps ensure coordination.

A review of state DOTs that successfully link their planning and operations functions revealed that all of them had a board or committee to coordinate these two functions broadly. These committees facilitate activities of mutual interest such as

- Developing network performance measures that are consistent across the agency;
- Coordinating the collection and storage of data and developing tools for data access. (Operations collects data from public [and sometimes private] sources to support incident management and traveler information. Planners increasingly recognize that such data can supplement data used for planning studies and travel forecasting.)
- Identifying strategies to address nonrecurring congestion in statewide, regional, and corridor studies, and congestion management;
- Developing models to quantify the impacts of operational investments for easier comparison to capacity expansion; and
- Overseeing the execution of the mobility-oriented strategies and objectives from a long-range plan.

The OTP update was developed by the Transportation Development Division of the Oregon DOT but had substantial support from other divisions to estimate transportation system need and analyze scenarios. As part of the OTP update, a "Maximum Operations" scenario was defined in coordination with the Office of Operations.

Mobility Council

The Maryland State Highway Administration created a "Mobility Council" to oversee mobility and congestion relief performance measures, one of six key performance areas that are part of the agency's strategic plan. The Mobility Council includes representation from planning, traffic, safety, and incident management. The Mobility and Congestion Relief performance measures include objectives and associated performance measures for Incident Congestion Delay and Recurring Congestion Delay.

Define Performance Measurement Framework

Traditionally, operations and planning staff have used separate performance measures with little coordination or consistency. Planning and operation collaboration provides decisionmakers with network performance measures that address a range of investment strategies, including measures of system reliability. Traditional mobility performance measures (e.g., volume-to-capacity [V/C] ratios) cannot effectively assess the reliability and safety benefits of operational investments and should be supplemented with operations-oriented measures.

WSDOT uses a suite of measures to identify and prioritize congested corridors. The network includes major interstates and arterials in and around Seattle, Tacoma, and Olympia. With many corridors experiencing some congestion, traditional metrics such as LOS yielded billions of dollars of needs over a 20-year time frame. WSDOT began to use measures of throughput efficiency to narrow the deficiency list by roughly one-third and focus scarce resources on the most needed corridors. The department uses maximum throughput to select projects for the state transportation improvement program.

Network performance measures helped convince WSDOT management that capacity solutions must be supplemented by operational solutions. Performance measures have helped justify expanded investments in operations, such as incident response and demand reduction programs. WSDOT uses before-and-after evaluations of operations projects to demonstrate their benefit in terms of reduced travel times or delay avoided.

In 2005, the National Transportation Operations Coalition (NTOC) identified and defined a number of potential key operations performance measures of national significance. Under NCHRP Project 20-7, *Guide to Benchmarking Operations Performance Measures,* the NTOC measures were pilot tested and refined (Table 7.1). These measures can be used as a starting point by state DOTs to identify and implement intra-agency network performance measures that support planning and operations functions.

Develop Measurement and Data Collection Methodologies

Data Collection

Both planning and operations functions make use of data, but often for different purposes. Planning typically uses data

Table 7.1. Potential operations performance measures.

Performance Measures	Definition
Average peak travel time	• Facility: Average time required to traverse a section of roadway during peak travel period • Reliability: Includes the additional time that must be added to a trip to ensure a traveler will arrive at a destination at, or before, the intended time 95% of the time • Trip: The average time required to travel from origin to destination on a trip that might include multiple modes during peak period
Throughput	• Person: Number of persons traversing a facility section or screen line per unit time • Vehicle: Number of vehicles traversing a facility section or screen line per unit time
Speed	• The average speed of vehicles measured in a single lane, for a single direction of flow, at a specific location on a roadway
Recurring delay	• Vehicle delays that are repeatable for the current time of day, day of week, and day type
Nonrecurring delay	• Vehicle delays in excess of recurring delay for the current time of day, day of week, and day type
Incident duration	• The time elapsed from the notification of an incident until all evidence of the incident has been removed from the incident scene
Extent of congestion	• Spatial: Miles of roadway in an area and time period with average travel times 30% longer than unconstrained • Temporal; The time duration during which more than 20% of the roadway sections in an area are congested as defined by the Spatial Extent of Congestion performance measure

Source: Adapted from *Guide to Benchmarking Operations Performance Measures*, NCHRP 20-7.

from a relatively small number of traffic recording stations strategically placed throughout the state for planning studies. DOTs also often have hundreds of traffic-monitoring devices on both highways and arterials that provide real-time data for incident management and traffic information. In addition, DOTs are examining possible system enhancements that make use of probe data collection devices (such as Bluetooth) and other new technologies to augment existing data collection efforts. Increased coordination of planning and operations functions has benefits for data collection and storage, including

- Increasing the usability of archived data for both operations and planning staff through improved access tools and greater attention to data quality; and
- Repurposing data between planning and operations to improve the efficiency of data collection and the robustness of analysis.

Sharing data also presents challenges. Planners, for example, need detailed and accurate volume, speed, and classification data for forecasting, while operations staff, more interested in quickly finding incidents, have a higher tolerance for less accuracy.

Analysis Tools

Planning typically makes use of regional or state travel demand forecasting models, project- and corridor-specific meso- and microsimulation models, and sketch-planning tools. Increasingly, planning staff are recognizing the need for tools to evaluate operational investments within the planning process so that these investments can be considered alongside capacity investments. There is a range of tools, including sketch-planning, microsimulation models, and custom models for major incidents (e.g., hurricane evacuation).

Relevant Data and Analysis Practices

Caltrans, working with the University of California, has developed a real-time performance measurement system (PeMS) for freeways. The system provides real-time freeway performance information and can perform detailed quick-response analysis on historical freeway performance, primarily through data from detectors. (https://pems.eecs.berkeley.edu/)

The Maryland State Highway Administration, working with the University of Maryland and several partners, has developed the Regional Integrated Transportation Information System, which serves as an archive and provides numerous data query tools for incident data, traffic detectors, and third-party probe data.

Georgia DOT Traffic Management Center staff developed a set of data validation checks and a quality assurance plan to smooth raw data gaps and increase the overall quality of data to levels satisfactory for other uses beyond operations, including planning. Planning staff now make use of such data in their studies.

The Portland Oregon Regional Transportation Archive Listing (PORTAL) is the official Archived Data User Service for the Portland Metropolitan Region. PORTAL provides a centralized database that facilitates the collection, archiving, and sharing of information/data for public agencies in the region. PORTAL has been used to support (1) development of arterial performance measures and (2) the region's congestion management process, transportation system plans, corridor plans, and system management and operations. (http://portal.its.pdx.edu/)

Planning and Operations Coordination in the Use of Analysis Tools

The Maryland State Highway Administration and the University of Maryland have developed an evacuation planning tool (http://oceancity.umd.edu/index.php) to support evacuation of the state's eastern shore beaches and resort communities. The tool was developed by highway operations staff; however, agency planning staff is interested in using the tool to conduct operational analyses for determining transportation system investments based on major incident scenarios, including evacuation of the state's eastern shore.

CHAPTER 8

Conclusion

Network performance analysis is part of a broad trend by transportation agencies toward using performance measures to support transportation programming and investment decisions. Agencies are recognizing the need to evaluate the transportation system as a network because of the various agencies, modes, and strategies that contribute to overall performance.

This guidebook has provided examples of how transportation agencies are implementing network performance to address congestion and system operations. Though network performance analysis has possible implications for all types of transportation investments, much of the work to date has focused on these challenges.

Summary of Building Blocks

The guidebook has identified three key building blocks needed to support network performance analysis. This section summarizes the key findings from the guidebook.

Partnerships

The scenarios have been organized around three basic types of partnerships: regional, peer-to-peer, and intra-agency. Though partnerships have been important for all of these scenarios, there are some clear differences.

Regional and intra-agency scenarios are less in need of a separate organization or formal partnership. Even the formal partnerships set up as part of the intra-agency scenario are committees that can be created by directive.

Where formal partnerships exist, a range of approaches may apply:

- In the multistate scenario, a strong independent organization focused on multistate objectives led the effort. Project-specific steering committees also may be needed to draw in other relevant partners.
- In the megaregional scenario, several organizations contributed important roles, including technical support, partnership facilitation, and others. The regional agencies involved already were familiar with one another.

Performance Measurement Framework

A framework for establishing performance measures is a critical component of establishing network performance. The framework helps a set of agencies define the transportation network under consideration, the relevant strategies to evaluate, and the measures to help assess network performance. The development of a framework is likely to be closely tailored to the specific parties involved and the issues of interest at the time. Each of the scenarios outlined developed unique frameworks for network performance, with different strategies and outcomes.

For example, in the multistate scenario, the performance measurement framework provided a means to consider the appropriate mix of public and private investment in various rail infrastructure projects. In the regional scenarios, the framework was built to help MPOs expand their area of concern to address investments and policy changes such as reliability, land use, pricing, and other nontraditional investments. Network performance analysis helps illustrate the impact of various types of investments and policies on overall system performance.

A framework should provide focused and clearly articulated goals, carried through to the selection of performance measures, to elicit support from participants. A well-stated agenda opens doors to collaboration.

Data/Methodology

Data and tools are a central part of considering network performance. A basic question of network performance is whether or not new measures are required. The research generally suggests that the measures are the same or similar to ones that have been used, but in many cases new or improved data or tools are needed to be able to capture the performance of the network. Examples of data and tools include the following:

- For the regional scenarios, a combination of scenario planning and tackling new issues requires sketch models or other tools that can capture the long-range benefits of issues such as reliability, pricing strategies, and land use strategies;
- For the multistate scenario, an economic analysis model helped the states compare strategies across state boundaries;
- For the megaregional scenario, significant work was needed to bind together several independent travel demand models used by the individual MPOs that made up the partnership; and
- For the intraregional scenario, data and tools were generally already available, but individual DOT departments were not necessarily aware of what other departments were using. Integrating data across departments requires understanding the specific needs and data quality requirements, as well as developing methods to access data for multiple purposes.

Summary

Performance measures have been widely accepted as valuable tools for use by transportation agencies as they look to increase accountability, make strategic investments, and fully understand the implications and impacts of programs and policies. This research effort looked at how those practices have been applied to network-level situations, across modes and jurisdictions, and the associated benefits and challenges. Conclusions from this effort include the following:

- Measuring network performance offers benefits that include understanding the implications of programs and improvements, selecting the best option to improve network mobility, and finding efficiencies through partnerships and data sharing.
- One basic question of this project is, "Are there network performance measures?" Network performance measurement is unique not in the process or measures used but in the partnerships and collaboration required. Working across agencies to establish common goals and developing methods for measuring those goals is inherently challenging. A range of approaches may be appropriate, depending on the specific agencies involved and their relationship to one another (i.e., peer institutions and existing agreements on cooperation). As such, this research project was organized around a common framework and a set of partnership scenarios.
- As regions expand past the traditional MPO boundaries and travel and economies become interdependent through the formation of megaregions, the importance of network-level performance measurement will increase. More agencies will find these tools and processes critical for addressing the transportation challenges they face.
- As agencies continue to engage in network-level performance measurement, the processes and practices will become more standardized and transferable.

This research project began with a question about measuring performance at a network level. Though clear technical challenges are noted throughout the final report and guidebook, it quickly became clear through the research that a deeper understanding of the partnerships necessary to consider network performance was required. Several partnership models are described here, but future research should take these models further; develop an understanding of the institutional, legal, and other challenges; and develop recommendations to help agencies apply these partnerships in the future, especially for the multistate and megaregional partnerships.

APPENDIX A

Key Literature

This section provides an excerpt of the literature that was reviewed for this project with a focus on material that was used to produce the guidebook. A more comprehensive literature review is available on request as part of the final report.

The Case for System-Level Performance Measures

Developing and monitoring network performance measures requires communication and coordination between individuals who plan the transportation system, develop policy, and manage operations. Existing system-level performance measures have come together through various collaborations between mixed groups of state agencies, MPOs, local governments, transit agencies, and others. Several common elements exist between these collaborations, which may begin to provide a framework that guides agencies when developing and implementing system-level performance measures. Some of the common experiences leading to collaboration and development of system-level performance measurement include

- **Demands from elected officials and the public for increased accountability and performance.** AASHTO's *State DOT Performance Management Programs: Select Examples* (AASHTO, 2007) includes several case studies illustrating how DOTs manage their agencies using performance measures. Although system-level management was not listed as a primary use of performance measures by agencies, "ensuring accountability and responsiveness to stakeholders," which involves increasing network connectivity, is included as a fundamental reason for implementing and expanding performance management programs.
- **Many of the transportation issues of greatest concern to the public today are those that require the ability to address different systems as a single network (e.g., congestion, safety, and security).** In addition, elected officials and the public are increasingly aware of the external impacts of the transportation system on the economy, the environment, and surrounding communities. With limited transportation budgets, there is increasing pressure on public officials and transportation agencies to ensure that projects that are funded are those with the best overall value and least negative externalities. Selecting projects in this context requires broad knowledge of existing system performance and the ability to evaluate the costs and benefits of alternatives.
- **Consideration of operations solutions over new construction.** As construction costs climb, federal and state transportation trust funds decline, and highway systems become built out, the focus of most transportation agencies is shifting from capacity improvements to maximizing operational efficiency (Brydia et al., 2007; Cambridge Systematics, 2005, 2007; Hendren and Myers, 2006; Meyer, 2001; Randall, 2007). With this change, DOTs and MPOs have begun examining the linkages between operations and other agency functions (e.g., capacity building, maintenance, and preservation) and reevaluating funding for different categories of improvements. This approach requires new measures that capture the impact of operational improvements more accurately than do traditional engineering measures and a more system-oriented performance measurement strategy. The FHWA's primer, *Opportunities for Linking Planning and Operations,* provides a framework for how performance measures can be used to link planning and operations departments and therefore policies and decisions.
- **Recognition of the complex nature of organizational decision making and policy setting.** Performance measurement is a constantly evolving process. State DOTs and other transportation agencies are under substantial political pressure to improve accountability and performance for system users. Several studies have examined the decision-making process within transportation agencies and their methods for developing performance measures (Bremmer et al., 2005; Larson, 2005; Poister, 2005). As organizations' understanding of the

complex interaction between different elements of the transportation system and surrounding environmental, economic, and social systems increases, organizations' decision-making processes also change. One result of this evolution has been an increased awareness of the need for performance measures and collaborations that span modes, agencies, and jurisdictions.

- **NCHRP Project 8-36A, Multimodal Tradeoffs Framework Development for Statewide Transportation Planning, provides guidance on conducting multimodal tradeoffs as part of the state planning process.** The Strategic Highway Research Program (SHRP 2) C02 project developed a framework for performance measurement of highway capacity projects that provides linkages to measures in the transportation planning and programming processes and across a range of impact areas. Together, these studies can act as a basis for developing performance measures that provide meaningful comparisons across modes and jurisdictions and assist agencies in responding to the demands of elected officials and the public.
- **Attempts to balance agency and user needs and perspectives on system performance.** Multiple studies show that system-level performance measures provide a means to link organizations' perspectives with the experience of those who use the transportation system (Adams et al., 2005; Cambridge Systematics, 2007; Hendren and Meyers, 2006; Shaw, 2003).
- **Common metrics, measures, and technology to span modes and jurisdictions.** The emphasis on operations over the past decade as a means to make more efficient use of existing capacity has resulted in the growth of methods and technology to monitor system operation in real time. This movement, combined with the development of travel-based performance measures, has resulted in means and methods of comparing mobility efficiency that is adaptable to multiple modes and can easily span jurisdictional boundaries. The wireless data age is putting increased pressure on transportation agencies to provide real-time data in the hands of users who expect accurate measurement of existing mobility conditions (NCHRP Project 20–7).

An increasing number of transportation agencies are utilizing performance-based management and planning. As this trend and those discussed above continue, recognition of the need for common measurable indicators that can be shared across organizational and modal boundaries increases. Through the process of collaboration, staff from different agencies, jurisdictions, and modes bring together different data, expertise, and methods. This is both a challenge and opportunity for system-level performance measurement, presenting communication challenges while creating opportunities to combine resources and perspectives to create measures that more efficiently set goals and track progress to improve overall user experience.

Best Practices in System-Level Performance Measures

For system-level performance measures to be successful, strong partnerships, solid policies, and implementable practices must be in place. The literature highlights the specific conditions that must exist regarding these important factors in the development and implementation of performance measures across modes and jurisdictions.

Partners

A major concern when developing system-level performance measures is determining what stakeholders should be involved in the process and the respective roles of each participant in implementing and monitoring measures once they have been established. Existing studies of such performance measures suggest that in order to be successful these programs require both traditional and nontraditional participation and support. Stakeholders involved in most successful system-level performance measurement programs include the following:

- **Entities accountable for network results.** Those involved in how the network operates should be the ones to decide what to measure, how to measure, and how to convey results. In the context of system performance measurement, this group of stakeholders could include
  - Federal, state, or local governments and departments;
  - MPOs;
  - Transit agencies; and
  - Nonprofit organizations (e.g., economic development, environmental, transportation, and other interest groups).
- **Staff in departments throughout participating agencies.** Like all successful performance measurement programs, system-level ventures require deep-rooted buy-in from staff in all levels of participating agencies. Working cooperatively with other agencies can lead to more robust data and perspectives to make system-level measures work most efficiently. Cascading systems that link performance at all levels to high-level strategic goals of all organizations involved in a collaboration have been effective at building ownership among staff. The most important step in perpetuating staff buy-in is to create practical measures tied to compelling priorities that are meaningful for all partner agencies.
- **High-level, committed leaders in partner agencies.** Support from high-level leadership is necessary for measures to withstand changes in leadership, political relationships, or policies. Just as performance measurement within a

single organization often needs a champion to succeed, committed leadership is required to promote incorporation of system-level measurement into organizational decision making. The champion should be someone familiar with the principles of social impacts, distribution of impacts, or relationships between transportation and other systems (Cervero et al., 2004; TransTech, 2004). Another approach to ensure commitment from agency leaders is to create a memorandum of understanding (MOU) among collaborating agencies and organizations, modeled after the MOU signed by 23 state agencies in support of the Efficient Transportation Decision-Making System (Edwards et al., 2005).

- **Legislators and policymakers.** One common motivation for creating system-level performance measures is the result of calls for increased accountability and performance from legislators and policymakers. These decisionmakers should be regularly updated on steps to develop and monitor system-level performance management programs and informed about the benefits of these efforts for system users. Support from legislators can help programs to withstand changes in organizational leadership and policies and also can help agencies to obtain or maintain funding for performance measurement programs.

Challenges

Performance management is a complex and evolving process. Expanding performance measurement programs to include system-level considerations creates additional complexities that accompany any coordination of activities among multiple actors and stakeholder groups with divergent interests. The successful development and implementation of performance measurement at the organizational level involves many challenges. System-level measurement attempts face many of the same challenges but require even stronger communication and collaboration skills to address. The most common challenges to system-level performance measurement identified in the literature include

- **Divergent priorities, goals, and funding among partner agencies.** The primary obstacle to interagency collaborations—around performance measurement or any other topic—is the time-consuming nature of developing partnerships (Venner, 2005). Transportation agencies have differing priorities, tight restrictions on the types and locations of projects that funding can be used for, and different motivations for participating in system-level performance measurement. For example, several studies have focused on transit agencies' and state DOTs' approaches to performance-based planning and management. The reports show that while DOTs are increasingly relying on performance measures as management tools and are becoming more sophisticated in using them for program evaluation, transit agencies have had difficulty using performance measures to make funding and programming decisions. These differences make developing and implementing performance measures across agencies difficult and time-consuming. Similar issues have been identified in studies of interagency environmental streamlining efforts. A 2004 Gallup survey of transportation agencies involved in these efforts found that collaborating organizations had notably different perceptions of how well efforts were working. Another survey of streamlining projects indicated that collaboration is hard work, time-consuming, labor-intensive, and expensive (Bracaglia, 2005).
- **Political barriers.** Transportation decision making is a complex and highly political process. Project selection and prioritization in particular is an issue of interest to the public and one that can engage many vocal and passionate interest groups. Agencies and local governments often compete for the same limited funding pools and are pressured to prioritize local projects and performance. Similarly, changes in administration or policy within one jurisdiction can cause tension, limit resources, and make system-level performance measurement difficult (Cambridge Systematics, 1999). These challenges can be overcome to some degree with strong leadership and broad support for the value of quantitative and performance-driven inputs into the decision-making process.
- **Speed of implementation.** Partner agencies will incorporate performance data into their decision making at various rates based on their level of buy-in and organizational structure (Pickrell and Neumann, 2001). Private-sector businesses tend to make decisions and implement changes more quickly while public-sector agencies tend to have slower, more complex decision-making processes and may be more resistant to change. This tendency has made implementing performance measures at any level a challenge for public agencies (Cambridge Systematics, 1999). Differences in speed of implementation among different agencies present a particular challenge and point of tension for system-level performance measure programs.
- **Data compatibility.** Data fuels performance-based management and transportation decision making. Complex transportation decisions involving system-level thinking require information that is timely, understandable, and standardized. Creating accurate, consistent data collection and reporting mechanisms to support performance management is a complex task for any organization. Developing efficient data-sharing processes, eliminating redundant data collection and storage, and streamlining workflows is difficult even within different departments of a single agency. These issues become even more important and complex when multiple agencies are involved.

- **Data sharing and compatibility have received much attention as a means to increase the efficiency, sustainability, and proactive thinking of management programs (Halfawy, 2008).** However, implementing data sharing and collection across multiple organizations remains a major challenge. In 2007, TRB hosted "Information Assets to Support Transportation Decision Making," a peer exchange organized to identify data gaps and best practices in data sharing in the transportation sector. The most successful examples of data collecting, sharing, and use at the system level that were identified in this exchange came from the specializations of safety and security. This work has been motivated by recent events that highlighted failings in existing processes and resulted in increased recognition of the need for evacuation routes and other plans that require intensive collaboration across modes and jurisdictions (TRB, 2007). Best practices identified by organizations involved in this work include the following:
  - Communicate opportunities and limitations of data assets to managers and partners;
  - Provide easy access to data and metadata;
  - Develop data business plans;
  - Standardize linear referencing systems to support integration; and
  - Conduct benchmarking analyses using national databases.
- **These approaches begin to provide a data-sharing framework to support system-level performance measurement.** Unfortunately, many of the methods outlined in the current literature are costly or time- and labor-intensive to develop and implement. As a result, standards for collecting, sharing, and using data to support system-level performance measurement should be agreed upon by all partners and documented in the early stages of measure development.
- **Lack of common terminology.** Many transportation agencies have implemented similar performance management programs but use different lexicons to describe the same inputs, outputs, and processes. For example, many municipalities use "dashboards" to track performance while others use "scorecards." The systems are very similar, but the difference in terminology impedes communication between municipal staff that could help both organizations to share their experiences and improve their systems. One of the first steps in any attempt to develop performance measures across agencies or jurisdictions should be to agree on a common set of terminology understood by all participants (TRB, 2005).
- **Cross-modal comparisons.** There is a lack of common performance measures that allow accurate comparisons across modes in terms of service levels, quality, travel times, and cost. It is difficult to create corridor-level performance measures and decide on the most efficient improvement option if there is no way to compare user benefit-costs of signal improvements versus transit service enhancement. According to several studies, measures that use "common denominators" such as speed, acceptable travel time, and person throughput are needed to facilitate system-level and multimodal management (Pratt and Lomax, 1996; Shaw, 2003).
- **Aggressive yet realistic targets.** Agencies need to make progress toward goals to get buy-in from partners and the public. If no progress is made or the goal is unobtainable, the program will fail. System-level performance measures need to address issues that partner agencies have the power to address. If targets are easily achieved and do not challenge agencies or influence decision making, data collection and measurement will be perceived as irrelevant.

Examples of System-Level Performance Measures in the Literature

Traditional performance measures are discussed at length in the literature (Brydia et al., 2007; Cambridge Systematics, 2000, 2005, 2007; Shaw, 2003). Multiple catalogs of established measures for specific modes (e.g., freight) and types of agencies (e.g., DOTs and MPOs) have been published (Harrison et al., 2006).

The literature describing specific system-level performance measures, however, is limited. These studies focus primarily on the collaborative elements of system-level performance measurement, such as best practices in developing system-level performance management programs and facilitating communication between partner agencies and jurisdictions. Very little is written about the actual performance measures used to successfully monitor system-level performance. This section will highlight some common system-level performance measures identified in the current literature.

- A major criticism of traditional, non-system-level performance measures used today is that many are descendents of measures conceived in the 1950s (Meyer, 2001). Many of these measures were developed with an engineering, capacity-building view in mind and focus on facility-type-specific measures of performance on individual segments of the transportation network.
- In recent years, the types of performance measures used in transportation planning and management have expanded to address a growing range of issues. These measures not only consider inputs (e.g., time, staff, and funding) and outputs (e.g., pavement quality and congestion) but increasingly focus on measuring outcomes from the perspective of both system managers and system users (Kittelson & Associates, Inc., et al., 2003; Poister, 1997; Poister and Van Slyke, 2001; Shaw, 2003).

Alternative Performance Measures for Transportation Planning: Evolution Toward Multimodal Planning states that system performance can be defined based on what is important to the owner and user of the transportation system. In the authors' view, both system- and lower-level measures are needed for effective performance measurement yet should be distinguished from one another.

According to several multimodal studies, mobility and accessibility should be incorporated as key measures of system performance (Meyer, 1995). For example

- Travel time and modal availability should be the foundation for mobility performance measures.
- Accessibility measures should be incorporated into project planning and system evaluation approaches.
- Market segmentation and distributional effects of mobility and accessibility changes should be part of measuring system performance.

Additional guidance in creating system-level performance measures comes from several specializations within transportation agencies that have led the way in developing innovative performance measures that cross boundaries between agencies, specializations, and jurisdictions. These collaborations have primarily surrounded several issues.

Environment and Land Use

Beginning with the Intermodal Surface Transportation Efficiency Act and National Environmental Policy Act, federal legislation requires consideration of land use and environmental impacts of transportation projects. These considerations are in their essence system-level measurements. To capitalize on the relationship between transportation and land use, transportation agencies must collaborate with surrounding municipalities. To measure environmental impacts agencies must consider larger natural systems and often partner with environmentally focused organizations such as watershed districts and the department of natural resources (Cambridge Systematics, 2004; Cervero et al., 2004; Rose et al., 2005). Examples of integrated planning efforts in this area and possible system-level performance measures are provided below.

Land use impacts include

- Corridor/access management;
- Number of street connections per 100 acres;
- Smart-growth policies;
- Acres of mixed-use or transit-oriented development;
- Open space and farmland developed;
- Amount of land developed and developed per capita;
- Job/housing balance;
- Percentage of workers within 15 to 30 minutes of their job;
- Percentage of jobs, dwelling units, and population within one-quarter and one-half mile of transit;
- Percent growth in areas with good/poor accessibility;
- Accessibility and number of destinations within 15 to 30 minutes of travel; and
- Overall density and density of approved development.

Environmental impacts include

- Wetlands and forest developed;
- VMT and VMT per capita;
- Emissions and emissions per capita;
- Gallons of gas consumed;
- Percentage of new roads with sidewalk and bike lane/path;
- Nonauto trips, transportation alternatives;
- Modal share for all trips;
- Water quality;
- Storm runoff (quantity and quality);
- Wildlife/habitat impacted;
- Visual quality/aesthetics;
- Cultural resources; and
- Geologic resources.

Many of these measures have been used to measure the performance of individual links/jurisdictions in the past but are potentially powerful system-level measures. Models requiring the use of quantitative input measures also have been used to measure and predict transportation and land use interactions (ICF Consulting, 2005).

Community Impacts

Several efforts have attempted to provide guidance for quantitatively measuring community impacts of transportation projects and their distribution among segments of the population (Cambridge Systematics, 2002, 2004; Edwards, 2004; Forkenbrock and Weisbrod, 2001; The Louis Berger Group, Inc., 2002; TransTech Management, Inc., 2004; Ward, 2005). Types of community impacts and possible system-level performance measures include the following:

- Number of residents exposed to noise in excess of established thresholds;
- Number of opportunities within a specific distance on a specific mode; and
- Results of visual preference surveys.

Context-sensitive solutions and distribution of benefits measures include

- Number of displaced persons;
- Number and value of displaced homes;

- Neighborhood cohesion;
- Accessibility to community services;
- Use of multidisciplinary teams;
- Measures of public engagement; and
- Definition and adherence to vision, goals, and objectives (TransTech Management, Inc., 2004).

Economic Development

The methods used to determine economic impacts of transportation investments often result in performance measures that aid decisionmakers in project or program selection. Many of these processes rely on lower-level performance measures as inputs (e.g., mobility through monetized travel-time savings and safety through crash reductions and associated costs) and as a result are easily adapted to measuring performance at the system level. These methods include

- Lifecycle cost;
- Lifecycle benefit;
- Net present value;
- Rate of return;
- Benefit–cost ratio;
- First-year benefit ratio;
- Payback period;
- Financial feasibility;
- Cost per new person-trip;
- Number and value of displaced businesses;
- Accessibility to employment, retail, new/planned development;
- Jobs created;
- Gross regional product; and
- Change in personal income (AASHTO, 1977; FHWA, 2003; Lewis, 1991; Shaw, 2003).

The measures listed above are a sample of those being used by organizations at the system level. Additional measures can be found in the discussion boards and literature available on the FHWA's Performance Measurement Exchange, System Performance Measurement Group website.

APPENDIX B

Detailed Case Studies

This appendix provides detailed information about each of the case studies conducted for this effort. Findings from these case studies were integrated into the scenario chapters of the guidebook. They are presented here related to the primary scenario they supported.

Regional Scenario—Defining Community Goals Across Jurisdictions

State and regional policy, program, project, and operational decisions can have significant implications for local communities. Conversely, local transportation projects and operational strategies can have impacts far beyond the borders of the municipal boundaries. This scenario documents statewide and regional entities working collaboratively with local governments and transportation providers to assess the impacts of these decisions on a systems level and fully understand and plan for the implications.

Capital District Transportation Committee, Albany, New York

Agency Name: Capital District Transportation Committee (CDTC)
Scale: Regional
Application: Multimodal Assessment/Interagency Planning Partnership

Description of the Program/Initiative

The CDTC is the designated MPO for the Albany, New York, area. The CDTC study area covers Albany, Rensselaer, Schenectady, and Saratoga counties, encompassing a total population of almost 800,000 (U.S. Census, 2000). The majority of the population is centered in the Albany metro area.

Within the regional long-range planning process, CDTC has explored questions about the region's future by undertaking extensive engagement with individuals, groups, and parties that extend beyond traditional MPO outreach efforts. They use core performance measures relating to both aggregate system performance and supplemental performance measures relating to specific elements of the systems. CDTC's performance measures have been used as a national prototype. The agency was one of the earlier MPOs to pay attention to system reliability, land use compatibility, and a wide range of environmental impacts. CDTC and its members have been active in providing significant support for community planning, transit service design, intermodal development, ITS deployment, demand management, and public participation. A regional vision is carried out at the local level to a degree that is exemplary (FHWA and FTA Certification Report, 2008).

A high level of collaboration is evident in their many partnerships. At the policy and planning level, CDTC has transit agency, airport, port, and Thruway Authority representatives serving as voting members. The collaborative ITS deployment on NY 5 involving five municipalities, CDTA, and the New York State Department of Transportation (NYSDOT) is a significant achievement and prototype. A regional ITS architecture has been cooperatively established. CDTC also has undertaken extensive community outreach programs though its Community and Transportation Linkages program.

CDTC has focused its efforts on many areas, including VMT reduction, congestion, environmental issues, land use planning, sustainability, and safety. There is a high level of planning and operational coordination among state and local governments, transit providers, the public, and other agencies. The collaborative planning processes have helped cultivate a planning environment that has increased CDTC's impact on the region.

The MPO staff view transportation as a means to an end. This "end" is not just "Point B" but rather outcome-based community goals such as "quality of life." A key goal that guides all of CDTC's work is creating a "quality region." The MPO has developed qualitative methods to measure quality of life and new quantitative measures, including reliability of network performance.

Description of Systems-Level Effort

CDTC's long-range plan, New Visions, is performance-based and stakeholder-driven. The updated 2030 plan continues CDTC's focus on travel behavior and land use issues that provided the foundation for the 2021 plan.[7] CDTC makes connections to its visioning and planning processes and further links these with performance measures to assess the system. New Visions 2030 stresses the need for urban investment and concentrated land use that will lead to sustainable growth and an improved quality of life. CDTC's approach to large-scale, presently unfunded "big-ticket" initiatives is to consider them as part of a vision toward which the Region can strive (http://www.cdtcmpo.org/rtp2030/c-bigideas2.pdf). These big-ticket items in the recent update of New Visions include

- Land use, transit, and environment:
  - Suburban town development centers;
  - Bus service expansion, BRT program with bus-oriented development;
  - Guideway transit system with transit-oriented development;
  - Travel demand management program; and
  - Clean, efficient vehicle program.
- Highway/corridor:
  - Managed lane program;
  - Street reconstruction and reconfiguration;
  - Roadway widening and connection programs;
  - Intelligent traffic management program;
  - Video surveillance and enforcement program (ITS); and
  - Comprehensive traffic safety program.

CDTC's highway strategies do not include major capacity expansion. CDTC has discovered through its planning and public engagement processes that a focus on highway expansion will not help reach many of its systemwide goals. Although the region experiences congestion, delay often results from incidents and other causes of non-recurrent congestion rather than excess demand. CDTC chooses strategies that are more aligned with regional goals, such as increasing highway reliability. Strategies that will improve reliability include management and operations strategies to improve network performance, such as ITSs and traffic management systems.

[7]http://www.cdtcmpo.org/rtp2030/say.htm

A major strategy CDTC undertakes is the Community and Transportation Linkage Planning Program. CDTC established this program to provide funding to communities to integrate land use and transportation planning. The driving force of the program is the idea that transportation and land use planning play a role in reaching the region's potential. It also has been an avenue to link regional plans with local projects and a tool to reach consensus on how the transportation network should perform. The Linkage program's objectives are to

- Support urban revitalization and redevelopment of existing areas;
- Improve street connectivity through access management;
- Enhance and develop activity centers and town centers;
- Enhance and develop transit corridors and environments that support transit;
- Encourage a greater mix and intensity of land uses;
- Develop bicycle- and pedestrian-friendly design standards;
- Create an integrated multimodal transportation network; and
- Protect open space.

Since 2000, CDTC has initiated a total of 61 Linkage studies in the region, making its integrated transportation–land use program one of the most extensive in the nation. By providing funding for cities, towns, and villages to prepare local transportation plans consistent with the New Visions plan, CDTC has helped increase the amount of local commitment to the regional plan and improve local coordination of transportation and land use planning (FHWA and FTA Certification Report, 2008).

CDTC also has focused efforts over the past several years on transportation demand management (TDM) activities. In partnership with CDTA and other organizations, CDTC began a pilot TDM program in 2001 and continues TDM efforts today. Jointly administered TDM programs include a web-based carpool matching program, guaranteed-ride-home program for transit users and carpoolers, a cash subsidy for transit passes through public employee unions, and a 6-month cash subsidy toward public or private transit services to encourage downtown employers to establish commuter programs.

In the planning process, CDTC widely engages the public to help link strategies and measures to goals. CDTC staff believes that all performance measures should be first approved through public process. For example, public opinion polls have shown that people are willing to tolerate traffic congestion levels if there are improvements to transit, walking, biking, safety, and landscaping. This interest in and understanding of public opinion helps CDTC choose appropriate measures that will help align network performance with community goals.

Performance Measures

CDTC is a best practice case for systemwide performance measures because it makes decisions based on broad community goals and highlights the most important links in the system for achieving efficiency rather than focusing on individually owned networks. The agency uses long-term measures to address the impacts of the connection between land use and transportation planning. Systemwide measures are used to achieve such outcomes as regional mobility, accessibility, connectivity, reliability, improved environment, and quality of life. By adopting a broad perspective on the transportation system, CDTC is collaboratively working toward improving network performance in the region—across jurisdictions and modes.

CDTC has both aggregate and supplemental performance measures (Table B.1). CDTC refers to aggregate performance measures as core measures. These measures are targeted at improving outcomes of network-level performance. Besides the traditional MPO focus on congestion delay and LOS, CDTC measures reliability and level of community compatibility.

In addition to CDTC's core measures, "supplemental" performance measures are used to describe more specific, facility-related targets such as infrastructure and service. Supplemental measures include highway infrastructure, transit infrastructure, goods movement, transit service, and human service. CDTC also has specific bicycle and pedestrian transport measures, such as center lane-miles with bicycle accommodations.

GHG emissions are an increasingly important measure for CDTC. The agency incorporates analysis of GHG emissions into its planning process through "full cost analysis," including emissions analysis and an analysis of the cost of the potential effects of climate change in the region. CDTC applies a cost analysis that includes an analysis of global warming costs to major system decisions such as the evaluation of TIP projects when applicable. CDTC also estimates the GHG emissions resulting from its long-range transportation plan, complying with New York State Energy Plan Section 3.2 requirements that require MPOs to estimate the energy and CO_2 emissions from their long-range plans and TIPs. CDTC has gone beyond the state requirements and produced GHG emissions specific to year, operating speed, and functional class.

Table B.1. CDTC core performance measures.

Measurement Area	Core Performance Measures
Access	Percentage of p.m. peak-hour trips transit accessible
	Percentage of p.m. peak-hour trips with transit advantage
	Percentage of p.m. peak-hour trips accessible by bicycle and walking
Accessibility	Travel time between representative locations
Congestion	p.m. peak-hour recurring excess person-hours of delay
	Excess person-hours of peak-hour delay per person miles traveled
	Excess person-hours of peak-hour delay per person
Flexibility	Reserve capacity on the urban expressway and arterial system (p.m. peak-hour vehicle miles of capacity)
Safety	Estimated annual societal cost of transportation accidents, millions of dollars ($M) [New PMs are under development]
Energy	p.m. peak-hour fuel consumption (thousands of gallons)
Economic cost	Annual vehicle ownership and operating costs for autos and trucks, millions of dollars ($M)
	Other monetary costs of transport: highway and transit facilities and service, parking facilities, environmental damage, millions of dollars ($M)
Air quality	p.m. peak-hour daily hydrocarbon (HC) emissions (kg)
	p.m. peak-hour daily nitrogen oxide (NO_x) emissions (kg)
Land use	Residential use traffic conflict: miles at LOS "E" or "F"
	Arterial land access conflict: miles at LOS "E" or "F"
	Dislocation of existing residences and businesses
	Community quality of life—factors that reflect community quality of life in the central cities, inner suburbs, outer suburbs, small cities and villages, and rural areas.
Environmental	Number of major environmental issues to be resolved to implement existing commitments
Economic	How does the transportation system support the economic health of the region?

Source: CDTC Congestion Management Process, 2007. http://www.cdtcmpo.org/rtp2030/materials/cm-doc.pdf.

Congestion management is another area in which CDTC has used performance-based planning measures. CDTC's new CMP is an update of the CDTC Congestion Management System. The CMP incorporates a new performance measure related to the reliability of the transportation system called the planning time index (PTI). CDTC's New Visions Working Group B, consisting of state and regional members, works to identify new meaningful performance measures and methods for evaluating travel needs.[8] The need for a measure of reliability came from CDTC discussions about quality of travel. The question being considered was, "Is 15 minutes of recurring traffic worse than occasional, nonrecurring congestion that lasts one hour?" Addressing this question led to the realization that reliability and LOS are different measures. For example, I-87 has the same LOS as I-90 but a worse planning time index, meaning that nonrecurring congestion disrupts travel time. Therefore, widening roads may not be a strategy to alleviate congestion because this is not a major solution for this kind of traffic. Rather, operational strategies would probably be most useful.

CDTC considers the planning time index to be one of its most effective systemwide measures for determining network performance. This index is developed using the NYSDOT's MIST database that records expressway speed and volume by lane every 15 minutes. CDTC collaborates with NYSDOT to manage the database.

Planning Time Index

Ratio of driving time on a "worse than average delay day" (95th percentile) to a "free-flow day":

- PTI >1.0: trip would take longer time;
- PTI =1.0: trip would take no extra time; and
- PTI <1.0: speed would be >55 mph even on the wor st" day.

Qualitative measures are employed to measure community compatibility and quality of life. The use of these quality-of-life indicators emerged in the 1990s. At the time, a major interstate interchange was proposed to be built on the front lawn of a community college. Impacts were not considered about how the plan would affect community quality of life; most of the focus was on improving LOS for the area. CDTC began making subjective measures about how compatible transportation plans were with the community quality of life, assigning Levels A through F for community impact.

[8] http://www.cdtcmpo.org/rtp2030/materials/wb-doc.pdf

To support this extensive network performance measurement program, CDTC has a robust data collection and reporting program. CDTC's data collection includes automatic traffic recorder counts; intersection traffic counts; vehicle, truck, and pedestrian trip generation; vehicle classification counts; bicycle and pedestrian shared-path volumes; transit ridership and park-and-ride lot usage; a variety of safety data, including crash location and frequency; and other data as necessary. All data collected by CDTC is organized and maintained for access by state government, local municipalities, public and nonprofit agencies and groups, consultants, and other interested parties.

CDTC uses an extensive new database that records expressway speed and volume by lane every 15 minutes (the MIST database). With the assistance of NYSDOT, CDTC developed new performance measures related to reliability. New opportunities for monitoring speed and delay on arterial corridors using GPS technology are being developed for data collection. These new databases and expanded performance measures will be used to revise the critical congestion corridors articulated in the CMP documents.

New opportunities for monitoring speed and delay on arterial corridors using GPS and other technologies also are being examined for data collection. CDTC is conducting tradeoff analyses to help analyze the actual congestion relief benefits achieved from CMS projects. Other potential data sources are emerging for CDTC, including data from the NYSDOT TRANSMIT program. The CDTC Regional Operations Committee also will continue to develop performance measures for operations and management. CDTC's core performance measures will continue to be incorporated into the CMP.

Supporting Processes, Methods, and Conditions

CDTC's collaborative planning processes have resulted in a high level of consensus within the region. CDTC works with NYSDOT, CDTA, CDRPC, local and state governments, and local stakeholders. The MPO has worked with more than 34 municipal communities in its Community and Transportation Linkage joint planning studies. CDTC funnels almost one-third of its federal money toward local communities through the Linkage program. This program is a cornerstone of CDTC partnerships with the community. CDTC also is working with the Regional Operations Committee to refine new congestion management performance measures and is collaborating with NYSDOT to develop procedures for the tradeoff analysis and strategy analysis measures to help analyze the actual congestion relief benefits achieved from CMS projects.

CDTC also is part of the New York State Association of Metropolitan Planning Organizations (NYSMPO). This organization is working on planning and research efforts toward common goals and has pooled some federal planning funds on joint projects. Through the ongoing development of the Safety Management System (based on NYSDOT's Safety Management Information System), CDTC collects, analyzes, and shares available regional safety data with regional safety partners, undertakes pilot safety projects, and uses regional GIS. CDTC is involved in the statewide NYSMPO Safety Working Group, collaborating with a wide variety of state safety partners to improve crash data systems in the state, develop local crash rates, and develop standardized safety audit processes.

The CDTC staff continues to work with regional partners in contributing to the regional GIS. GIS applications include the regional bike-hike trail maps, bike and pedestrian data mapping and analysis, crash data mapping, and analysis for the Linkage studies. CDTC coordinates with NYSDOT, the NYS Department of Environmental Conservation, and others on updating natural and cultural resource maps for environmental planning and uses GIS in long-range planning. CDTC also works with CDRPC to process GIS data and incorporate parcel-level data and high-resolution orthophotography for the entire region.

Obstacles

One challenge that CDTC has been working on is using performance measures to link the congestion management process to the long-range planning process, thus aligning congestion management strategies with broader community goals. Reaching CDTC's community-developed vision depends on the successful outcome of many initiatives, including the New Vision principles, strategies, and actions.

SACOG Metropolitan Transportation Plan for 2035

Agency Name: Sacramento Area Council of Governments (SACOG)
Scale: Regional
Application: Multimodal Assessment/Interagency Planning Partnership

Description of the Program/Initiative

SACOG is the designated MPO for the counties of Sacramento, Sutter, Yolo, Yuba, Placer, and El Dorado (except for the Lake Tahoe Basin). The Metropolitan Transportation Plan (MTP) for 2035 is proposed to chart a 28-year course for transforming the region's transportation system by identifying various problems in the metropolitan transportation system and proposing solutions that address those problems. The MTP 2035 includes proposals for new and improved transit options, safe and well-connected bicycle and pedestrian facilities, a network of high-occupancy vehicle lanes, and real-time information about conditions on every highway and transit route in the region.

Description of Systems-Level Effort

The SACOG staff has been working on interregional travel studies, identifying Sacramento's interregional transportation connections. These connections include major interstate corridors, state highways, Amtrak passenger rail, intermodal station and bus express, freight rail, airport, and inland seaport. SACOG uses measures and indicators to determine the status and condition of this interregional system.

Performance Measures

- Congestion delay
  - Congested VMT per household (region average);
  - Percentage of total travel in congested conditions in peak periods; and
  - Percentage of total travel in congested conditions midday period.
- Travel time
  - Percentage of trips less than 30 minutes long during peak periods;
  - Percentage of trips less than 15 minutes long during midday period; and
  - Percentage of total transit trips less than 45 minutes long.
- Auto travel
  - VMT per household (regionwide average).
- Transit travel
  - Transit trips per 100 households.
- Travel mode choice
  - Percentage mode share of total trips.
- Reasonable transit choice
  - Percentage of all transit stops served by at least one route with frequency 15 minutes or less.
- Fairness by location
  - Comparative average travel time per person (in minutes).
- Labor market
  - Percentage of work trips less than 20 minutes duration; and
  - Percentage of households that can access downtown within 30 minutes during peak periods.
- Freight delivery
  - Average travel time per truck trip (3+ axle trucks).
- Service delivery
  - Average V/C on urban freeways midday period.
- Commuter carpooling
  - Percentage of work trips by carpool;
  - Air quality;

  – Total VMT per day; and
  – Daily heavy truck VMT (3+ axle trucks).
- Energy conservation
  – Total VMT per day; and
  – Daily heavy truck VMT (3+ axle trucks).

Supporting Processes, Methods, and Conditions

SACOG has been recognized by the Environmental Protection Agency as one of the winners of a 2004 National Award for Smart Growth Achievement. Winners were recognized for innovative approaches to development that strengthen community identity and protect the environment. SACOG partnered with Valley Vision, which resulted in more than 5,000 participants in the process of refining regional alternatives for future growth.

The Sacramento region has several ITS cooperative efforts that are facilitated via the Sacramento Region ITS Partnership, an advisory committee made up of local and state transportation personnel. There also is a multimodal, multijurisdictional “smart corridor” collaborative effort of the County of Sacramento, the Sacramento Regional Transit District, Caltrans, the California Highway Patrol, and the American River Fire District.

Obstacles

Traffic congestion within the region continues to significantly increase. Currently, the Sacramento Region has 2.2 million people and it is anticipated the region’s population will increase to 3.2 million in 2030. Limited interregional passenger options and accessibility is a significant challenge throughout the Sacramento Region. Transportation funding is not keeping up with the demand for transportation projects due to California and the Sacramento Region’s increase in population and vehicle miles traveled.

SANDAG: Congestion Management Strategies

Agency Name: San Diego Association of Governments (SANDAG)
Scale: Regional
Application: Multimodal Assessment/Interagency Planning Partnership

Description of the Program/Initiative

Functioning as the region’s MPO, SANDAG plans and manages major elements of San Diego’s regional transportation system. This MPO has integrated the congestion management process into the regional planning process and uses a comprehensive set of systemwide performance measures. SANDAG also works to integrate demand management and capacity management. There are many ITS projects, corridor-oriented projects, and strategic congestion management projects, such as HOT lanes, in the region.

Description of Systems-Level Effort

An important strategy for maximizing the efficiency of the region’s existing transportation system is using performance measures to manage the system. Although the region’s surface transportation elements—freeways, roads, and transit systems—can be managed separately, they are interdependent and require a comprehensive multimodal management focus to achieve SANDAG’s mobility goals. SANDAG refers to this comprehensive approach as integrated performance management.

Performance Measures

The RTP uses performance measures to plan for a scenario that, assuming reasonably expected revenue sources, decreases traffic congestion in the region. Key highway performance indicators used to evaluate and improve congestion include

- Speed;
- Volume;
- Vehicle hours of delay;
- VMT;
- Highway network peak-hour level of service;
- Carpool and transit speed; and
- Work trip mode splits during peak periods.

Supporting Processes, Methods, and Conditions

The RTP, Mobility 2030, contains objectives that include increasing transit ridership, improving response to congestion problems, and regularly measuring the performance of the regional transportation system. The CMP is an integral aspect of the RTP and is updated every 2 years. The CMP analysis is within the Systems Management section of the RTP. CMP tools and strategies can be applied within the framework of an objectives-driven approach to address specific transportation goals.

SANDAG works with the U.S. DOT as a pioneer site in the Integrated Corridor Management (ICM) program. This federal initiative encourages the application of technology and commitment by network partners to reduce congestion along corridors. SANDAG is managing the integration of corridor assets, such as tolling, value pricing, and bus rapid transit, with ICM practices in the San Diego region.

SANDAG works together with Caltrans on many initiatives. Within systems management, their collaboration includes HOT lanes, development of corridor systemwide deficiency plans, and performance monitoring efforts. The San Diego Transportation Management Center integrates Caltrans' Traffic Operations and Maintenance in a unified communication and command center that provides communications, surveillance, and computer infrastructure to coordinate transportation management on state highways.

Obstacles

The largest challenge in fighting congestion and improving the mobility of people and goods in the region is the growing population. Another large barrier to decreasing the amount of traffic in the region has been finding adequate funding.

Puget Sound Regional Council Vision 2040 (Destination 2030 Update) Tolling Initiative

Agency Name: Puget Sound Regional Council
Scale: MPO/Regional
Application: Tolling/ITS/TDM

Description of the Program/Initiative

As one strategy in their Vision 2040 (Destination 2030 Update), the Puget Sound Regional Council is integrating an impact analysis of six tolling alternatives on the region. The outcomes of the analysis will be vetted through a series of management strategies and finally expansion strategies to arrive at the final selection of alternatives.

Description of Systems-Level Effort

The alternatives are being analyzed based on their impact to the system and must accomplish the following:

- Improve the mobility of people and goods in the Puget Sound region;
- Create efficient land use patterns for the provision of infrastructure, facilities, and services;
- Promote economic prosperity;
- Protect the natural environment;
- Promote an overall high quality of life; and
- Distribute transportation benefits and costs equitably.

Performance Measures

System-level performance measures used in the Destination 2030 Update fall under seven categories:

- Transportation efficiency
  - Travel-time savings;
  - Reliability benefits;
  - Vehicle operating cost savings; and
  - Other user costs.
- Finance
  - Facility operating costs;
  - Capital costs;
  - Operating revenues; and
  - Influence of finance on the economy.
- Growth management
  - Population in regional geographies;
  - Employment in regional geographies;
  - Jobs and housing balance in counties; and
  - Population and jobs in regional growth centers and jobs in MICs.
- Economic prosperity
  - Accessibility to high-wage employment;
  - Accessibility to cluster employment; and
  - Accessibility to freight generators.
- Environmental stewardship
  - Vehicle emission cost savings;
  - Runoff from impervious surfaces; and
  - Ability to retain open space.
- Quality of life
  - Accident cost savings;
  - Nonmotorized travel; and
  - Redundancy.
- Equity
  - Geographic equity;
  - Income equity; and
  - Distribution of benefits to passenger and freight users.

Supporting Processes, Methods, and Conditions

The system-level analysis is linked to the long-range planning process for the region. All involved stakeholders must be on board to understand tolling as a demand management tool, with implications across all aspects of the system (see above categories).

Obstacles

No major obstacles were uncovered at this point.

Alameda Corridor

Agency Name: Alameda Corridor Transportation Authority (ACTA)
Scale: Corridor
Application: Infrastructure Improvements

Description of the Program/Initiative

The Alameda Corridor is a 20-mile-long rail cargo expressway linking the ports of Long Beach and Los Angeles to the transcontinental rail network near downtown Los Angeles.

The corridor runs primarily along, and adjacent to, Alameda Street. It is a series of bridges, underpasses, overpasses, and street improvements that separate freight trains from street traffic and passenger trains, facilitating a more efficient transportation network. The project extends through or borders the cities of Vernon, Huntington Park, South Gate, Lynwood, Compton, Carson, Los Angeles, and the County of Los Angeles. Construction of the corridor began in April 1997. Operations began in April 2002.

The Alameda Corridor project evolved from over a decade of study of increasing freight/cargo demand in the port area and the impact on the surrounding transportation infrastructure and community. The ports of Long Beach and Los Angeles are the two busiest container ports in the country and, together, the fifth busiest port complex in the world. The rail network serving the ports was not sufficient to accommodate rapidly increasing cargo volumes. The Alameda Corridor consolidated four low-speed branch rail lines, eliminating conflicts at more than 200 at-grade crossings, providing a high-speed freight expressway, and minimizing the impact on communities. Specific benefits of the project, as noted by the Alameda Corridor Transportation Authority (ACTA), include

- More efficient freight rail movements;
- Reduced traffic congestion;
- Improvements to Alameda Street;
- Multiple community beautification projects;
- Reduced train emissions and reduced emissions from idling cars and trucks;
- Reduction in delays at railroad crossings; and
- Reduced noise pollution from trains.

Description of Systems-Level Effort

Planning, constructing, and operating the Alameda Corridor was a multijurisdictional and multi-agency effort to improve transportation and economic issues associated with significantly increased growth in port-cargo demand, at a corridor and a regional level.

In October 1981, the Southern California Association of Governments (SCAG) created the Ports Advisory Committee (PAC) in response to growing concerns about the ability of the surface transportation system to accommodate increasing levels of traffic in the port area. PAC members included local elected officials as well as representatives of the ports of Los Angeles and Long Beach, the U.S. Navy, the Army Corps of Engineers, affected railroads, the trucking industry, and the (former) Los Angeles County Transportation Commission (LACTC).

In 1984, on the basis of PAC's recommendations, the SCAG Executive Committee adopted a plan for the consolidation of all port-related railroad traffic onto the former Southern Pacific San Pedro Branch. The proposed plan promised to augment train speeds in addition to reducing vehicular traffic delays at grade crossings, thus reducing air and noise pollution and improving safety.

In 1985, SCAG created the Alameda Corridor Task Force, which included members of PAC with the addition of the California Public Utilities Commission and each of the eight cities along the corridor. PAC worked on the institutional arrangements and funding and developing consensus on various aspects of the project.

In 1989, the two San Pedro Ports provided the seed funding for design and environmental studies and also took the lead in creating an agency to oversee design and construction. During the same year, the cities of Los Angeles and Long Beach formed a Joint Powers Authority (JPA) called "Consolidated Transportation Corridor Joint Powers Authority." The JPA name was later changed to "Alameda Corridor Transportation Authority." The goal of ACTA was (and still is) to create a more efficient rail system that would reduce traffic delays and improve environmental quality along the corridor. ACTA's seven-member Governing Board includes two representatives from each port, a member of each city council, and a representative of the Los Angeles County Metropolitan Transportation Authority (previously LACTC). The Alameda Corridor environmental impact report/environmental impact statement was approved in 1993. Construction started in 1997.

Following the April 2002 opening, operations have been overseen by a four-member Alameda Corridor Operating Committee, staffed by ACTA personnel, which includes one representative each from the Port of Long Beach, Port of Los Angeles, Burlington Northern Santa Fe Railway, and Union Pacific Railroad. The Governing Board continues to provide policy direction to ACTA staff regarding additional projects and planning studies.

Performance Measures

The first phase of the initial PAC Alameda Corridor study, completed in 1982, dealt with the problems of highway access to the ports. In this phase, the study addressed a number of problem areas and recommended a cost-effective set of highway improvements, including the widening of certain streets. The second phase, a study of rail access, was completed in 1984. Additional highway improvements were recommended, but the focus of the second phase was concern over the impact of projected train traffic on communities north of the ports.

On the basis of a review of online and published material, it is assumed that performance measures developed for the initial planning studies focused on the economic impact of the corridor (e.g., jobs created/removed, change in gross state product), community impact (e.g., neighborhood disruption, environment justice), air quality (e.g., emissions reduction), and congestion reduction (e.g., average daily train traffic and cargo volumes and the impact on on-road truck and passenger vehicle traffic, speeds, and level of service).

The Alameda Corridor Air Quality Benefits Report (Final Report June 2005) was published on the ACTA website. This study was commissioned to quantify the direct air quality benefits of the corridor as well as the benefits of new infrastructure projects that would support more use of the corridor and therefore create additional air quality benefits. Performance measures used for this study include Emissions Reduction (tons)—Reactive Organic Gas, CO, NO_x, PM_{10}, and SO_x.

Supporting Processes, Methods, and Conditions

The Alameda Corridor passes through jurisdictions of eight cities: Los Angeles, Long Beach, Vernon, Huntington Park, Lynwood, South Gate, Compton, and Carson. In addition to these cities, the Alameda Corridor study efforts involved private railroads, the two San Pedro Bay ports, and other state, regional, and local public agencies, including SCAG. Coordination and consensus building with various agencies (as well as with the general public) was a complex process but essential to the success of the project. The process involved multiple stakeholders, each with its own self-interest: ports that were investing large sums of money, private railroads that were going to share a common right of way with their competitors, regional agencies such as SCAG and Los Angeles County Metropolitan Transportation Authority that were interested in easing traffic congestion, and the cities through which the corridor passed. The informal process of building consensus and more formalized process to define ACTA Board membership and authority took time and was difficult to negotiate, but ultimately ensured successful implementation of the project.

ACTA addressed many community issues by implementing a large number of economic development programs for local residents. It also developed the Alameda Corridor Business Outreach Program to assist disadvantaged businesses in learning about and competing for work on the project. ACTA also developed formal MOU agreements with each city along the corridor to address construction mitigation measures.

Innovative funding arrangements were developed to pay for the project itself. The $2.4 billion Alameda Corridor was funded through a unique blend of public and private sources. Revenues from user fees paid by the railroads will be used to retire debts incurred in planning and building the project.

Obstacles

A key obstacle was the mid-Corridor cities that were concerned about the local effects of construction activity, increased rail traffic, and other negative impacts on residents and businesses adjacent to the corridor. These cities argued that while the benefits of the project were widely dispersed regionally and even nationally, its external costs and adverse impacts were highly concentrated in the areas through which the corridor passed. The dissenting cities were focused primarily on the local economic benefits of the project and believed inadequate attention was being paid to their economic development needs (this ultimately led to a lawsuit which ACTA won)—hence the multiple local economic development incentive programs that ACTA eventually implemented. This should be investigated to assess if/how ACTA used technical analysis and particular performance measures to highlight economic, or other, benefits of the project for either the courts involved in the lawsuit or the jurisdictions and communities affected by the project.

Information used for this description, and more on the Alameda Corridor, can be found at the following web pages:

http://www.acta.org/newsroom_factsheet.htm.

http://www.acta.org/.

http://www.acta.org/PDF/Alameda%20Corridor%20AQ%20Benefits%20Report_061005.pdf.

http://www.metrans.org/pdfs/AlamedaCorridorWhitePaper.pdf.

I-15 Integrated Corridor Management Project

Agency Name: San Diego Association of Governments (SANDAG)
Scale: Corridor
Application: Data collection, evaluation, and dissemination

Description of the Program/Initiative

The San Diego ICM Project is one of eight sites selected by U.S. DOT under the national Integrated Corridor Management Initiative.

The I-15 Corridor is the primary artery for the movement of commuters, goods, and services from inland northern San Diego County to downtown San Diego. The I-15 ICM effort will allow the corridor to serve a growing number of interregional trips through a multi-institutional partnership and the use of multimodal transportation improvement strategies. The I-15 ICM will allow the region to address regional transportation needs by accelerating existing SANDAG "Regional Transportation Plan" planning efforts; optimizing operations from an overall network perspective as opposed to individual network perspective; and allowing for more efficient response to variations in demand among networks.

Description of Systems-Level Effort

The I-15 ICM operational goals are as follows:

- The corridor will give travelers the opportunity to make seamless and convenient shifts among modes;

- The corridor will enhance mobility for people, goods, and services;
- ICM will enhance current levels of existing interoperability between field elements and functional environments or systems; and
- ICM places a focus on improving throughput, productivity, connectivity, safety, and accessibility.

The I-15 Integrated Corridor Management System (ICMS) includes a number of integrated systems and facilities:

- Lane control systems;
- Advanced transportation management systems;
- Advanced traveler information system (511);
- Regional transit management systems;
- Emergency management systems (e.g., WebEOC);
- Managed-lane control system;
- Regional event management system—public safety CAD systems; and
- Regional high-bandwidth microwave network.

Performance Measures

I-15 ICM performance measures will be based on existing RTP performance measures such as

- Average travel time (minutes) by mode (door-to-door);
- Work trip average travel speed (per auto trip);
- Work trip average travel speed (per transit trip);
- Work trip average speed (per carpool trip); and
- Percentage of total travel in congested conditions (peak period and all day).

Supporting Processes, Methods, and Conditions

The San Diego I-15 ICM will be managed collaboratively and cooperatively through ongoing partnerships among the SANDAG, Caltrans, the Metropolitan Transit System, the North County Transit District, the California Highway Patrol, and the cities of San Diego, Poway, and Escondido.

The San Diego I-15 ICM partners have improved the level of institutional coordination among stakeholders by developing and executing an MOU and developing a project charter. They are leveraging the existing regional institutional infrastructure.

The San Diego I-15 ICM has been selected by U.S. DOT for participation in Stage 2: Analysis, Modeling, and Simulation, under the national ICM initiative. This funding support and the strength of the regional partnership increase the potential for successful future ICM deployment. Ultimate deployment will likely hinge on selection by U.S. DOT for Stage 3: ICM Deployment.

Obstacles

No major obstacles were uncovered.

Maryland I-270 Integrated Corridor Management Project

Agency Name: Agency Lead: Maryland State Highway Administration (SHA)
Scale: Corridor
Application: Data collection, evaluation, and dissemination

Description of the Program/Initiative

The Maryland I-270 ICM Project is one of eight sites selected by U.S. DOT under the national Integrated Corridor Management Initiative.

Agencies/organizations currently partnering for the I-270 ICM project include the

- FHWA;
- FTA;
- Research and Innovative Technology Administration;
- Maryland SHA;
- Maryland Transit Administration;
- Montgomery County Department of Public Works and Transportation;
- The University of Maryland; and
- Washington Metropolitan Area Transit Authority (WMATA).

The I-270 Corridor is in Montgomery County, Maryland, just outside Washington, DC. The corridor is approximately 20 miles long and consists of various transportation networks, including

- The Freeway Network (including I-270);
- The Arterial and Connector Route Network (including MD-355);
- The MARC Commuter Rail Network;
- The WMATA Metrorail Network;
- The Maryland Transit Administration Commuter Bus Network;
- The WMATA Metrobus Network; and
- The Montgomery County Ride-On Bus Network.

The I-270 Corridor, also referred to as the Technology Corridor, links significant suburban residential concentrations with the major employment regions of Northern Virginia, downtown Washington, DC, and the Capital Beltway, and along the I-270 Corridor itself. As with most urban areas in the United States, the trend in the metropolitan Washington, DC, area has been that development expands outward from the city. However, most commuters in the I-270 Corridor are heading not into downtown Washington but to other suburban locations. Because of high-traffic volumes in the corridor, and the impact that incidents even outside the corridor can have on I-270 conditions, congestion has become a monumental problem.

The goals of the Maryland I-270 ICM project include the following:

- Optimize mobility, reliability, and safety;
- Strengthen corridor-level decision support;
- Enhance reliable, real-time information to customers; and
- Promote multimodal operations support and travel within the corridor.

Description of Systems-Level Effort

The I-270 ICMS will focus on traveler and operations management decision support by emphasizing corridor transportation systems management, traveler information dissemination, and systems evaluation by leveraging and improving upon current data collection, fusion capabilities, and corridor transportation system integration. By consolidating, disseminating, and archiving transportation-related data from stakeholder agencies in the corridor, the I-270 ICMS will

- Provide improved information for a variety of purposes, including corridor transportation planning, management, traveler information, and emergency response;
- Provide corridor transportation data fusion to allow an overall view of the corridor's transportation network;
- Upgrade transportation data exchange capabilities of participating agency systems in the corridor as well as the region;
- Upgrade the multimodal transportation systems management capabilities of the stakeholder jurisdictions for corridor transportation operations;
- Upgrade traveler information dissemination capabilities at the corridor system level;
- Upgrade corridor multimodal incident response and emergency preparedness capabilities; and
- Provide the means to easily access corridor transportation data and produce corridor-level performance measures reports for decisionmakers.

Funding for the initial planning of the I-270 ICM and the creation of a Concept of Operations, System Requirements, and Data Collection Plan has come from U.S. DOT under the national ICM initiative along with matching funds from the Maryland SHA.

The critical operational needs of the corridor, as identified in the Concept of Operations, include the following:

- Addressing nonrecurring congestion through
  - Enhanced multimodal approaches to managing incidents;
  - Better tools/mechanisms for sharing multimodal real-time information; and
  - Better tools to support operations-oriented and traveler decision-making capabilities.
- Enhanced signal operation/optimization capabilities on the corridor arterial network and improved arterial network system monitoring.
- Improved transit management and transit parking system management capabilities.
- Improved traveler information delivered pretrip and en route along with multimodal decision support capabilities for individual trips.
- Improved real-time system monitoring capabilities across all modes and networks.

An I-270 ICM System Requirements document has been developed to identify the initial set of requirements necessary to build the Maryland I-270 ICMS in a manner that will ensure the combined stakeholder vision of having transportation operations within the I-270 ICM corridor work at peak efficiency by optimizing the use of the capacities of the transportation modes in the corridor.

Though the project has developed a specific ICM Steering Committee, future plans are to integrate the institutional infrastructure within existing entities such as the newly formed Metropolitan Area Transportation Operations Coordination (MATOC) Partnership. MATOC has been formalized through a regional MOU and includes representation from the

- Maryland DOT;
- Virginia DOT;
- District of Columbia DOT;
- Washington Metropolitan Transportation Authority; and
- Transportation Planning Board (TPB) at the Metropolitan Washington Council of Governments [Note: The TPB is the designated MPO for the National Capital Region].

The rationale for moving ICM into the MATOC partnership is that successes and lessons learned in the I-270 Corridor could be duplicated in other metropolitan-area corridors.

Performance Measures

In developing the Maryland I-270 ICM Concept of Operations, a list of potential performance measures was identified based on Corridor operational goals. During Stage 2: Analysis, Modeling, and Simulation (AMS), the I-270 ICM Team, with support from the University of Maryland and the U.S.

DOT AMS Team, will use the TransModeler simulation package to validate the potential performance measures.

TransModeler will be used to help answer questions related to whether the strategy will result in an improvement, where and when the operational impacts will occur, and who will benefit. In some instances, modifications may be required so that the TransModeler tool can be successfully applied or alternative modeling and simulation tools may be used. Following is a summary description as to how the TransModeler package will be used to validate select key performance measures:

- **Average Travel Time Under Normal Conditions.** Using TransModeler, travel time can be reported as (1) a system-wide average; (2) by specific time periods, locations, or origin–destination pairs; or (3) by vehicle/driver type. Additional relevant measures of effectiveness (MOE) might include average speed, number of stops, and delays (see average delay per trip, below).
- **Travel Time Index (TTI).** This index is a ratio of travel times in the peak period or other corridor condition to a target or acceptable travel time (typically, free-flow/on-schedule conditions are used). The TTI indicates how much longer a trip will take during a peak time. Using TransModeler, travel-time delay can be used as a surrogate for TTI in that travel-time delay represents the difference between the experienced travel time and travel time under free-flow conditions. In applying this performance measure, for example, the percent change in travel time for the entire I-270 ICM network can be analyzed by examining the application of an operational strategy to select O–D pairs (e.g., local residents or through travelers).
- **Buffer Time Index (BTI).** This measure expresses the amount of extra "buffer" time needed to achieve on-time performance 95 percent of the time (i.e., late one day per month). Travelers could multiply their average trip time by the BTI, and then add that buffer time to their trip to ensure they will be on time 95% of all trips. An advantage of expressing the reliability (or lack thereof) in this way is that a percent value is distance and time neutral.
- **Average Delay per Trip.** TransModeler supports simulation of several types of incidents and events, including stalled vehicles or traffic accidents blocking one or more lanes in a road section, or closure of a road to all or some types of vehicles. For analysis purposes, the simulation can "schedule" the occurrence and clearance of an incident/event and its severity in terms of impact to the traffic capacity. For example, a construction work zone may block or slow down traffic in a specific set of lanes during a given period; a roadway may be closed for a special event; or an incident might occur at a particular location and time.
- **Incident Response.** Incident response performance measures will continue to be addressed through the existing MD CHART system along with existing CORSIM-based simulation models that have been used for a number of years to measure and evaluate incident response and clearance times.
- **Time Required to Channel a Potential Evacuation.** Given the proximity of the I-270 Corridor to Washington, D.C., considerable attention has been given to evacuation plans in response to terrorist threats and specifically the time required to implement these plans. The University of Maryland has developed models based on CORSIM for evacuation simulations of the Maryland Eastern Shore and for the Maryland suburbs of Washington, D.C. These models will be refined and expanded for I-270 ICMS purposes.
- **Impact of Real-Time Traveler Information.** TransModeler can be used to analyze the conditions under which a traveler information message should be provided and, for example, where and when a DMS message is most effective. The model allows updated travel times to be available to predefined groups of travelers. These travelers will be able to use the travel information to determine whether they should choose an alternative route when their regular route has become unusually congested. By analyzing the travel time between two groups of drivers (those who receive real-time traveler information and those who do not), modelers will be able to derive indicators as to whether an information-based operational strategy is beneficial or not.
- **Modal Shares.** TransModeler has extensive built-in existing capabilities for modeling transit operations, such as traffic signal priority, BRT lanes, queue jumping, transit-only signal phases, and AVL. Though mode choice during run-time is not currently available, the I-270 team will work with Cambridge Systematics and TransModeler developers to implement mode-switch logic (e.g., pivot-point mode choice model application) using the built-in application program interface.
- **Average Parking Availability by Day and Time of Day.** Parking MOEs are not currently available within TransModeler; however, developers are working on this capability as part of a future release.

Obstacles

Maintaining funding support for the I-270 ICM through continued participation in U.S. DOT's national ICM initiative will greatly facilitate implementation success. If funding is not obtained for future stages (Stage 2: Analysis Modeling and Simulation and Stage 3: Deployment), momentum may be lost while the I-270 ICM partners weigh options for continuing the effort with alternative funding. The alternative funding would likely come from existing agency operational budgets.

Minnesota I-394 Integrated Corridor Management Project

Agency Name: Agency Lead: Minnesota Department of Transportation (MnDOT)
Scale: Corridor
Application: Data collection, evaluation, and dissemination

Description of the Program/Initiative

The Minnesota I-394 ICM Project is one of eight sites selected by U.S. DOT under the national Integrated Corridor Management Initiative.

The I-394 Corridor includes I-394 from west of I-494 to the Minneapolis central business district and encompasses parallel State Routes 55 and 7 as well as a number of north/south connecting arterials. The I-394 ICM initiative is looking to improve operations in the corridor by addressing problems associated with

- Gaps in coordination between traffic and transit centers during "normal" and incident conditions;
- Gaps in incident data on arterial networks;
- Lack of traveler information for arterials and transit; and
- Planning for special event congestion.

The I-394 ICM project seeks to address these problems by

- Providing traveler information across all networks and modes, including freeway, transit, and arterial travel times as well as park-and-ride availability;
- Improving interagency communication and coordination, including improved incident management and detection on arterials, coordinated incident signal timing plans, and transit rerouting during incidents; and
- Reducing congestion and improving trip reliability.

Description of Systems-Level Effort

The primary stakeholders in the I-394 ICM effort are MnDOT, Hennepin County, City of Minneapolis, Metro Transit, SW Transit, Plymouth Transit, and the Minnesota State Patrol. MnDOT is the lead agency and has formed a specific ICM Project Steering Committee and working groups to oversee the effort.

The I-394 ICMS will create an ICMS data hub used to connect the following existing systems:

- MnDOT Traffic Operations Center;
- Metro Transit Control Center;
- MnDOT Arterial Signal Group;
- Hennepin County Arterial Signal Group;
- City of Minneapolis Arterial Signal Group;
- City of Minneapolis Emergency Management System;
- Hennepin County Emergency Management System; and
- Minnesota State Patrol Emergency Management System.

Performance Measures

Following are the proposed I-394 operational objectives and associated performance measures:

- Reduce variation in travel times across the network
  - BTI: Time that travelers must allow to ensure they are on-time 95% of the time;
  - Maximum travel times experienced by travelers across the network throughout the corridor;
  - Range of travel times (and variability) across the network experienced by travelers; and
  - Percentage of "late" bus routes throughout the corridor.
- Maintain options for travelers
  - Average parking availability per facility and time of day;
  - Comparisons of transit, HOV/HOT lanes, freeways, and arterial route performance; and
  - Percentage of corridor (routes and modes) reported on in real time (travel times, delays, space availability, speeds, etc.);
- Monitor and understand changing available capacity
  - Percentage of corridor (routes and modes) reported on in real time (travel times, delays, space availability, speeds, etc.).
- Encourage pattern changes to better use spare capacity
  - Percentage of drivers altering route or mode based on traveler information; and
  - Average capacity utilization across all modes during incidents and normal conditions.
- Inform travelers of incidents and impacts
  - Number of events where viable alternates are delivered to travelers (either via phone, web, or push);
  - Number of callers receiving alternate route/mode information; and
  - Web page hits and call volumes during incident events.
- Manage traffic around events
  - Number of closures where vehicles are routed onto appropriate alternate routes;
  - Number of times alternate plans are implemented; and
  - Response/clearance times for major events.
- Travelers are aware of their modal and route options
  - Web page hits, phone requests, and push deliveries of specific route/mode options.

- Travelers do not experience delays without also being informed of options
  – Travelers' feedback after incidents and events.

Supporting Processes, Methods, and Conditions

The I-394 ICM program has significant potential for success. As a result of the I-35W bridge collapse, communications and coordination between stakeholders in responding to changing traffic conditions have greatly improved. In addition, Minnesota was selected by U.S. DOT under the national Urban Partnership initiative. The I-394 ICM can leverage this effort, which includes converting I-35W HOV lanes to MnPass HOT lanes; enhancing arterial traffic management on Hwy 13; increasing transit traveler information (park-and-ride lot availability, next bus arrival times, travel time comparisons); and improving traveler information across all networks and modes.

Obstacles

No major obstacles were uncovered at this point.

I-75 Integrated Corridor Management, Dallas, Texas

Agency Name: Dallas Area Rapid Transit (DART)
Scale: Corridor
Application: Data collection, evaluation, and dissemination

Description of the Program/Initiative

The U.S. 75 ICM Project is one of eight sites selected by U.S. DOT under the National Integrated Corridor Management Initiative.

The Dallas Fort Worth (DFW) area is the fifth most congested region in the United States and the worst region for growth in congestion. The DFW population is 6 million, with 1 million added every 8 years. The U.S. 75 Corridor is a critical regional corridor in which travel demand continues to grow. There is no ability to expand freeway, arterial, or alternate route infrastructure. U.S. 75 operates as a fully controlled access freeway with continuous frontage roads and HOV. The corridor includes 167 miles of arterials, the DART Bus Network (including express service), and DART light rail. There are three city Transportation Management Centers, one State Transportation Management Center, a Transit Management Center, and a Toll Authority (Dallas North Tollway) Transportation Management Center in the corridor.

The U.S. 75 ICM Vision is to "Operate the U.S. 75 Corridor in a true multimodal, integrated, efficient, and safe fashion where the focus is on the transportation customer."

Description of Systems-Level Effort

The U.S. 75 Corridor system network consists of

- 272 lane-miles of freeways with frontage roads,
- 31 lane-miles of HOV facilities,
- 2 light rail lines,
- 30 bus routes,
- 816 signals,
- 167 center-lane-miles of arterial,
- 9 park-and-ride lots,
- 12 miles of pedestrian/bike trails, and
- 105 lane-miles of toll road.

The U.S. 75 ICMS will integrate the various corridor Transportation Management Centers, the Freeway System, Arterial Systems, and the DART Transit System (13 member cities).

Performance Measures

The ICM strategies under examination are based on a performance measure approach that will be multimodal or modal independent, or both. Common measures will be used across agencies and jurisdictions. Specific identified strategies at this time include

- Improved traveler information and operational strategies to promote modal shift;
- Enhanced data sharing among stakeholders and responders; and
- Development of new tools to support modeling for operational prediction and optimization.

Supporting Processes, Methods, and Conditions

The U.S. 75 ICM partners include DART; the Cities of Dallas, Highland Park, Richardson, Plano, and University Park; the North Central Texas Council of Governments; the North Texas Tollway Authority; and the TxDOT Dallas District. An Operating Agency Team and Technical Support Team have been organized under the lead agency, DART. An existing regional ITS MOU executed in 1999 includes the team members and existing regional ITS committees provide project oversight.

The U.S. 75 ICM has the following transportation goals:

- Increase corridor throughput;
- Improve travel-time reliability;

- Improve incident management; and
- Enable intermodal travel decisions.

Further, the following community goals have been identified:

- Encourage business development;
- Sustain economic activity; and
- Enable emergency services.

Obstacles

The U.S. 75 ICM has been selected by U.S. DOT for participation in Stage 2: Analysis, Modeling, and Simulation under the national ICM initiative. This funding support and the strength of the regional partnership increase the potential for successful future ICM deployment. Ultimate deployment will likely hinge on selection by U.S. DOT for Stage 3: ICM Deployment.

New Jersey Future in Transportation

Agency Name: New Jersey DOT (NJDOT)
Scale: Local
Application: Multimodal Assessment/Interagency Planning Partnership

Description of the Program/Initiative

New Jersey Future in Transportation (NJFIT) is an NJDOT commitment to working with local municipalities to conduct a series of integrated land use and transportation planning studies. These projects are working to balance future development and redevelopment of each community with all aspects of transportation, including accessibility, mobility, safety, multimodality, and the natural environment of the corridor. Specifically, NJFIT hopes to achieve

- Affordable transportation solutions that increase community satisfaction;
- Sustainable transportation solutions that break the sprawl cycle with integrated transportation and land use; and
- Deliverable transportation solutions that satisfy the needs of all parties involved.

Through NJFIT, NJDOT provides assistance with local land use and transportation planning and the application of various tools (context-sensitive solutions, etc.) to help communities reach the goals.

Description of Systems-Level Effort

NJDOT launched this effort as a result of the realization that dealing with congestion on a segment-by-segment basis did not help overall mobility. It sees NJFIT as a way to focus on improving the performance of the overall system through coordination with local and county system improvements and plans.

For example, the Route 1 Regional Growth Strategy is looking at the corridor between Trenton and New Brunswick and finding ways to reduce congestion while enhancing the economy. The project is multijurisdictional and multimodal. In another project NJDOT is investigating the option of realigning a four-lane urban freeway and reconstructing it as a three-lane urban boulevard. In addition to reducing speeds along the roadway because of the new alignment, the project would improve pedestrian access between the riverfront and the rest of the city of Trenton. City officials and NJDOT staff expect the city to realize economic benefits as a result of this effort.

Performance Measures

Performance measures vary by project. NJFIT does not require the use of performance measures, but each project is working under the framework of impact areas and balancing the relevant issues (e.g., congestion, environment, economy) in defining the project.

Supporting Processes, Methods, and Conditions

NJFIT is based on collaboration and partnerships among all levels of government (state, county, local) to determine the best and most comprehensive solutions to a problem. NJDOT provides various funding sources and local technical assistance for municipalities that are conducting planning studies that meet the requirements of the NJFIT program.

Obstacles

No obstacles are identified for this project.

Regional Scenario—Multimodal and Multistrategy Investment Prioritization

San Francisco Bay Area Project Performance Assessment for Transportation 2035 Plan

Agency Name: Metropolitan Transportation Commission (MTC)
Scale: Regional
Application: Benefit–Cost

Description of the Program/Initiative

The San Francisco Bay Area, the second largest economic and population center in California, is home to over 7 million people and 3.5 million jobs. The region has a robust transportation network, including highways, bridges, heavy rail, light rail, buses, and ferries that crisscross the Bay and serve the peninsula. Growth projections predict a 26% increase in population and a 50% increase in jobs by 2035. This growth will continue to put strain on the region's transportation system. Geographic constraints in the already densely developed area make capacity expansion challenging.[9]

The Metropolitan Transportation Commission (MTC) serves as both the state-designated regional transportation planning agency and the federally mandated MPO. MTC has responsibility for the nine-county San Francisco Bay Area, consisting of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma. The organization is governed by a 19-member policy board. Fourteen commissioners are appointed by local elected officials, two members represent regional agencies, and three nonvoting members represent federal and state transportation agencies and the federal housing department.

MTC is responsible for updating the RTP and reviews requests for state and federal funding grants to ensure the projects are compatible with the plan. Per the 1991 Intermodal Surface Transportation Efficiency Act and the Transportation Equity Act for the 21st Century, MTC also is responsible for determining the mix of transportation projects needed to meet the needs of the growing region.

In 2006 MTC began updating its RTP, the draft of which was released in December 2008.[10] The *Draft Transportation 2035 Plan: Change in Motion* (T-2035) serves as the roadmap for investing the $226 billion in funding that is projected to be available over the next 25 years. As an outcome of the plan development process, MTC set ambitious goals to consider and incorporate current and impending issues that impact and are impacted by the transportation network. MTC and its partners recognized that the Bay Area was faced with issues such as climate change, foreign oil dependency, air quality, economic growth, and social equity issues. By calling the plan "Change in Motion," they take on the challenge as a region to "anticipate change, instigate change, and, most of all, succeed in putting change in motion."[11]

MTC began the process of developing this plan by setting forth the following vision:

- Where mobility and accessibility are ensured for all Bay Area residents and visitors, regardless of race, age, income or disability; and
- Where our bicycle and pedestrian facilities, public transit systems, local streets and roads, and highways are all safe and well-maintained and take us when and where we need to go; and
- Where an integrated, market-based pricing system for the region's carpool lanes (via regional high-occupancy toll (HOT) network), bridges and roadways helps us not only to manage the demand on our mature transportation system but also pay for its improvements; and
- Where our lively and diverse metropolitan region is transformed by a growth pattern that creates complete communities with ready, safe and close access to jobs, shopping and services that are connected by a family of reliable and cost-effective transit services; and
- Where technology advances move out of the lab and onto the street, including clean fuels and vehicles, sophisticated traffic operations systems to manage traffic flow and reduce delay and congestion on our roadways, advanced and accessible traveler information that allows us to make informed travel choices, and transit operational strategies that synchronize fare structures, schedules and routes to speed travel to our destinations; and
- Where we have a viable choice to leave our autos at home and take advantage of a seamless network of accessible pedestrian and bicycle paths that connect to nearby bus, rail and ferry services that can carry us to work, school, shopping, services or recreation; and
- Where we lead and mobilize a partnership of regional and local agencies, businesses and stakeholders to take effective action to protect our climate and serve as a model for national and international action; and
- Where our transportation investments and travel behaviors are driven by the need to reduce our impact on the earth's natural habitats, and
- Where all Bay Area residents enjoy a higher quality of life.[12]

Using this vision, T-2035 incorporates key changes and trends that are on the horizon, such as climate change, volatile oil prices, an aging population, rising construction costs, and the uncertainty of federal transportation funding. It described these issues through the three "E" principles—equity, economy, and environment—and set the following goals as shown in Table B.2.

Description of Systems-Level Effort

MTC used performance measurement at three stages to guide the RTP. The overall goal was to identify the approach that would most effectively lead to the outcomes stated in the defined vision. The performance measurement assessment was done in three stages:

1. MTC established performance objectives that would reflect the improved conditions described in the vision. In the past, goals used by MTC in long-range transportation planning were set to keep things at the same level, to keep them from worsening. The objectives in this version were

[9] http://www.mtc.ca.gov/planning/2035_plan/DRAFT/2-Trends.pdf

[10] At the time of this writing, the draft plan was out for public review and comment.

[11] http://www.mtc.ca.gov/planning/2035_plan/DRAFT/Intro.pdf

[12] http://www.mtc.ca.gov/planning/2035_plan/DRAFT/1-Overview.pdf, p. 6

Table B.2. The three Es.

Es	Goals	Performance Objectives[13]
Economy	Maintenance and safety	**Improve maintenance** Local streets and roads: Maintain pavement condition index of 75 or better. State highways: Distressed land-miles no more than 10% of system. Transit: Average asset age no more than 50% of useful life and average distance between service calls of 8,000 miles. *Sources: State and local strategic plans*
		Reduce injuries and fatalities Motor-vehicle fatalities: 15% from today. Bike and pedestrian injuries and fatalities: 25% each from 2000 levels. *Source: California State Strategic Highway Safety Plan*
	Reliability	**Reduce delays** 20% per capita from today. *Source: California's Strategic Growth Plan*
	Freight	
Environment	Clean air	**Reduce vehicle miles traveled and emissions** Vehicle miles traveled: 10% per capita from today. Fine particulate matter ($PM_{2.5}$): 10% from today. Course particulate matter (PM_{10}): 455 from today. Carbon dioxide ($C0_2$): 40% below 1990 levels. *Sources: State regulations and laws*
Equity	Access	**Improve affordability** 10% reduction from today in share of earnings spent on housing and transportation costs by low- and moderately low-income households. *Source: Adapted from the Center for Housing Policy*

Source: http://www.mtc.ca.gov/planning/2035_plan/Supplementary/T2035Plan-Perf_AssessmentReport.pdf, p. 3.

set to actually see an improvement in conditions. To determine what would be required to reach these objectives, MTC used the measures to analyze a series of financially unconstrained What If scenarios.

2. MTC conducted the Project Performance Assessment, which measured the cost-effectiveness of individual proposed investments in the context of the performance measures. The outcome of this analysis highlighted those projects that were outliers—having either a large impact on the established objectives or very little impact.
3. MTC performed a program performance assessment of the proposed projects in the draft Transportation 2035 plan.

This process provided MTC with the information needed to look across modes and throughout the entire nine-county transportation network to determine the projects that would most directly affect the region's goals and objectives.

Effort involved using performance objectives to select the most cost-effective projects and programs for inclusion in the RTP for the nine-county San Francisco Bay Area. Analysis performed at the systems level used the regional travel demand model and included several modes and programs: HOT lanes, highway, transit, operations, bicycle, clean air program, transportation for livable communities, lifeline transportation program, local streets and roads maintenance, and transit capital maintenance.

Performance Measures

The performance objectives established for the Transportation 2035 report are derived from the three Transportation 2035 goals: economy, environment, and equity. They were intended not to stand as simple outcomes for the long-range transportation plan but to provide a roadmap for testing scenarios. The objectives were developed using partner agencies' plans and policies.

To gather an understanding of what it would take to reach the performance objectives, MTC conducted a What If

[13]http://www.mtc.ca.gov/planning/2035_plan/Supplementary/T2035Plan-Perf_AssessmentReport.pdf

analysis using three different infrastructure investment and policy plans:

1. A program of freeway operations strategies;
2. A regional HOT lane network with bus enhancements; and
3. Extensive rail and ferry expansion.

The budgets for these projects were not constrained and ranged from $600 million to $64.2 billion in capital costs. Two sensitivity tests were conducted on the three packages, to see how each demand-based strategy would affect the objectives. The pricing-sensitivity test measured how a set of user-based pricing strategies would affect travel behavior, and the land use sensitivity test looked at an alternative land use forecast that shifted employment and residential growth to existing centers and areas with existing or planned transit. By means of the regional travel demand forecasting model, the analyses of these three investment packages and two sensitivity analyses provided the following conclusions:

> 1. The sheer magnitude of project growth in population (25%) and jobs (55%) over 25 years overwhelms transportation system capacity.
> 2. Infrastructure alone does not generally help us reach the objectives; however, Freeway Operations is effective for congestion relief.
> 3. Policy approaches such as land use and pricing have much bigger effects. Pricing can be introduced in the near term, though not likely to the degree examined in the pricing sensitivity test. Focused growth can help achieve the objective's targets in the longer term.
> 4. Other approaches will be needed, as well. In particular, technology advances in vehicles and fuels are needed to help meet the emissions objectives. In addition, we will need to change our behavior in ways that reduce driving, for example through creating incentives to telecommute.[14]

Specific to the objectives, the three What If scenarios provided the following insights:

- **Reduce congestion.** This was the only objective for which an investment package had a marked impact.
- **Reduce VMT.** None of the scenarios or strategies brought the projected VMT down to the target level.
- **Reduce particulate emissions.** The land use and pricing strategies have more impact than the infrastructure investments, but none of them achieve the objective target levels.
- **Reduce carbon dioxide emissions.** The land use and pricing strategies have more impact than do the infrastructure investments, but none of them achieve the objective target levels.
- **Improve affordability of transportation and housing for low- and moderately low-income households.** The pricing and land use strategies have much bigger impacts than do the infrastructure investments. Focused growth policies decrease the cost of transportation, but the pricing strategies increase the cost because many populations will need to continue to rely on vehicles for at least some trips.

Finally, a cost-effectiveness analysis was conducted on the investment packages without the land use and pricing strategies, and then again with the two sensitivity tests. The freeway operations package remains most cost-effective under all sets of conditions; however, when the pricing and land use strategies are added, the gap between the freeway and the transit packages closes significantly.

These performance measurement calculations provided a baseline and context for MTC to begin looking at the performance of specific projects.

Project Performance Assessment

To capture the impact of particular projects on the RTP's objectives, MTC conducted both a qualitative and quantitative project performance assessment. Table B.3 lists MTC's quantitative evaluation measures. The purpose of the exercise was to identify those projects that would most strongly support the objectives and those that would most strongly undermine the objectives.

The analysis assigned each project, regardless of mode type or area of the region, a benefit–cost ratio scope (high, medium-high, mid-range, and low). The projects in each of the benefit–cost ratio categories were then looked at in terms of the other quantitative measures.

The qualitative assessment provides supplemental information to the quantitative assessment by giving it a ranking of "strongly support," "support," or "neutral toward" a list of established criteria that are associated with each goal.

Each project was looked at in the context of each goal to determine whether it addressed that goal. The number of goals that each project supported was used to identify high-performing projects.

Program Assessment

As the third step in the assessment process, MTC evaluated how the proposed plan meets the objectives of the adopted

[14]http://www.mtc.ca.gov/planning/2035_plan/Supplementary/T2035Plan-Perf_AssessmentReport.pdf, p. 11

Table B.3. MTC quantitative project evaluation measures

T-2035 Performance Objective	Quantitative Project Evaluation Measures
Reduce congestion	Benefit–cost ratio (monetized), reflecting
Reduce emissions	Recurrent delay (vehicle hours)
Reduce collisions and fatalities	Nonrecurrent delay (vehicle hours
	Transit travel time
	Particulate matter emissions ($PM_{2.5}$ and PM_{10})
	Carbon dioxide emissions
	Fatal and injury collisions
	Direct user costs (vehicle operating and, in some cases, auto ownership costs)
	Public and private cost savings from performing on-time maintenance
Reduce vehicle miles driven	Reduction in vehicle miles traveled (VMT) and cost per VMT reduced
Reduce emissions	Reduction in carbon dioxide emissions and cost per ton reduced
Improve affordability	Cost per low-income household served by transit (trial measure)

Table B.4. MTC program assessment criteria

Transportation 2035 Goals	Criteria for Determining Support
Maintenance	• Advances maintenance of the existing transportation system
Congestion relief (reliability and efficient freight travel) — Includes roadway safety	• Improves freight mobility • Improves transit mobility, effectiveness, or efficiency • Improves local mobility or circulation • Completes a critical transportation gap (geographic or temporal) • Institutes or enables a new user-based pricing system • Implements technology-based operations or traveler information • Improves roadway safety
Emissions reduction	• Provides an alternative to driving alone • Improves transit mobility, effectiveness, or efficiency • Marketing, education, and incentive programs that encourage mode shift away from driving alone or during peaks
Focused growth	• Located within a proposed or planned priority development area • Connects to priority development areas
Access and safety (nonmotorized)	• Provides a transit alternative to driving on a future priced facility • Provides an alternative to driving alone • Improves access for youth, the elderly, and disabled persons • Improves safety for pedestrians and cyclists • Reduces transportation or housing costs for low-income households

measures. Table B.4 identifies the criteria for determining consistency with MTC's objectives. The proposed investments include roadway maintenance and rehabilitation, a regional HOT network, a regional bicycle network, funding for land use and transportation connection programs, paratransit, and other programs targeting climate change, operations, and transit.

Using the regional travel demand model, MTC calculated the impact of the projects proposed in the Transportation 2035 plan. The findings of the analyses were that the planned investments would point the region in the direction of meeting the stated objectives, but that there was still a gap between the targets and outcome. The analysis showed that the objectives would not be met without additional land use, pricing, and technology strategies that would provide additional benefits.

Supporting Processes, Methods, and Conditions

The processes for creating T-2035 and the results of these processes were developed and reviewed in consultation with the Partnership Ad Hoc Committee. The Partnership Ad Hoc Committee is dedicated to performance assessment and includes representatives from state, regional, and local transportation agencies, the Bay Area Air Quality Management District, the Association of Bay Area Governments, and the Bay Conservation and Development Commission.

Obstacles

None. The performance assessment is complete, findings have been presented to the Commission and in public outreach, the project approach has been documented, and the T-2035 plan currently is in the Environmental Impact Report, Air Quality Conformity Analysis, and Equity Analysis stage.

Florida DOT Strategic Intermodal System

Agency Name: Florida Department of Transportation (FDOT), Central Office
Scale: Statewide
Application: Multimodal Assessment/Interagency Planning Partnerships

Description of the Program/Initiative

Florida's Strategic Intermodal System (SIS), established in 2003, is a statewide network of high-priority transportation facilities, including the state's largest and most significant commercial service airports, spaceport, deepwater seaports, freight rail terminals, passenger rail and intercity bus terminals, rail corridors, waterways, and highways. The SIS was established to enhance Florida's economic competitiveness by focusing limited resources on those transportation facilities that are critical to Florida's economy and quality of life.

Description of Systems-Level Effort

The SIS includes a designated system of corridors, facilities, and services of statewide and interregional significance. The program guides funding decisions and allows for integrated funding of transportation modes to make strategic investments for the state and region.

Performance Measures

The SIS Strategic Plan, adopted in January 2005, identifies goals and recommended objectives for managing and measuring the performance of the SIS. These include the following:

1. **Goal:** A safer and more secure transportation system for residents, businesses, and visitors.
   – **Performance Data:** National and state fatality rates for vehicles on SIS highways; bicycle, pedestrian, and motorcycle fatality and serious injury rates on SIS highways; commercial vehicle crash rates on SIS highways.
2. **Goal:** Effective preservation and management of Florida's transportation facilities and services.
   – **Performance Data:** Percentage of SIS highway pavement meeting FDOT standards; percentage of FDOT-maintained SIS bridges meeting FDOT standards; percentage of SIS highways meeting FDOT maintenance standards.
3. **Goal:** Increased mobility for people and for freight and efficient operations of Florida's transportation system.
   – **Performance Data:** Person-hours of delay on Florida's SIS highways.
4. **Goal:** Enhanced economic competitiveness and economic diversification.
   – **Performance Data:** Accessibility of population and employment centers to SIS facilities.
5. **Goal:** Enriched quality of life and responsible environmental stewardship.
   – **Performance Data:** Qualitative information on successes and challenges of SIS implementation, including consideration of lane use, community, and environmental issues, and coordination with partners and the public.

Supporting Processes, Methods, and Conditions

The planning process for the SIS includes system designation based on adopted criteria and thresholds; needs assessment to identify unprogrammed SIS needs based on adopted statewide modal plans; a project prioritization process to develop a Phased Cost Feasible Plan with 10- and 20-year components; and a finance strategy that incorporates the investment policy and forecasts of anticipated revenues, innovative financing, and joint funding by public and private partners.

Obstacles

The first annual performance report for the SIS is still under development. Performance measures and objectives for the SIS are continuing to be refined.

Washington State Department of Transportation Performance Measurement Program

Agency Name: Washington State DOT (WSDOT)
Scale: Statewide
Application: Multimodal Assessments/Interagency Planning Partnerships

Description of the Program/Initiative

WSDOT is well known for applying performance management tools to nearly every aspect of agency business. The agency publishes a comprehensive quarterly performance report, the Gray Notebook. WSDOT uses performance measurement to guide decision making in congestion management, including capital planning, demand management, and operations.

Description of Systems-Level Effort

WSDOT uses a suite of measures to identify and prioritize congested corridors. With many corridors experiencing some congestion, evaluating traditional metrics, such as LOS thresholds, yielded billions of dollars of needs over a 20-year time frame. To address this problem, WSDOT began to use throughput measures of efficiency such as speed thresholds to identify highway deficiencies. This approach has narrowed the deficiency list by roughly one-third and enables WSDOT to focus scarce resources on the most needed corridors. The department uses the maximum throughput measure to select projects for inclusion in its proposed program of highway improvements (the Highway System Plan), which is ultimately presented to the legislature.

WSDOT uses its congestion measures to support funding increases. The data has helped WSDOT gain public and legislative support in its ability to deliver the right programs and projects effectively. The performance measures have convinced WSDOT executive-level management that new capacity alone cannot solve their problems; operations and management must be a part of the solution. Performance measures have allowed WSDOT to establish and expand investments in operations, such as incident response and demand reduction programs. WSDOT uses before-and-after evaluations of operations projects to demonstrate their benefit in terms of reduced travel times or delay avoided.

In addition to using congestion measures to plan, select, and fund projects, WSDOT has been able to use performance measures to reveal trends or emerging problems that led to corrective action by the agency. Examples follow:

- Correcting an increase in HOV travel times. Recent data revealed an increase in travel times as a result of more frequent use of the HOV lanes. WSDOT is developing an action plan to restore travel times on HOV lanes.
- Identifying a major source of nonrecurring congestion. To decrease incident response time, WSDOT has implemented an incentive towing program that provides tow-truck operators with a financial incentive to clear incidents involving heavy trucks within 90 minutes of dispatch.
- Focusing the Commute Trip Reduction Program on the most congested corridors. A review of the Commute Trip Reduction Program revealed that it would be more efficient if efforts were focused on highway corridors with the most congestion.

Performance Measures

WSDOT tracks these specific measures:

- **Vehicle throughput.** Measures how many vehicles move through a highway segment in an hour;
- **Peak travel time.** Measures how long it takes to complete a route during the peak period of congestion;
- **95% reliable travel time.** Measures how long it takes to complete a route at 95% worst travel time; and
- **Annual cost of delay.** Measures the cost of congestion for system users.

These measures are reported in the Annual Congestion Report, included in the September edition of the Gray Notebook.

Supporting Processes, Methods, and Conditions

WSDOT has managed to integrate performance measures throughout the agency's transportation work. This creates overall agreement and buy-in and ensures that data is collected and recorded consistently and accurately. This type of commitment and consistency offers transparency and accountability to legislators and public officials. WSDOT also recognizes that there are limitations to performance measurement. When the data is being used for decision-making purposes, it is always presented with a thorough analysis and narrative.

Obstacles

WSDOT continues to struggle with the inherent difficulties of performance management. Specifically, it has found that measures often indicate the symptoms but not the cause of the problem, and at times are not sensitive enough to measure actual change. In addition, there are limitations to the data collection and analysis that can be conducted.

Transportation MAP (Metropolitan Atlanta Performance) Initiative

Agency Name: Georgia Regional Transportation Authority (GRTA)
Scale: MPO/Regional
Application: Annual Report/Scorecard

Description of the Program/Initiative

GRTA spearheads the cooperative effort between the Authority and its partner agencies, FHWA, the Atlanta Regional Commission, the Georgia Department of Transportation (GDOT), the Georgia Department of Natural Resources, and the Metropolitan Atlanta Rapid Transit Authority (MARTA), to complete the annual Transportation MAP (Metropolitan Atlanta Performance) report. A steering committee composed of the representatives of the regional transportation agencies and others guides the development of this annual transportation performance measurement effort. The MAP report provides a regional performance snapshot of progress toward improving mobility, transit accessibility, air quality, safety, and overall Atlanta transportation system performance.

Description of Systems-Level Effort

Baseline and target goals for various measures (described below) were initially established based on 2000 or 2001 data. Initial targets were established for 2006. The specific targets, respecting the unique quality of each measure, were set after review and discussion by appropriate professionals from the respective agencies. Each year, after the data is collected and certified, the agencies present a report of the region's progress in meeting the targets that have been set. New measures and targets are developed and added to the report (referred to as the Transportation MAP report) as they become necessary.

The inaugural MAP report was compiled in 2003. The 2004 report included data on average travel times and the TTI on the sections of the freeway system where the GDOT's real-time traffic monitoring system (NaviGAtor) is operational. The 2005 report added measures of travel-time reliability: the Planning Time Index (PTI) and BTI. Several transportation system performance indices were included in the 2007 report. Finally, two new safety measures were introduced in the 2008 report.

The 2008 Transportation MAP report can be accessed at http://www.grta.org/PDF_Files/2008_Transportation_MAP_Report.pdf.

The travel times, PTI, or BTI by freeway segment can be found in the appendix to the report at http://www.grta.org/PDF_Files/2008_Transportation_MAP_Appendix.pdf.

Performance Measures

The performance measures in this report are tracking the Atlanta transportation system's performance. These measures, grouped in five areas, are listed below.

- Mobility
  - Freeway TTI;
  - Freeway PTI;
  - Freeway BTI;
  - Daily VMT per licensed driver/per person;
  - Pavement condition rating;
  - Transit passenger miles traveled; and
  - Annual transit passenger boardings.
- Transit Accessibility
  - Population and employment within walking distance to transit;
  - Transit revenue service hours; and
  - Passenger trips per transit service hour.
- Air Quality
  - Daily vehicle emissions (relative to 2000 levels).
- Safety
  - Traffic crash fatalities/traffic crash fatality rate;
  - Pedestrian and bicyclist fatalities/pedestrian and bicyclist fatality rate per 100,000 population; and
  - Roadway clearance time.
- Transportation System Performance
  - Atlanta Transportation Performance Indices (roadway services index, transit services index, roadway emissions index, roadway safety index).

Supporting Processes, Methods, and Conditions

These performance measures are used for informing the decision makers and the general public about the state of Atlanta's transportation system. The measurements are intended to identify problem areas and assist the region in effectively investing limited transportation funds.

The collaborative process among the region's agencies extends beyond performance measurement. In some specific cases it helped identify data collection issues and improve data quality control procedures. In other instances data gaps and needs, such as the lack of reliable arterial data, are clearly identified. Another interesting feature of this performance measurement effort is that it uses some already existing data sources (such as GDOT's archived NaviGAtor data). This allows for cost-effective data use and sharing.

Obstacles

GRTA and its partners made a concerted effort to choose and present measures that are relatively easy to understand, a task that was difficult because of the measures' technical nature. Specific attention was paid to selecting, presenting, and visualizing the performance measures so that that they are clear and appeal to a broad audience. One example is choosing travel time and indices based on travel times instead of speeds because it was found that people relate to travel times better than they do to speed.

Initially targets were set for some measures based on technical projections or historical trends. However, these targets are regional in nature, and as a rule they are not under the control of a single agency. Therefore, a structured process is required for coordinating targets, the associated responsibilities by individual agencies, and accountability for reaching the adopted targets. The participating regional agencies are now working on establishing such target-setting processes.

Other lessons learned are as follows:

- Find a performance measurement champion or become one;
- Start small and gradually grow your performance measurement;
- "Borrow" from the best practices;
- Make use of already existing data;
- Keep it simple and succinct;
- Have a significant story or message to tell;
- Keep your audience in mind; and
- Get regular feedback from stakeholders and users.

The Transportation MAP initiative was essentially a bottom-up attempt to impact transportation policy in the greater Atlanta region. Although the initiative was technically a success, the challenges ahead primarily involve influencing partner agencies to use the results of the initiative to influence policy and funding. To that end, several initiatives are in place. GRTA is working with Georgia DOT on a strategic plan of the transportation system. This high-level plan is scheduled to be available soon for legislative use. Similarly, the Atlanta Regional Commission, which is the MPO for the Atlanta region, is working cooperatively with GRTA and other partner agencies to establish new systemwide performance targets for the Atlanta region.

The progression is one of cooperation to unified vision to coordinated action. Cooperation among regional agencies remains a struggle, though improvement in some areas is evident.

Metropolitan Council Transportation Policy Plan, Congestion Management Process, and Transportation Audit

Agency Name: Metropolitan Council (Met Council) and Minnesota Department of Transportation (MnDOT)
Scale: Regional
Application: Multimodal Assessment/Interagency Planning Partnership

Description of the Program/Initiative

The Metropolitan Council (Met Council) serves the Minneapolis–St. Paul area as the region's MPO. The Twin Cities area has a long history of congestion management activities, with one of the nation's most extensive and sophisticated ramp metering systems. The Met Council's Transportation Policy Plan, under the umbrella of the 2030 Regional Development Framework, contains policies and strategies designed to slow the growth in congestion and to improve mobility in the region. The recommendations within this plan call for several strategies, including investing in multimodal transport, expanding transit services, and encouraging local communities to interconnect arterials and local streets, pathways, and bikeways. The CMP is linked directly to the most recent update of the Transportation Policy Plan. Met Council and MnDOT work together on several corridors within the Twin Cities region.

Description of Systems-Level Effort

Many of Met Council's performance measure and benchmarks are systemwide. Met Council works with MnDOT on corridor projects, ramp metering systems, and other system-level efforts.

Performance Measures

Met Council performs a regional transportation audit every four years per Minnesota legislative requirement. It includes a review of the transportation system's performance since the last performance audit, a comparison of the performance to peer urban areas, and a comparison of service to existing standards or benchmarks.

Systemwide performance measures reported in the audit include

- Number of lane-miles of new principal arterials built each year;
- Miles of congested freeway;

- Highway traffic volume changes;
- Percentage of miles in a congested condition;
- Transit ridership;
- Transit service (vehicle revenue miles);
- VMT per capita per day; and
- Peak-hour transit capacity.

MnDOT produced a Statewide Transportation Plan in 2003 that uses a variety of performance measures. These performance measures are placed into three categories: mature, emerging, and developmental. Performance measures include travel-time reliability, miles of managed corridors, and miles of bus-only shoulders.

Supporting Processes, Methods, and Conditions

The "Team Transit" concept came about in the 1990s between Met Council and MnDOT to help facilitate transit operations and usage. MnDOT now builds expressways and arterials with 12-foot shoulders that can be later converted to bus lanes as needed. The agencies involved in creating Team Transit included the Center for Transportation Studies at the University of Minnesota, the Minnesota State Patrol, representatives from the Twin Cities and other municipalities served by transit, MnDOT, and Metro Transit.

The region's Urban Partnership Agreement (UPA) undertaking, a collaboration between Met Council and MnDOT, includes tolling/congestion pricing (including priced dynamic shoulder lanes), additional ITS deployment related to TDM (parking, transit info, etc.), BRT expansion, and public-private telecommuting initiatives. It also includes conversion of HOV lanes to tolled HOT lanes. A major underpinning of the UPA approach in the Twin Cities is the development of extensive real-time information with wide accessibility.

Obstacles

The Twin Cities region has been a leader in specific congestion management strategies in the country, yet due to several factors, including increased population growth, congestion has been on the rise. If the current congestion growth is not addressed, the lane-miles of congested metropolitan highways will increase from just over 1,900 miles in 2000 to over 2,500 miles in 2030.

Urban Partnership Agreements—Seattle (Lake Washington)

Agency Name: U.S. DOT, Washington State Department of Transportation, Puget Sound Regional Council, King County
Scale: MPO/Regional
Application: Tolling/ITS/TDM

Description of the Program/Initiative

The Lake Washington Urban Partnership is a cooperative agreement to employ innovative traffic management tools for improving traffic flow along State Route 520, Interstate 90, and the Lake Washington corridor. The urban partnership includes the comprehensive use of four key strategies: tolling/congestion pricing, transit, telecommuting/flextime, and technology.

The agreement calls for a new variable tolling system that could improve traffic flow on the SR 520 corridor and provide up to $500 million to replace the aging SR 520 Lake Washington floating bridge over Lake Washington. "Open road" electronic tolling equipment will allow tolls to be collected at freeway speeds through the use of in-vehicle transponders. Supplemental automatic cameras will read license plates for vehicles not equipped with transponders.

Substantial transit improvements also are planned to further reduce congestion and provide travelers with alternatives to driving and paying congestion tolls. Forty-five hybrid buses will be purchased and bus stops will be improved by providing patrons with real-time bus arrival information (at seven stops) as well as improved passenger shelters and lighting (at two stops). Park-and-ride facilities also will be expanded.

The partnership will provide for expanded opportunities to travel by ferry as well. Ferry investments include supporting the Mukilteo multimodal terminal, providing high-speed, low-wake passenger ferries and other vessels for the Puget Sound, enhancing passenger-only ferry service to and from Vashon Island, supporting the Kingston Express ferry service, supporting a Pierce County ferry system, and repairing the Guemes Island ferry dock.

The region will build on its already highly acclaimed telecommuting and travel demand management efforts through outreach to employers and transportation management associations regarding alternative transportation options and incentives to use them. The region will use its own funds to improve traveler information and trip planning services for employees, as well as expand marketing of the region's Guaranteed Ride Home program.

Finally, the region is committed to using active traffic management techniques that will allow for the detection of incidents, facilitate the removal of disabled vehicles, and provide travelers with real-time information about traffic conditions. Technology will include the use of 511 and electronically changeable roadway signage as well as the use of variable speed limits to facilitate smoother traffic flow during peak travel periods.

Description of Systems-Level Effort

The partnership allows for investment across modes and jurisdictions to address congestion on a corridor level. Because of the significance of SR 520 and Interstate 90 to the regional transportation system, investments made at the corridor level will have significant regional impact as well.

Performance Measures

There are no predetermined measures at this time, but measures involving congestion intensity, scope, duration, number of vehicles, and number of passengers are candidates for evaluating improvements.

Supporting Processes, Methods, and Conditions

The U.S. DOT has initiated UPAs with cities that have applied for Urban Partnership status. Five cities were selected as urban partners in August 2007: Miami, Minneapolis–St. Paul, New York City, San Francisco, and Seattle. These cities received priority consideration for available federal discretionary funds (about $1 billion in total) across a dozen grant programs, including transit funds, ITS funds, and Value Pricing Pilot Program funds.

Obstacles

No obstacles have been identified for this project.

Urban Partnership Agreements—Miami

Agency Name: U.S. DOT, Florida Department of Transportation, Miami-Dade MPO, Broward County MPO, Broward County Transit, Miami-Dade Transit, Miami-Dade Expressway Authority, and Florida's Turnpike Enterprise
Scale: MPO/Regional
Application: Tolling/ITS/TDM

Description of the Program/Initiative

The Miami–Ft. Lauderdale region is creating a 21-mile managed-lane facility on I-95 between I-395 and I-595. The managed-lane network will consist of four managed lanes (two in each direction) between downtown Miami and the I-95/Broward Boulevard Interchange in Broward County. The managed lanes will allow free access for registered vehicles with more than three occupants, while vehicles with one to two occupants will be required to pay variable tolls that will be adjusted based on demand. Toll rates will be adjusted as often as every 3 minutes in order to maintain free-flow conditions on the managed lanes at least 90% of the time. Open-road tolling at freeway speeds will occur through the use of toll transponders and video license plate readers. Changeable message signs will display variable toll rates for vehicles not meeting the occupancy requirements, and a camera-based system will be deployed for violation enforcement.

The managed-lane network will be used as the backbone of a BRT system, which will be subsidized through the toll revenues. The BRT service will operate within the managed-lane network between downtown Miami and destinations north along I-95 to the I-95/Broward Boulevard Interchange. As a result, bus service across the county line will be seamless, eliminating the need for transfers at the Golden Glades park-and-ride facility. Reliability of bus service also will improve, as bus speeds are anticipated to increase to 50 mph once buses operate within a managed lanes environment (compared to 22 mph previously). New express bus service routes will be provided north-south along U.S. 441/SR 7 and SR 817 and east-west on Hollywood/Pines Boulevard. Other transit improvements include the implementation of transit signal priority at 50 intersections along U.S. 441/SR 7 and SR 871; improvements to the I-95/Broward Boulevard park-and-ride lot; two new uniquely branded stations for the express/BRT services; and construction of pedestrian facilities at one of the two new stations.

Description of Systems-Level Effort

The partnership allows for investment across modes and jurisdictions to address congestion on a regional level.

Performance Measures

There are no predetermined measures at this time, but measures involving congestion intensity, scope, duration, number of vehicles, and number of passengers are candidates for the improvement evaluation process.

Supporting Processes, Methods, and Conditions

The U.S. DOT has initiated UPAs with cities that have applied for Urban Partnership status. Five cities were selected as urban partners in August 2007: Miami, Minneapolis–St. Paul, New York City, San Francisco, and Seattle. These cities received priority consideration for available federal discretionary funds (about $1 billion in total) across a dozen grant programs, including transit funds, ITS funds, and Value Pricing Pilot Program funds.

Obstacles

No obstacles were identified for this project.

City of Boulder, Colorado

Agency Name: Boulder Public Works Department (City of Boulder, Colorado)
Scale: Local
Application: Multimodal Assessment/Interagency Planning Partnership

Description of the Program/Initiative

The City of Boulder, Colorado, is a national leader in the promotion of alternative modes such as walking, biking, and transit. The Boulder Department of Public Works Transportation Division provides for the mobility of persons and goods by developing and maintaining a transportation system with emphasis on transit, pedestrian, bicycle, and vehicular transportation; street maintenance, and bikeway maintenance. The division also manages the Boulder Municipal Airport.

The Transportation Advisory Board (TAB) consists of five members appointed by city council, each to 5-year terms. TAB reviews and recommends changes to the Transportation Master Plan based on metric assessments. The city has a comprehensive performance measurement system. The Master Plan states current funding scenarios and provides action plans to improve the system further. The City of Boulder's 2003 Transportation Master Plan has won two awards: the 2004 Metro Vision Award for the Denver Regional Council of Governments and the National 2004 Institute of Transportation Engineers (ITE) Best Practices Award.

Description of Systems-Level Effort

The city has achieved great success with both intermodal and multimodal transportation networks. Many of their performance measures are system-level measurements, such as the Citywide Mobility Index that was created by aggregating the corridor levels of service and facility performance measures for pedestrian, bicycle, transit, and roadway.

Performance Measures

- Alternative modes as a percentage of total trips;
- VMT;
- Percentage of arterial lane-miles congested;
- Air quality (CO_2, NO_x, and VOC emissions); and
- Facility performance (bicycle, pedestrian, and transit).

Supporting Processes, Methods, and Conditions

The City of Boulder creates several documents that reflect citizen opinions, transportation patterns, and other trends. These documents include citizen transportation surveys, a weekly information packet, a transportation metrics presentation to the city council, and modal shift reports.

Obstacles

No major obstacles were uncovered at this point.

Peer-to-Peer Scenario—Multistate Partnership for System Operations

Mid-Atlantic Rail Operations Study (MAROps) Phases I and II

Agency Name: I-95 Corridor Coalition, NJDOT, DelDOT, PennDOT, MDOT, VDOT, CSX, Norfolk Southern, Amtrak
Scale: Multistate
Application: Benefit–Cost Analysis

Description of the Program/Initiative

Phase I: This study is an initiative of the I-95 Corridor Coalition, five Mid-Atlantic states, and three railroads to address regional transportation as a system. The study recognized the need to manage system capacity by building system-oriented institutional relationships and developing system-responsive funding strategies. The objective of this study was to identify choke points or physical points in the rail system (bridges, tunnels, track segments) that have reduced capacity and operational capabilities—in comparison to the rest of the system—in the Mid-Atlantic region's rail network and develop a program to improve freight and passenger flows through those areas.

Phase II (in progress): This project will undertake a more detailed analysis and explanation of the benefits outlined in the Phase I MAROps work. The key objectives of MAROps Phase II are to review improvements since Phase I, update the freight demand forecasts for the region, and review the MAROps program; detail the benefits of the revised MAROps program, moving from the regional level analyzed in Phase I to show benefits accruing to individual states, rail/highway corridors, industry sectors, and potentially major metropolitan areas; and develop and demonstrate transferable methods of assessing the public benefits of public–private partnerships in financing rail improvements.

Description of Systems-Level Effort

This multistate effort looks at congestion in the rail network on a regional level. The partners have come together to identify the chokepoints that have the greatest impact on the region and in Phase II will be measuring these impacts on the many stakeholders.

Performance Measures

The performance analysis for MAROps Phase II focuses on determining who benefits from investments in freight rail infrastructure and who should pay for those investments. The analysis currently is in development but will use a handful of performance measures for each of several potential beneficiaries, including the Mid-Atlantic region and each of the several states and metro areas affected by the investments, the nation as a whole, the freight and passenger railroads providing service in the Mid-Atlantic, and railroad passengers, shippers, and ports who use the rail system to travel or deliver goods. General areas for measurement are listed in Table B.5.

Supporting Processes, Methods, and Conditions

The project is sponsored by the I-95 Corridor Coalition, providing a forum for agencies to convene to discuss transportation on a regional level. Using matching funds, the coalition was able to secure additional funding from each state for this project and the necessary buy-in from DOTs and railroads to make the project effective. The culmination of Phase I was a list of 71 projects that the partners agreed on as the key rail bottlenecks in the region. The opportunity to present these findings for consideration during reauthorization created an incentive for the partners to participate.

Obstacles

Turning a study into policy and implemented projects and obtaining funding for the projects remain challenges.

I-95 Corridor Coalition Vehicle Probe Project

Agency Name: I-95 Corridor Coalition; core participants include NJDOT, DelDOT, PennDOT, Maryland SHA, VDOT, NCDOT. Participation is open to all coalition members from Maine to Florida.

Scale: Multistate Region/Corridor, including primarily freeways and major arterials

Application: Data collection, evaluation, and dissemination

Description of the Program/Initiative

The coalition is a partnership of state DOTs, regional and local transportation agencies, toll authorities, and related organizations, including law enforcement, transit, and port and rail organizations from Maine to Florida (including the District of Columbia), with affiliate members in Canada. I-95 Corridor Coalition members work together to reduce congestion, increase safety and security, and ensure that the entire transportation network supports economic vitality throughout the region. The coalition pursues a wide range of projects and activities related to providing reliable and timely travel information and coordination of incident response and freight movement within the corridor and across different modes of travel.

Table B.5. Potential measurement areas by beneficiary.

Beneficiary	Area of Potential Performance Measurement
Region, states, metro areas, and nation	• Economic impacts • System efficiency • Environmental • Maintenance costs • Safety
Freight railroads	• Market share • Throughput • System reliability • Environmental impacts • Safety • Operations and maintenance cost
Passenger railroads	• Ridership • Throughput • System reliability • Environmental impacts • Safety • Operations and maintenance cost
Rail passengers	• Travel costs • Travel time • Access to service
Shippers	• Business cost • Access to service • Service reliability • Transit time
Ports	• Market access • Business cost • Throughput • Safety

The I-95 Corridor Coalition's Vehicle Probe project is a ground-breaking initiative, intended to provide comprehensive multistate monitoring of traffic flow within the corridor. The objective of this project is the acquisition of traffic flow information using probe technology (GPS-equipped vehicle fleets, cellular geolocation, or a combination of the two) for both freeways and signalized arterials. The information produced by this project will be used to support a number of coalition activities such as corridorwide traveler information, incident management, and performance measurement. The wide-area coverage provided by this project is designed to support the unique planning, engineering, and operational needs of a heavily traveled, multistate corridor encompassing several metro areas.

Member agencies will benefit from the Probe Project by receiving traffic flow information relevant to their respective jurisdictions, including both in-state and border-state data. The data from the system will support the operation of 511, display of travel times on variable message signs, and traffic management during incidents. The data also will be available to support all internal applications such as planning and engineering. Coalition members also will be able to utilize the contract developed for this project to expand coverage within their jurisdictions, to aid in website development, and to interface with existing traffic management systems.

This project is unique in that, for the first time, information will be available to support implementation of long-distance, interjurisdictional diversions that are characteristic of major incidents that have a multistate impact, as well as the metrics and performance measures accompanying such large-scale events. In addition, mobility performance measures such as travel times and reliability can now be developed for the corridor using a common data source that spans political and jurisdictional boundaries.

Description of Systems-Level Effort

The coalition and member agencies have targeted the use of the probe data for various applications and uses. Targeted applications include

- Project monitoring website for use in member's Traffic Management Centers;
- Central archiving service;
- Providing input to corridorwide management tools such as the Integrated Corridor Analysis Tool (ICAT) systems and the Information Systems Network (ISN);
- Integration into member agency 511 and other traveler information services;
- Enhancement of incident management for events that span jurisdictional boundaries; and
- Corridorwide operations performance measures.

Use and integration of the data has begun in several areas. The project monitoring website was implemented by the vendor (INRIX). This website provides all agencies with a common view of the corridor using a real-time color-coded map, as well as real-time speed and travel-time information through the same interface. The same website provides access to a data archive maintained by the vendor. The archive is logged at 5-minute intervals using the segmentation used in the data feed (INRIX uses Traffic Message Channel codes). Other archive and data distribution networks such as ICAT and ISN as well as member agency systems have begun integrating the vehicle probe data into their data formats and network segmentation for use by their member constituents.

Performance Measures

Apart from the individual agency use of the data, the I-95 Corridor Coalition is preparing for corridorwide performance measures. The targeted measures include travel time, travel-time reliability, and all of their derivatives. Also of interest are incident duration metrics as they apply to major incidents of interjurisdictional impact.

Supporting Processes, Methods, and Conditions

The I-95 Corridor Coalition is a partnership of state departments of transportation, regional and local transportation agencies, toll authorities, and related organizations, including law enforcement, transit, and port and rail organizations from Maine to Florida (including the District of Columbia), with affiliate members in Canada. I-95 Corridor Coalition members work together to reduce congestion, increase safety/security, and ensure that the entire transportation network supports economic vitality throughout the region. The coalition pursues a wide range of projects and activities related to providing reliable and timely travel information, coordination of incident response and freight movement within the corridor and across different modes of travel, and electronic systems to make payment of tolls and transit fares easier. Because the efficiency of passenger and freight movement through the region is not limited to one mode or facility, the work of the coalition encompasses all modes and highway facilities, with an emphasis on facilitating long-distance transportation that traverses state jurisdictional boundaries. By leveraging resources, sharing information, and coordinating programs, the coalition adds value to the individual member organization's activities and provides a synergy for more dynamic and seamless transportation solutions throughout the corridor.

Seed funding for the project was provided by the coalition via federal funds. The core system, funded for 3 years, includes

1,500 miles of freeways and 1,000 miles of arterials spanning New Jersey to North Carolina. Member agencies have the option to expand coverage or extend the duration of coverage up to a full 10 years. New Jersey already has added 424 miles of freeway coverage to encompass the majority of freeway miles within New Jersey. North Carolina and South Carolina are planning similar expansions, with many other states contemplating similar actions.

A key aspect of the project was the development of a data rights and ownership policy that allowed for liberal use of the data by the coalition and member agencies while still protecting the vendors' ability to resell the data to other commercial clients.

Key documents include the project RFP, contract, and data use agreement. All of these are available on the coalition website at http://www.i95coalition.org/vehicle-probe.html.

Obstacles

Several unanticipated difficulties arose during implementation of the contract. These difficulties arose not from the language or terms of the contract but from the nature of the coalition and the structure of the procurement. As the coalition is not a legal business entity, the contract for the traffic monitoring system was executed between INRIX and the University of Maryland (on behalf of the coalition and its member organizations). The difficulty in implementing the terms and conditions stemmed from the multistate nature of the coalition. Because the contract was executed in Maryland, under Maryland law, the participation of other public entities was fraught with issues of state sovereignty and contracting regulations and restrictions. To implement the contract, each participating coalition member needed to recognize and bind themselves to the terms of the contract and take upon itself the liability for any breach of terms originating from its access and use. The process involved a data use agreement (DUA) to be executed by member organizations to that effect. Because of varying state laws on contracts, the form of the DUA required customization for different coalition members, a process that required unanticipated time because of the required legal review and input.

Megaregional Partnerships to Address Growth

San Joaquin Valley Blueprint

Agency Name: California Partnership for the San Joaquin Valley (SJV)
Scale: Megaregional
Application: Multi-Agency Planning

Description of the Program/Initiative

The SJV region has a total population of 3.4 million residents within eight counties: Kern, Tulare, Kings, Fresno, Madera, Merced, Stanislaus, and San Joaquin. The California Partnership for the San Joaquin Valley forecasts that the SJV will grow by an additional 1.4 million people by the year 2020—a population increase of more than 40%.[15] By the year 2050, the regional population is expected to grow to more than 7 million. The forecasted growth, as well as current concerns that include mobility, environment, quality of life, and economic development, has motivated regional planning partnerships.

Historically, SJV transportation planning agencies, the California Department of Transportation (Caltrans), and the FHWA have coordinated components of the transportation network to meet the needs of interregional travelers. In 1992, the eight Regional Transportation Planning Agencies (each within a council of government [COG] structure) entered into an MOU to ensure a coordinated regional approach to transportation and air quality planning efforts. The MOU established a coordinated system of transportation and air quality planning, programs, and data analysis/forecasting.

In 2006, Governor Schwarzenegger signed Executive Order S-5-05 that established the California Partnership for the SJV. The main focus of the unique public–private partnership was to improve regional economic vitality and quality of life. One of the six major initiatives within the California Partnership's 2006 Strategic Action Plan is to build a 21st-century transportation mobility system. The California Partnerships Transportation Workgroup developed a Transportation Action Plan with specific goals, objectives, and indicators that can be used by the entire region.

To develop a comprehensive plan for the region, the eight valley COGs jointly applied for grants from the California Department of Business, Transportation and Housing and the SJV Air Pollution Control District. The SJV Blueprint Process has drawn on the work of the California Partnership to help support coordinated data collection and integration needs for the region. The Blueprint Process is "an unprecedented example of local jurisdictions demonstrating increased regional identity and a unified purpose in addressing the region's challenges."[16] All eight COGs within the valley agreed to participate in the Blueprint Process. The Blueprint Process has consisted of a substantial public outreach effort and scenario planning initiative that used a common set of goals and measurements. In the implementation phase, the COGs expect the Blueprint plan to be used to improve the performance of the transportation system and improve overall quality of life in eight valley counties.

[15] www.sjvpartnership.org
[16] http://www.fresnocog.org/files/Blueprint%20Summary%20-%20Brochure.pdf

The SJV faces many transportation challenges, and with a growing population, these challenges are expected to increase. Congestion on the major corridors (Highway 99 and Interstate 5) has increased commute travel times, delayed goods movement, and worsened air quality. Land use trends in the valley have contributed to these problems.

The public continues to express frustration with these issues, and other concerns, such as loss of open space and agriculture land, water supply depletion, poor air quality, lack of quality jobs and affordable housing, and a belief that the quality of life in the region is diminishing.

These megaregional planning processes will help develop a macro strategy with recommendations incorporated into a regional Blueprint plan. The processes will ideally align local and regional goals and enable the region to better understand how local decisions (e.g., land use) affect the entire region.

Description of Systems-Level Effort

The California Partnership and the Blueprint planning process for the SJV have different yet complementary strategies. Each initiative has a transportation component. These joint planning efforts are helping to coordinate a regional vision and a common set of goals, performance indicators, and strategies.

The California Partnership's Strategic Action Proposal was developed in October 2006. The recommendations include the building of a 21st-century transportation mobility system. The strategic actions for this recommendation include the following:

- Implement various corridor plans and help improve mobility within the region;
- Implement transportation projects that support the regional land use strategy;
- Implement a plan to facilitate goods movement in the region;
- Develop a sustainable multimodal system; and
- Ensure that any state high-speed rail system, if implemented, meets the needs of the region and helps achieve economic development goals.

The SJV Blueprint Process involves the integration of transportation, housing, land use, economic development, and environmental data to produce scenarios to the year 2050. The starting point for the Blueprint Process was the creation of a "status quo" scenario projection of how all eight local communities would grow based on current trends. Alternative scenarios were developed based on various land use, transportation, conservation, and housing plans. The Blueprint Process will hopefully provide a decision-making tool that combines currently separate and distinct data sets into one that will allow for multijurisdictional planning and the coordination of infrastructure plans with broader community goals.

Guiding questions for the Blueprint planning process include the following:

- How should we grow?
- Where should we grow?
- How will we travel around the region?
- How will growth affect our environment?
- How will growth impact our overall quality of life?

The Blueprint Process has included public meetings and scenario planning sessions that involved a broad array of stakeholders. Engaging the public at this level is an enormous undertaking but over the past 2 years the Blueprint Process has successfully engaged communities in a bottom-up approach. This public outreach is helping produce coordinated regional planning that is aimed at improving the transportation system and other outcomes. Figure B.1 illustrates the bottom-up approach of the planning process that moves from local input to a regional vision yet ultimately keeps decision-making power and implementation strategies within the jurisdiction of local communities.

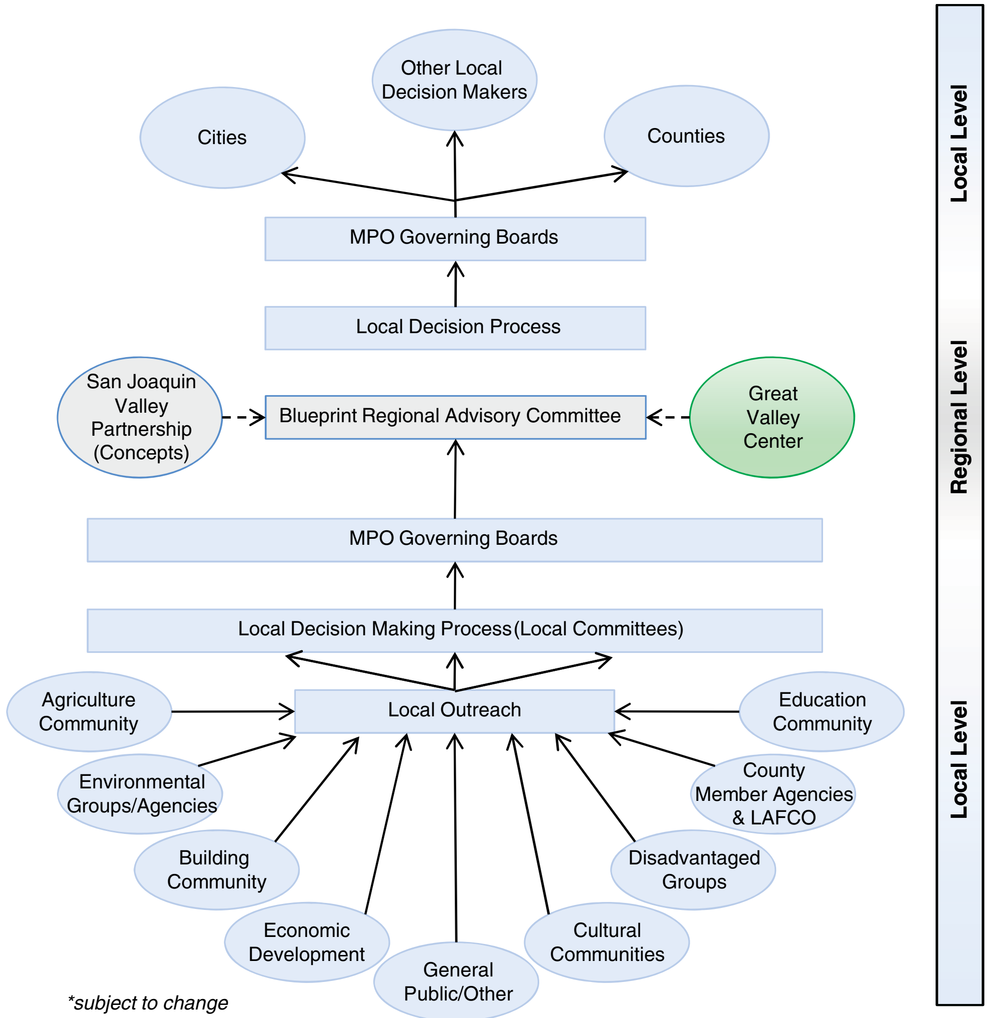
The Blueprint planning processes and the California Partnership within the SJV are megaregional planning initiatives. The results of these planning processes include the coordination of a regional vision, goals, objectives, and strategies. Further, the region is sharing data and using coordinated network-level performance measurements.

Coordinated planning on a widespread regional scale will potentially bring about regionwide programs and operational agreements. Corridor 99 is one example in which the counties recognize the need to work together to fund and implement strategies needed to reach the goals of the Blueprint Process and the California Partnership. Another example is organized data collection and monitoring efforts.

Performance Measures

The California Partnership Transportation Work Group developed a set of transportation system indicators. These indicators will be used to track progress on how well the region is meeting the strategic goals developed by the California Partnership. These indicators include

- Throughput and velocity,
- Roadway conditions,
- Vehicle hours of delay,
- Quality rating of roadway conditions,
- Transit availability
- Goods movement productivity,
- Safety,



Source: Adapted from San Joaquin Valley Regional Blueprint Process.

Figure B.1. Blueprint planning process.

- Roadway enhancements, and
- Deployment of ITSs.

The Blueprint Process committees developed a set of performance measures to be reviewed and adopted by each COG for the Blueprint planning process. Valleywide goals and performance measures were developed with input from COG project managers and the SJV Professional Planners Group. They are being used throughout each component of the Blueprint Process. All performance measures used by counties during the Blueprint processes were reviewed, evaluated, and selected based on the current data available and the current forecasting capabilities.

Though additional performance measures could be valuable in evaluating the scenarios, some COGs currently lack the enhanced modeling capacity necessary to generate them. Moreover, because there are differences not only between counties but also within counties, using one set of exclusive performance measures was a challenging task. Therefore, the COGs agreed to use one common set of valleywide measures as base measures and use additional measures based on their own unique planning needs and county goals. Table B.6 presents the valleywide measures adopted by each COG.

During the second valleywide Blueprint Summit, facilitated by GVC in January 2009, the public officially recommend a preferred scenario. Figures B.2 and B.3 show the transportation-related performance measures used at the summit to compare scenarios (Scenario A is status quo). Only two transportation-related performance measures were used in the process: VMT and GHG emissions from mobile exhaust. Scenario B was the scenario chosen by each county in the county-level Blueprint processes. At the regional summit held in January 2009, participants chose Scenario C—a scenario that increases density levels almost twice as high as does Scenario B.

Table B.6. Blueprint valleywide performance measures.

Blueprint Valleywide Performance Measures		
Category & Measures	**Tool(s)**	**Methodology**
Transportation Measures		
Person-hours and vehicle-hours of travel (per day)	traffic model & mode split model	Simple extraction from traffic model. IS also indicative of energy consumption.
Person-hours and vehicle-hours of delay (per day)	traffic model & mode split model	Estimated with or without a mode split model, and is a measure of congestion on the network. Person-hours helps compare across modes.
Reliability of travel times	traffic model	Approximated based on percent of links operating at Level of Service E or F (congested)
Mass Transit		
Mode split	mode split model	Percent non-SOV (ratio of person-trips to vehicle-trips)
Increase proportion of transit usage	mode split model	Estimate with mode-choice model and/or with demographic data extrapolations.
Transit suitability	GIS	Compactness rating based on density and shape of urban area
Air Quality		
Reduction of emissions	traffic model, EMFAC (or other)	Based on VMT and trips, which comes from existing travel models. Emissions model EMFAC or perhaps other (URBEMIS)
Reduction in VMT per household	traffic model	Simple extraction from traffic model.
(Reduction in truck-related emissions)	Mode choice	Cannot be estimated right now, but would be a very good measure. Valley-wide Truck Model is in development.
Housing / Jobs / Balance		
Change in jobs/housing ratio	UPlan or other	Measure the change in jobs/housing ratio on a county-wide or regional basis
Community Balance	GIS	Change in percentage of workers living in communities that have a jobs/housing balance
Agriculture Land Conservation		
Reduction in ag land conversion	GIS, UPlan	Acres of ag lands (prime & nonprime) converted. Measure productive ag land if possible.
Environmental Conservation		
Reduction of impacts to environmental resources	GIS, UPlan	Acres of environmental resources impacted. Identify total and breakdown by type.

Source: Merced County, http://www.sjvalleyblueprint.com/process.htm.

The counties within the SJV also share data and modeling techniques to monitor the transportation system and to plan for a coordinated regional system. Part of the Blueprint funding was directly used for GIS, land use modeling, and visualization technology to forecast where urbanization will be by 2050. The land use model, UPlan, developed by the University of California at Davis (UC Davis), provided technical and data support to the COGs and local governments in this project. This information was coordinated across the different counties to produce megaregional models.

An SJV Regional Modeling Group was initiated to update valleywide traffic and land use models and to coordinate GIS and other data. Local transportation planners met to evaluate modeling tools and select models. In 2006, the SJV Blueprint Model Steering Committee (MSC) and the Land Use Modeling User Group were formed, resource agencies were consulted, existing data was converted and harmonized, and regional models were developed. In March, 2007 the MSC hosted an environmental resource workshop featuring mapping and modeling data from the eight COGs and UC Davis Information Center for the Environment that had been developed in support of the California Partnership. Since the inception of the Blueprint Process, the MSC and COG modelers have used UPlan to coordinate modeling efforts and have collected regional GIS data to help develop the valleywide performance measures. All county-level scenarios in each Blueprint county planning process were analyzed using land use, traffic, and air quality models in order to compare the scenarios based on performance measures.

Supporting Processes, Methods, and Conditions

The California Partnership for SJV is composed of 10 working groups, including the Transportation Working Group, which has adopted a 10-year Strategic Action Plan for the region. The mission of the Transportation Working Group is to "build innovative transportation systems to increase travel choices and improve mobility, regional and state goods movement, air quality, and economic prosperity" (California Partnership website).

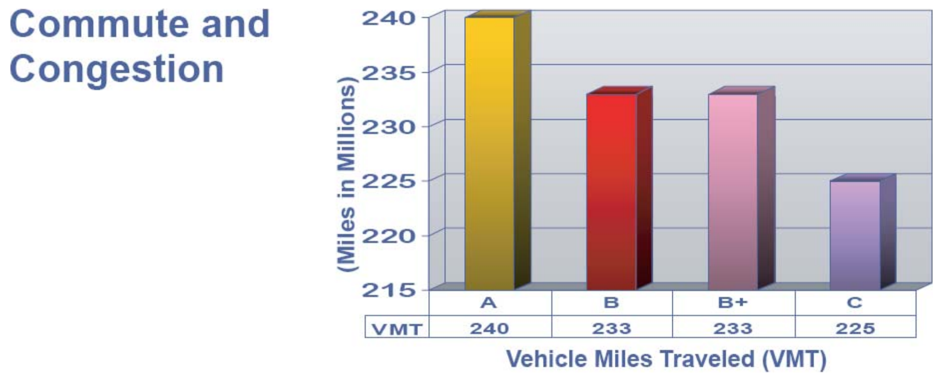


Figure B.2. Performance measure for regional Blueprint Summit.

The eight SJV COGs are working with the GVC. The GVC, a nonprofit community development organization, acts as the regional facilitator for the valleywide portion of the Blueprint Process. The GVC also provides the headquarters for the Transportation Working Group of the California Partnership and is helping facilitate the regional Blueprint Process. With the help of GVC, each COG has facilitated a dialogue to engage local communities in a visioning process that has been incorporated into a valleywide vision. The bottom-up approach is anticipated to encourage local decision makers to embrace and promote the regional vision. The California Partnership's Working Groups developed the macrostrategies for the region; these strategies are being examined through the Blueprint planning process. The SJV Air Pollution Control District also has been an active partner.

The COGs also have worked closely with Caltrans and UC Davis on many technical activities. The UC Davis Information Center for the Environment has supported the California Partnership and has modeled scenarios and helped develop performance measures for the Blueprint Process. The SJV members have a history of working together on air quality issues because they are part of the same regional air quality basin. Modelers that have worked together across counties on air quality issues also have joined efforts to work on the Blueprint Process. These modeling partnerships have been a key factor to the success of a common set of performance measures.

The Blueprint Regional Advisory Committee is central to the entire Blueprint effort. The committee has several purposes: to make regional recommendations pertaining to the creation of the San Joaquin Valley Blueprint, act as a champion of the final Blueprint vision, advocate its implementation with local jurisdictions, and promote the regional strategies at the state and federal levels. There also is a Blueprint Professional SJV Professional Planners Group consisting of regional land use and other professional planners from each county that provided a regional framework to develop the guiding principles used in the community outreach and scenario planning process. An interregional/intraregional/local partnership called the Blueprint Learning Network helps coordinate shared data and learning experiences about the megaregional planning effort. The SJV Regional Policy Council, consisting of two elected officials from each COG, made the final Blueprint scenario recommendation based on county and regional planning sessions.

Obstacles

Challenges lie in maintaining the bottom-up approach of the Blueprint Process. The COGs have each engaged local jurisdictions and decision makers in the Blueprint Process, discussing a very challenging issue: local land use decision making. While local jurisdictions are often weary of regional

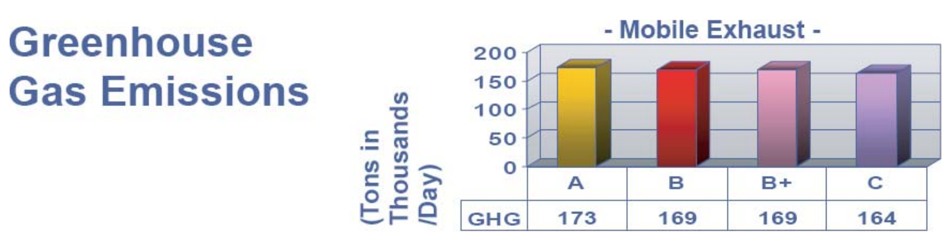


Figure B.3. Performance measure for regional Blueprint Summit.

plans that have implications for local decision making, the bottom-up approach of the Blueprint Process has facilitated a collaborative process. In the implementation phase, region-wide plans will need to be analogous to the plans developed by each county through the Blueprint planning process or local jurisdictions could view the plan as top-down.

In addition, making the connection between the measures in the Attainment Report and project funding decisions has been challenging.

Intra-agency Scenario—Linking Planning and Operations at a State DOT

Maryland DOT Transportation Trust Fund

Agency Name: Maryland DOT (MDOT)
Scale: Statewide
Application: Flexible funding

Description of the Program/Initiative

The Maryland Transportation Trust Fund is unique in that it allows complete flexibility across modes in project prioritization and selection. There is no required funding level for any given mode, thereby allowing the agency to select projects based on their impact to the network, regardless of modal category.

Each county annually provides DOT with its Priority Letters, outlining each jurisdiction's top transportation priorities for state funding. These project requests are then vetted by the Secretary of MDOT, the Department's Modal Administrators, and the Maryland Transportation Authority to determine which projects should be added to the Consolidated Transportation Plan (CTP). Projects are selected based on their support of the objectives and goals set in Maryland's Transportation Plan, LOS, safety, maintenance issues, how the projects may encourage economic development, availability of funding, and the input received from the public and local officials. The governor and secretary make the final decision about which projects to include in the CTP each year.

Description of Systems-Level Effort

The flexibility of the Maryland Transportation Trust Fund enables a systems-level perspective, on a statewide basis, for funding across all modes and jurisdictions. However, the state lacks a process to link quantitative measures systematically to this process.

Performance Measures

MDOT tracks performance measures in its annual Attainment Report. However, these measures are not linked to project selection and funding.

Supporting Processes, Methods, and Conditions

Maryland transportation officials support the importance of mode-neutral funding. By facilitating the bottom-up approach of the project recommendations, they involve the perspective of all levels of government.

Obstacles

Creating the connection between the measures in the Attainment Report and project funding decisions remains a challenge.

Oregon Transportation Plan

Agency Name: Oregon Department of Transportation (ODOT)
Scale: Statewide
Application: Multimodal Assessments/Interagency Planning Partnerships

Description of the Program/Initiative

The Oregon Transportation Plan (OTP) is the State of Oregon's long-range transportation plan. The OTP was originally developed in 1992 and the most recent update was completed in 2004. The OTP provides a 20-year vision for the Oregon DOT, identifies transportation system needs across all transportation modes in the State, and provides an evaluation of the level and type of investment appropriate for transportation.

Description of Systems-Level Effort

This statewide effort looks at transportation system needs across all transportation modes. Of note was the focus on analyzing and modeling the impacts of transportation system operations investments relative to capacity investments. The OTP included a detailed needs analysis for system operations, a white paper that identified the potential for operations to improve system performance in Oregon, and an analysis of a future planning scenario called "Maximum Operations" which assumed future state funding would be put toward highway and transit operations. The state plan attempted to provide a balanced analysis of different investment priorities—capacity expansion, operations, tolling—as well as the impact of alternative future scenarios—land use change, declining revenue, and change in fuel prices.

Performance Measures

The OTP included a rigorous performance analysis of several plan scenarios. Measures examined how much individual performance measures were expected to increase or decrease for a scenario relative to a baseline scenario. Specific performance measures included

- Average delay,
- Travel time,
- Transportation costs relative to income,
- Employment and employment accessibility,
- Average trip distance,
- VMT per trip,
- Total land consumption,
- Land consumption relative to economic output,
- Transit accessibility, and
- Safety (crash) costs.

Supporting Processes, Methods, and Conditions

The OTP was developed by the Transportation Development Division (TDD) of the Oregon DOT but had substantial support from other divisions to estimate transportation system needs and analyze scenarios. For the "Maximum Operations" scenario, TDD and the ITS Office worked closely together to define and analyze the scenarios. The analysis for the OTP was generated primarily using the state travel demand forecasting model, which is a sophisticated planning tool that analyzes the relationship between transportation, land use, and the economy.

Obstacles

The OTP presents a high-level analysis that convincingly demonstrates that the Oregon DOT should invest more in transportation system operations at a statewide level. However, translating that policy guidance into specific transportation projects poses a challenge.

APPENDIX C

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Abbreviations and acronyms used without definitions in TRB publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation