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Performance Measures to Improve Transportation Systems

Summary of the Second National Conference

KATHERINE F. TURNBULL, Texas Transportation Institute

Rapporteur

August 22–24, 2004
Beckman Center
Irvine, California

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This report has been reviewed by a group other than the authors according to the procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

The views expressed in the presentations and papers contained in this report are those of the authors and do not necessarily reflect the views of the Transportation Research Board, the National Research Council, or the sponsors of the conference.

The conference was sponsored by the Transportation Research Board, the Federal Highway Administration, and the Federal Transit Administration.

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Preface

On August 22–24, 2004, the Transportation Research Board (TRB) convened the Second National Conference on Performance Measures in Irvine, California. The conference—sponsored jointly by TRB, the Federal Highway Administration, and the Federal Transit Administration—brought together approximately 125 individuals from across the transportation planning communities, at national, state, regional, and local levels and from the public and private sectors and academia. More than 20 state departments of transportation participated in the conference, along with a similar number of local and regional agencies.

The first National Performance Measures Conference was held in November 2000. With transportation agencies just beginning to explore performance measures at that time, the first conference focused on the definition of performance measures. Potential measures were identified, and their use within transportation agencies was encouraged. Since 2000 the use of performance measures has increased greatly, both in the number of agencies adopting them and in the applications of the measures. Thus the second national conference continued the dialogue on the use of performance measures in transportation agencies and provided a forum to exchange perspectives on performance measures used throughout the transportation delivery process.

The Second National Conference on Performance Measures had two primary objectives: to explore the implementation and use of performance measures and to discuss how to monitor the impact of performance measures on the delivery and quality of transportation services. To plan the conference, TRB assembled a committee, appointed by the National Research Council, to organize and develop the conference program. The planning committee was cochaired by Lance Neumann and Sandra Straehl. The summary of the conference was prepared by Katherine Turnbull of the Texas Transportation Institute, who also supported the committee in

developing the conference program and inviting selected speakers and participants.

The program was designed to maximize the exchange of information and perspectives among the participants. Two workshops, Performance Measures Basics and Communicating Transportation Systems Performance and Measurement, were held at the beginning of the conference. Resource papers were commissioned on the five themes discussed during the conference:

- Performance Measures—State of the Practice,
- Impact of Performance Measures on Internal and External Relationships,
- Tying Together Performance-Based Program Development and Delivery,
- Data and Tools Required to Support Decision Making, and
- Measuring Performance in Difficult-to-Measure Areas.

The papers were presented in panel sessions, and each was followed by a panel discussion. The panels, composed of experts from across the country, explored aspects of each topic in more depth. Breakout sessions to encourage the exchange of information and experience followed. The conference participants also had the opportunity to hear a report on an International Scan of Performance Measures.

This conference summary report is based on the conference agenda. The presentations made in each conference session are summarized, starting with a presentation by the resource paper authors and continuing through the panel discussion. The breakout sessions are summarized at the end of the main report. These summaries highlight a variety of agency experiences with the use of performance measures and identify research that could improve the use of performance measures. The resource papers prepared for the confer-

ence appear in this document, and a list of conference attendees is provided.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's Report Review Committee. The purposes of this independent review are to provide candid and critical comments that will assist the institution in making the published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the project charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

TRB thanks the following individuals for their review of this report: Mark E. Hallenbeck, University of Washington, Seattle; Charles L. Purvis, Metropolitan Transportation Commission, Oakland, California; and

Sandra Straehl, Montana Department of Transportation, Helena.

Although the reviewers listed above provided many constructive comments and suggestions, they did not see the final draft of the report before its release. The review of this report was overseen by C. Michael Walton, University of Texas at Austin. Appointed by the National Research Council, he was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered.

The committee thanks Katherine Turnbull for her work in preparing this conference summary report and extends a special thanks to the Federal Highway Administration and the Federal Transit Administration for providing the vision and encouragement that made the conference the success that it was.

SESSIONS AND TOPICS

Opening Session

Tony Kane, Moderator, *American Association of State Highway and Transportation Officials*
Lance A. Neumann, *Cambridge Systematics, Inc.*
Gloria Shepherd, *Federal Highway Administration*
Theodore H. Poister, *Georgia State University*
Douglas MacDonald, *Washington State Department of Transportation*

WELCOME

Tony Kane

On behalf of the Transportation Research Board (TRB), the American Association of State Highway and Transportation Officials (AASHTO), the Federal Highway Administration (FHWA), the Federal Transit Administration (FTA), and other sponsors, it is a pleasure to welcome you to the Second National Conference on Performance Measures. The first conference was held in 2000.

This conference focuses on the ultimate purpose of performance measures: to improve transportation services for our customers. The opening session this afternoon highlights the objectives of this conference and summarizes the state of the practice in the use of performance measures by transportation agencies at different levels of government throughout the country.

Representatives from some 20 state departments of transportation are participating in this conference. An equal number of personnel from local and regional agencies are attending. Performance measurement and performance-based management aids the decision-making process at all levels of government. Our partners in the private transportation sector also use performance-based management—for example, to ensure the timely delivery of freight and the efficient movement of travelers.

We have seen numerous changes and advances in the application of performance measures within

transportation agencies since the first conference in 2000. Legislation and policy directives at the federal, state, and local levels have influenced the use of performance-based management techniques. Performance measures are also being used by transportation organizations throughout the world. The Monday night session will highlight examples of international applications of performance-based management.

Representatives from a number of state departments of transportation will discuss the evolving role performance measures are playing in the decision-making process during sessions throughout the conference. During my tenure at FHWA and the past 4 years at AASHTO, I have seen advances in the state of the practice with performance-based management. State departments of transportation have a strong interest in sharing their experiences and in learning from the experiences of others.

At AASHTO, we are developing a new strategic plan for 2005 through 2010. Performance measurement plays a key role in the new strategic plan, which was developed by a 15-member committee made up of secretaries of state departments of transportation. The plan will be voted on by the board of directors at the annual meeting in Philadelphia this September.

The Conference Planning Committee has done an excellent job of organizing interesting sessions. I hope you will participate actively in the conference and share your thoughts and ideas on performance measures.

CONFERENCE OBJECTIVES

Lance A. Neumann

It is a pleasure to welcome you to the Second National Conference on Performance Measures on behalf of the Conference Planning Committee and the TRB Committee on Performance Measurement. I would like to recognize Sandy Straehl from the Montana Department of Transportation, who served with me as cochair of the Conference Planning Committee.

Many of you participated in the first conference, which focused primarily on defining the concept of performance measurement, identifying potential performance measures, and promoting the use of performance-based management within transportation agencies. In the 4 years since the first conference, we have seen widespread use of performance measures by state departments of transportation and a continuing interest in this topic at all levels of government.

We have learned a great deal over the past 4 years through projects and studies sponsored by FHWA, TRB, the National Cooperative Highway Research Program, state departments of transportation, and other agencies. As a result, the planning committee believed that this conference should focus on the implementation and use of performance-based management and how we monitor progress to ensure that these programs do make a difference in the delivery of transportation products and services.

The planning committee wanted to highlight the wealth of experience in the use of performance measures at this conference and especially to share lessons learned. The workshops this morning provided a great starting point for sharing experiences and learning from each other.

This conference focuses on the implementation of performance measures as a practical management tool and on the steps needed to accomplish this goal. As with the first conference, the topics to be covered over the next 2 days are both broad and comprehensive. The sessions focus on a series of themes the planning committee identified as important in promoting the implementation and ongoing use of performance measures. The workshops this morning addressed the basics of performance measurement and communications.

This opening session highlights the use of performance measures at state transportation agencies and presents the views of a senior executive on the use of performance measures in a political decision-making environment. The second session this afternoon will explore the influence of introducing performance measures on internal organizational relationships, as well as external institutional relationships and partnerships.

The first session on Monday will examine linking performance management in plan development, program

development, and budgeting with performance management in program and project delivery. Experience indicates that this link is critical to the successful use of performance-based management. Potential issues and opportunities associated with the data needed for performance measures will be addressed at the second session on Monday.

Speakers at the Monday night session will share information on the international experience with performance-based management. The conference will close on Tuesday with a session on performance areas that are difficult to measure.

You will also have the opportunity to share your experiences and views during the breakout sessions on Monday and Tuesday. These sessions focus on a variety of topics and issues and will add to the breadth of the conference. You are encouraged to participate in the breakout sessions that best meet your interests.

FHWA and FTA helped fund this conference. The members of the planning committee put forth creative ideas, hard work, and dedication in organizing this conference. Kim Fisher, Freda Morgan, and other TRB staff provided outstanding support. Finally, Katherine Turnbull of the Texas Transportation Institute (TTI) will be compiling the conference proceedings.

In summary, the conference objectives include defining the state of the practice and acknowledging recent work in the use of performance measures, sharing experiences and resources, and identifying key areas that need further research or additional peer exchange. I encourage you to participate in all parts of the conference actively. I look forward to productive discussions.

Thank you for participating in this important conference. I look forward to hearing your thoughts and ideas in helping to advance the state of the practice in the use of performance-based management.

WELCOME AND FEDERAL PERSPECTIVE

Gloria Shepherd

It is a pleasure to participate in this conference on behalf of FHWA. We at FHWA have been pleased to work with many other partners in organizing and supporting this important conference.

I should recognize my colleagues at FHWA who helped with the conference planning activities and who are participating in the session. Jeff Lindley, Director of Operations, willingly supported funding the conference. Jeff will be speaking at the second session this afternoon. Dave Ginger is participating, and Mike Halladay from Safety will be speaking Monday night. I also recognize Bob Arnold, who was on the international performance measures scan, and the other FHWA staff participating in the conference.

As you can tell both by FHWA's willingness to be a funding partner and by the number of staff participating in this conference, performance measures are an important subject at FHWA. We assisted in sponsoring a performance measures peer exchange in South Carolina this past May. Representatives from a number of states shared their experiences in the use of performance measures at the peer exchange. One of the areas of interest was implementing performance measures in specific program areas, including safety, asset management, and operations. Discussions focused on both potential performance measures and implementation strategies for incorporating performance-based management into state transportation agencies.

The summary of this peer exchange has been posted by TRB as an e-circular at trb.org/publications/circulars/ec073.pdf. Numerous stakeholder groups are also interested in the application of performance measures by transportation agencies. Among the stakeholders are public officials, interest groups, and environmental organizations. They are interested in how transportation agencies allocate public funds and make decisions on project priorities.

Performance-based management can help state departments of transportation communicate needs and priorities to the public and to decision makers. Communicating effectively with these groups is especially important in times of limited resources. Requests for additional funding, bonding authority, and other financing options have been considered in many states recently. Clearly communicating how these funds will be used and tracking progress on promised projects appear to be important factors in successful initiatives.

We have an obligation to ourselves as transportation professionals and to the public we serve to spend funds effectively and efficiently. The use of performance measures helps ensure that transportation agencies follow up on commitments.

FHWA also helped sponsor a roundtable discussion of performance measures and statewide transportation planning in Washington, D.C., in October 2003. Issues discussed at the roundtable included strategic planning; measurement of the cost and performance of alternative projects; and techniques to compare, prioritize, and select alternative investments. Modal investment strategies, monitoring of the performance of transportation organizations and multimodal transportation systems, and techniques for communicating performance measures to stakeholders were also discussed. The issue of how we communicate with the public and with policy makers is important. These groups want to know how public funds are being spent. They want to know what improvements or better services they will receive from increased investments in the transportation system.

At FHWA, we are interested in working with you to address these issues and other topics of concern. We

need to look at how performance measures can improve the safety and the efficiency of our transportation system. We are also interested in the use of performance measures to enhance the planning process. We are interested in how well the transportation planning process works, how well it informs the public, and how we can improve long-range plans.

We at FHWA are pleased to participate in this conference. We look forward to continuing to partner with all of you to enhance the use of performance measures with all elements of the transportation system. Thank you.

STATE OF THE PRACTICE OF PERFORMANCE MEASUREMENT

Theodore H. Poister

As one who has had a window on this field for many years, it is a privilege to be able to participate in this conference. It is clear that interest in the use of performance measures has grown tremendously over the past 20 years. At this point performance measurement has become an integral part of the way many state departments of transportation do business.

It may be helpful at the outset to remember the overall governmental context within which performance measures are applied. The federal Government Performance and Results Act of 1993 requires all federal agencies to develop and use performance measures. Most states have some type of executive or legislative mandate to use performance-based management, and many state transportation agencies have been using performance measures for a number of years. There are also initiatives at the local government level, although they are not as far reaching. Phoenix, Arizona; Dallas, Texas; Charlotte, North Carolina; and Dayton, Ohio, are just a few cities that have been using performance measures for some time.

Little research has assessed whether management matters and whether performance measures matter. We believe that performance measures make a difference, but research to support this conclusion is lacking. Two recent studies focus on the impacts of strategic planning and management. The first examined police departments throughout the country, and the second focused on fire departments in New York State. Both studies (1, 2) concluded that management does make a difference and that agencies with strong management practices, including performance measures, do perform better than agencies without strong management practices.

One of the more ambitious research projects is the Government Performance Project (GPP), which was conducted by a group of university researchers and *Governing* magazine. Complete information with regard to the

purpose, approach, and results is available at gponline.org. Through an extensive survey and follow-up site visits and interviews, the project graded all 50 state governments, a sample of federal agencies, and 25 local governments over a 3-year period. The agencies were graded on financial management, human resources, information technology, capital management, and managing for results. Planning, goal setting, and management and evaluation were included in the assessment. (See additional information at gponline.org.)

As you might expect, grades for the various states varied widely. A second round of the GPP focusing on state departments of transportation and environmental protection programs in particular, in addition to general state government, is under way. All the state transportation departments will be involved in this effort.

I think transportation agencies are on the leading edge in the application of performance measures. At the federal level, transportation agencies participated in testing many planning and measurement efforts. At the state level, the transportation agencies are frequently the leading agencies in applying performance-based management. At the local level, transit agencies have used performance measures for many years. For example, the city of Charlotte, North Carolina, pioneered the use of the balanced scorecard in the public sector, and the Charlotte Department of Transportation was the city agency selected to pilot test the balanced scorecard application.

There has been substantial growth in the development and use of performance measures by transportation agencies during the past 20 years, especially in the past 5 to 10 years. Currently, transportation agencies vary widely in the approaches used and the level of expertise within the agencies.

Recent trends and the current status of performance measures can be examined from a number of perspectives. We can focus on what is being measured, how performance is being measured and reported, and how performance measures are being used in the decision-making process.

We can first look at what state transportation agencies are measuring. We are seeing a move toward more comprehensive approaches in the application of performance measures. We are also seeing performance measures being used as part of transportation agencies' overall strategic management processes. A number of transportation agencies use the balanced scorecard application, and many of them have adapted or modified the original balanced scorecard model to meet their own particular needs. (See the resource paper "Performance Measurement in Transportation: State of the Practice" in these proceedings for examples of balanced scorecard models.)

Figure 1 is an example of a logic model developed out of the tradition of evaluation research. It provides an example of how evaluation research maps programs and services, system performance, and impacts. Imme-

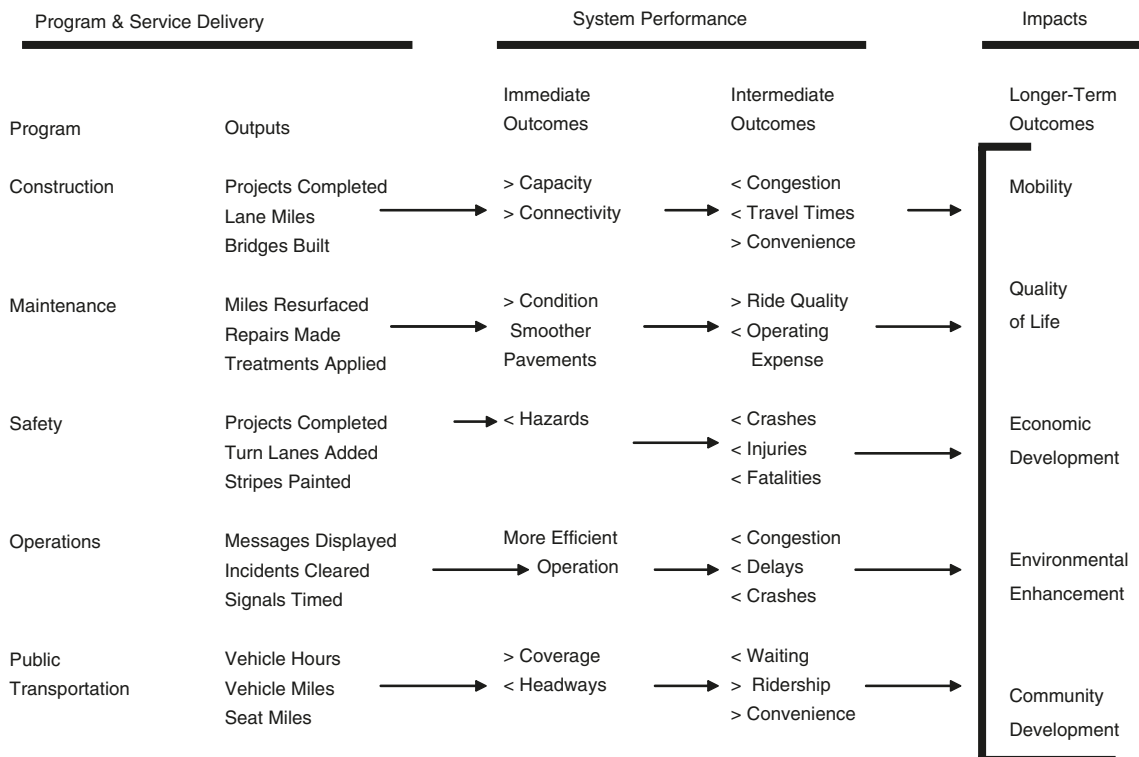


FIGURE 1 Example of transportation program logic model.

diate, intermediate, and longer-term outcomes are all identified and monitored. While the outputs focus on agency activities and service delivery processes, the immediate outcomes tend to focus on conditions, such as pavement smoothness. The intermediate outcomes focus more on system performance, such as travel times and safety. The longer-term outcomes address broader impacts. This model is an example of the holistic approach being used at many transportation agencies.

Many performance measures focus on transportation agency operations. Incident management represents one function that has come to the forefront recently. State departments of transportation realize that clearing incidents quickly is important in maintaining traffic flow and minimizing secondary accidents. For example, the Maryland State Highway Administration's CHART Program measures incident duration, initial response time, and overall recovery time.

Performance measures at many state departments of transportation address program delivery. The Virginia Department of Transportation's new strategic plan focuses on the effective delivery of annual state transportation improvement plans. Many states have experienced increases in funding, which result in more programming activities. That generates additional pressure to deliver the program. For instance, Georgia's budget will roughly double as a result of the governor's new Fast Forward program. Thus, on-time and on-budget performance measures continue to be a major focus at many state transportation agencies. Cycle times for overall projects, as well as particular elements, are also being considered. The Pennsylvania Department of Transportation has 10 teams examining all aspects of program delivery to streamline the process, and they are attempting to develop performance measures in each of those areas.

Performance measures at many state departments of transportation continue to address system condition. Pavement condition, pavement roughness, and bridge condition are common performance measures at most state departments of transportation. Safety performance measures also continue to be important. Typical safety performance measures focus on crashes, injuries, and fatalities. Other elements such as pedestrian and bicycle accidents and at-grade railroad crossing accidents are measured in some states. Improving safety continues to be a high priority of FHWA as well as state and local transportation agencies.

Applying performance measures to traffic flow and congestion is a growing area of interest. Volume-capacity ratios have traditionally been used to measure congestion. The annual urban mobility report published by TTI examines performance measure data for 75 urban areas in the country. The reports present the travel time index, percentage of congested vehicle miles traveled

(VMT), delay per person, percentage of congested lane miles, cost of congestion, and percentage of congested time for each area.

FHWA's urban congestion report examines monthly data for 10 metropolitan areas that are instrumented to provide real-time data. Performance measures used in that report include the travel time index, the buffer index, the average duration of congested travel per day, and the percentage of congested travel.

Some agencies apply performance measures to environmental and economic factors. Environmental indicators may address acres of wetlands replaced, acres of reforestation, storm water enhancements completed, and air quality noncompliance days in urban areas. Economic development indicators may focus on jobs created or retained through initiatives where transportation is a contributing factor.

Many state departments of transportation conduct regular customer satisfaction surveys. Regular surveys of motorists or the public at large are conducted in Minnesota, New Mexico, Illinois, Kentucky, Pennsylvania, Ohio, Georgia, and many other states. Florida uses a mix of survey methods for different customer segments, such as resident travelers, visiting travelers, disabled travelers, property owners, and elected government officials. The Minnesota Department of Transportation is one of the few state departments of transportation with an in-house market research group. The department conducts regular surveys of residents and other user groups. The Pennsylvania Department of Transportation conducts an annual highway administration customer survey. This program includes a large sample mail-out survey to obtain reliable data at the county level. The findings are presented at the county and district levels on an annual basis. The information is used in the development of an annual work program for each district.

Performance is measured and reported by state departments of transportation in a variety of ways. Performance measures focus on resources and workload, outputs, service quality, efficiency, and productivity. Other measures may examine outcomes, cost-effectiveness, benefit-cost ratios, return on investment, and life-cycle costs.

Performance indicators are specified in a number of ways. How performance measures are specified is important. For example, performance measures addressing highway safety often include traffic fatalities per 1,000,000 VMT and traffic fatalities per 100,000 residents. The results of these two measures may suggest different problems and solutions. Pavement condition measures typically include the percentage of lane miles in good condition and the percentage of VMT on lane miles in good condition. Focusing on just one of these measures would promote different types of project programming and investment decisions.

Many indices are used with performance measures. Examples include pavement rating scales, productivity indices, and customer satisfaction indices. The Florida Department of Transportation focuses on 11 key measures tied to strategic objectives and executive board initiatives. These measures are reviewed on a monthly basis. Some of these measures, including work program delivery, employee satisfaction, system condition, system performance, and customer satisfaction are weighted indices combining numerous indicators.

The Ohio Department of Transportation's organizational performance index (OPI) focuses on the performance of 12 districts and 88 county-level maintenance units. The OPI consists of measures in eight functional areas, most of which are indices themselves. These measures are also combined into a single index of overall department performance. The aggregate OPI provides a reading of overall performance at the executive level. Where there is slippage, managers can drill down to look at specific measures in individual districts to identify problems and formulate corrective actions.

Benefit-cost ratios are also used as a performance measure by some state departments of transportation. Benefit-cost ratios are typically estimated for projects in the planning stage. However, VicRoads in the state of Victoria, Australia, tracks aggregate benefit-cost ratios after the fact for all projects completed during a given year. The agency monitors an achievement index for all completed projects. It examines the actual benefit-cost ratios after 2 years in relation to the benefit-cost ratios originally estimated.

State transportation agencies use a number of methods and techniques to report performance measure data. These formats include scorecards, dashboards, and roll-up and drill-down features. Performance measures are reported both internally and externally. State transportation agencies communicate performance measures to the public and other external stakeholders through reports, updates, and Internet sites. For instance, the Maryland Department of Transportation publishes an *Annual Attainment Report of Transportation System Performance*. The Washington State Department of Transportation issues a *Measures, Markers, and Mileposts* report. The Virginia Department of Transportation uses a quarterly report card or project dashboard on the department's Internet site.

Many states use performance measures for integrating strategic planning and management. Pennsylvania, Minnesota, Kentucky, Virginia, Maryland, California, Illinois, South Carolina, New Mexico, and Georgia all emphasize performance measures linked to strategic planning processes.

Performance measures are also used in the transportation systems planning process in some states. Performance-based planning uses performance mea-

asures to tie planning to goals, standards, and targets for system performance. Ohio, Minnesota, and Pennsylvania emphasize this approach.

Performance measures are used in some states for programming and project selection. These efforts use performance measures to evaluate alternatives and assess trade-offs in costs and performance among competing projects. They typically focus on pavement, bridge, safety improvement, and congestion mitigation projects. Montana has a performance programming process, and New York uses an asset management program with reduction in excess user costs as a common performance criterion.

Other states use performance measures in program and project delivery. Management information systems track the achievement of project milestones and the budget status of individual projects to monitor on-time and on-budget measures, usually on a district and statewide basis. Many states, including Virginia, Washington, and California, report project status data to the public on their Internet sites.

Operations management represents another area for applying performance measures. One approach applies performance-based management for districts, divisions, and organizational units through goal setting and measurement with regard to business plans, program plans, work programs, and operating plans.

Performance measures may also be used internally. One example of an internal program is employee performance planning and evaluation. Examples of this approach include South Carolina's accountability system, the California Department of Transportation's performance agreements, and Ohio's career professional service. Performance-based budgeting is also used in some states. Examples of performance-based budgeting include Colorado's investment strategy, Minnesota's activities-based budgeting focused on project and service lines, and New Mexico's program budget.

The use of performance measures in contract management appears to be increasing at many state transportation agencies. Performance measures may address contract design, construction, maintenance, and services. Comparative measurement and benchmarking may be used in these efforts.

Many transportation agencies are integrating various performance measurement systems. The Florida Department of Transportation integrates the Florida long-range transportation plan, the short-range component, the annual strategic objectives, and the executive board initiatives through performance measures. The Minnesota Department of Transportation's measurement pyramid helps link the use of performance measures in the different plans.

In conclusion, a number of common themes have emerged since the first national conference on this topic

in 2000. First, the state of the practice continues to advance. Second, there continues to be wide variation in programs among state departments of transportation, with practices evolving within individual agencies. Third, some agencies have mature measurement systems. These include a range of interrelated measurement programs, alignment of measures with goals and objectives, performance reporting tailored to audiences, systematic procedures for reviewing performance data, and data used to strengthen planning and decision making and communication with external stakeholders. Finally, agencies are learning from each other and sharing experiences with different approaches.

A number of recent trends can also be identified. First, measures are more strategic and outcome- and customer-oriented. Second, while there is an emphasis on program delivery, a strong focus on system performance continues. Third, we are seeing an increased use of customer satisfaction measures. Fourth, more holistic approaches are being applied in terms of coverage and integrating systems. Fifth, performance is being monitored at various levels with data analysis systems providing roll-up and drill-down capabilities. Sixth, the use of standards and numerical targets is increasing.

Other recent trends include more sophisticated software applications, system support, and data displays. While there is greater proliferation of performance measures, some departments of transportation are recognizing the need to focus more selectively on a few vital measures. There are also more disciplined efforts to align measures with goals and objectives and to focus on real-time, actionable measures. It is also fair to say that many departments of transportation are making more intentional use of measurement systems to support other management, planning, and decision-making processes. Finally, there is increased reporting of performance data directly to the public and other stakeholders to promote transparency in government.

A number of continuing challenges face transportation agencies in the application of performance measures. Some of these challenges include agreeing on common terminology for terms such as dashboards, benchmarking, and performance management (see the resource paper "Performance Measurement in Transportation: State of the Practice" on pages 81–98 of these proceedings for examples). As will be discussed in other sessions, we need improved measures in difficult-to-measure areas, such as congestion, delay, travel time, and reliability; freight transportation; environmental impacts; and safety and security. Developing measures that facilitate cross-modal comparisons with regard to service levels, quality, travel times, and costs is also important.

Obtaining systematic feedback from other external stakeholders beyond motorists and the public at large, such as other user groups, local governments, legisla-

tors, and the media, continues to be a challenge. Interpreting the implications of customer feedback in relation to engineering and professional planning criteria is also a challenge. Setting appropriate targets that are aggressive yet realistic continues to be a challenge. And many states need to use measures in a more disciplined way to articulate the relationship between strategic plans and transportation system plans more clearly.

We also need to place greater emphasis on measuring results after projects have been completed. Implementing workable comparative measurement systems to support benchmarking and process improvement represents another challenge for many state departments of transportation. Strengthening linkages between measurement systems and employee performance management processes is also being considered. Finally, institutionalizing strategic planning and performance measurement more effectively in agencies, through developing both internal and external buy-in, continues to be a challenge for many transportation agencies.

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USING PERFORMANCE MEASURES IN A POLITICAL DECISION-MAKING PROCESS

Douglas MacDonald

I appreciate the invitation to participate in this conference. In listening to the other speakers this afternoon, I am struck by what is being accomplished by different transportation agencies throughout the country. Performance measures are being applied in a wide range of situations to improve the transportation project selection process and the delivery of transportation services.

I was asked to discuss performance measures and the political decision-making process. I think you can simplify the discussion of politics and performance measures by focusing on a single mission. That mission is to increase the investment in transportation assets and services. In addressing this mission we first have to convince the public of the value received for tax dollars. We must also convince the public that what we are going to do with the next tax dollar makes sense.

It is important to start with the fundamental issue that we are in a crisis situation in transportation. More funding is needed for transportation, and it is critical that we address transportation investment needs. The reasons for the current crisis are well known. First, our transportation infrastructure is aging. Second, our current system is not keeping up with the demands of a growing population. Third, funding for transportation has been diminishing. Finally, transportation is a critical component of our economic and social well-being. I think most people would agree that these four conditions define a crisis situation for our transportation system.

The solution to this crisis is more funding for transportation. To obtain additional funding we need to focus on two key elements. First, we must convince taxpayers that they get a dollar's worth of value for a dollar's worth of tax. Transportation agencies must be accountable to the public. Performance-based management can help establish and maintain accountability.

Performance measures provide internal guidance to ensure that agencies are in fact providing a dollar's worth of service for a dollar's worth of tax. Performance measures help identify performance weaknesses as well as performance strengths. Agencies must address their weaknesses. One of the criteria an agency can use to test the ability of its performance measures system is what has been learned about the agency's strengths and weaknesses. The integrity of a performance measures system is also critical.

The integrity of performance measures is linked to an agency's credibility. In the political process, credibility is

critical. It takes a long time and a lot of effort to establish credibility with policy makers. Credibility can be lost quickly if inaccurate information is presented or if attempts are made to cover up errors or problems.

All of the performance measures described in the previous presentations are relevant to accountability and reporting on values. The measures addressing project and service delivery are especially important. I think policy makers and the public in many states are interested in project delivery performance measures. Delivering projects on time and on budget has become the mantra at transportation agencies. Delivering projects on time and on budget is not easy, as we all know.

I was fortunate to have a lot of experience in project delivery before coming to the Washington State Department of Transportation. I spent 9 years as head of the agency responsible for cleaning up the Boston Harbor. At any given time, we had 25 to 30 prime contractors working to modernize the wastewater treatment system and plant. The benchmarks for compliance on the cleanup were set by a federal district court judge, who entered the schedule for improvements as an order of the court. We had a large and complicated program to address the requirements. We were also fortunate, however, to have an excellent federal district court judge. He brought a lot of proactive judgment to the process. By meeting schedules and being accountable, we were able to build strong working relationships with the various groups involved in the cleanup process.

Some state transportation agencies are experiencing an infusion of new funding. These funds are frequently

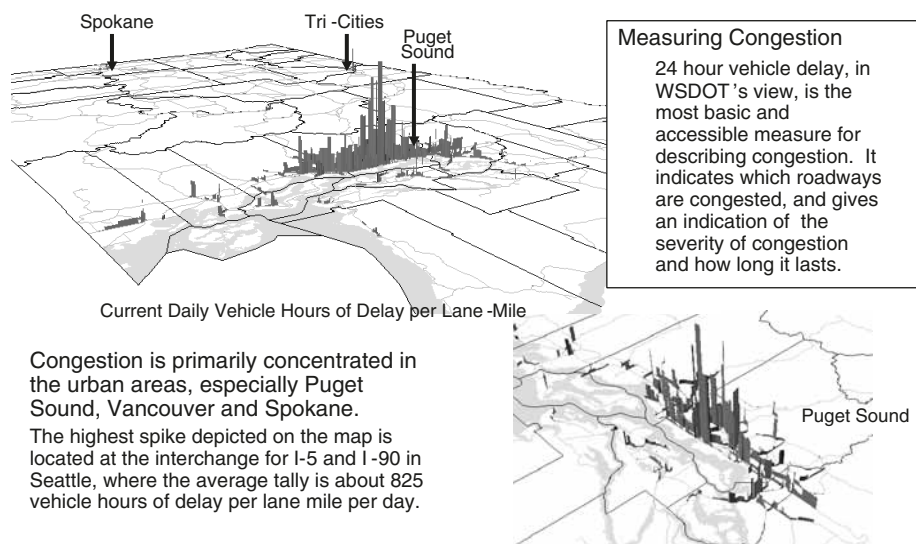


FIGURE 2 Current daily vehicle hours of delay in Puget Sound region. With demand growing and supply stagnant, congestion as measured by traveler delay has increased. WSDOT = Washington State Department of Transportation.

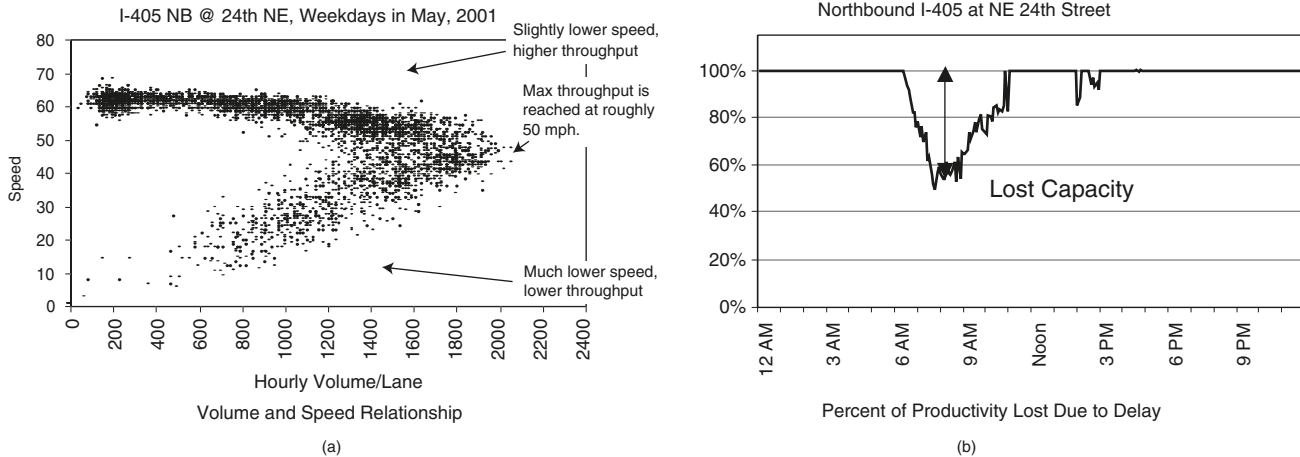


FIGURE 3 Relationship between delay and efficiency. (a) Maximum freeway throughput is typically at speeds of 45 to 50 mph. This accommodates about 2,000 vehicles per hour per lane. System throughput drops dramatically when traffic volume forces speeds to drop below 50 mph. (b) During the peak period on I-405, congestion reduces the throughput of the two general-purpose lanes in Renton to the capacity of one free-flowing lane.

linked to specific projects or programs, however. In Washington State, the recently passed Nickel Tax program is dedicated to some 150 to 160 projects over the next 10 years. We are committed to delivering the projects on time and on budget, but we all know the difficulties that can arise in constructing and reconstructing transportation facilities.

It is important to build credibility in meeting on-time and on-budget expectations. One way to build credibility is to use narrative reporting in addition to charts and other graphics. Do not underestimate the effectiveness of telling your story, including possible problems, in narrative reporting.

The second part of accomplishing our mission is to convince taxpayers that what we are going to do with the next tax dollar makes sense. I think one of the traps transportation professionals sometimes fall into is to talk about strategies. I suggest that we do not invest in strategies. We invest in opportunities. We have opportunities to do various things with available funding. The challenge is to use performance measures to help define and select among the opportunities generated for additional investments. As the Monday evening session on the international scan will point out, performance measures have been used in Canada, Australia, New Zealand, and Japan to target, deliver, and measure safety projects.

As you all know, there are many ways to describe congestion. Among them are trip times, travel speeds, trip-time reliability, delay times, and the buffer index. One of the techniques we saw used in Japan on the scan tour illustrates traveler delay.

We believed this was a powerful way to present information on congestion to the policy makers and the pub-

lic graphically. Figure 2 is one example showing current daily vehicle hours of delay per lane mile in the Puget Sound region. We also use Figure 3 to illustrate the relationship between delay and efficiency. Figure 4 shows the percentage of productivity lost because of delay on freeways in the Puget Sound region.

There are two ways of dealing with the congestion problem. We can increase capacity and we can increase efficiency. We know that incidents and accidents degrade the efficiency of our freeways and that one way

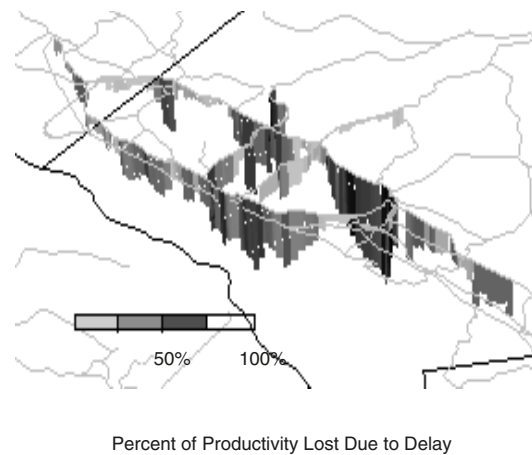


FIGURE 4 Percentage of productivity lost to delays in the Puget Sound region. Lost productivity on Puget Sound freeways is staggering. In the peak travel period on an average weekday, delay causes significant loss in productivity—as much as 60 percent.

to increase efficiency is through the use of incident response teams or highway helper programs. We have documented the average delay savings with incident response teams through the use of performance measures. Presenting this type of information to policy makers and the public is critical to build support for these types of programs.

We have also been able to use performance measures and monitoring to show the benefits of restriping a segment of SR-167 from two lanes to three lanes, which was suggested by a commuter, and the opening of a high-occupancy vehicle lane extension on I-5 South.

Both of these situations provide powerful information to present to policy makers and the public concerning the benefits of transportation improvements and what the department can do with additional funds.

The key is to use this type of information to build a balanced program that includes both operational and capital improvements, along with enhancement projects, that will provide the greatest return on investments. The ability to tell the story and to communicate with policy makers is a key part of the process. We must clearly articulate where transportation funds come from and how they are allocated.

Impact of Performance Measures on Internal and External Relationships

Robert Johns, Moderator, *University of Minnesota*
Mark C. Larson, *Minnesota Department of Transportation*
Lisa Klein, *Metropolitan Transportation Commission*
Sarath Joshua, *Maricopa County*
Jeffrey Lindley, *Federal Highway Administration*
David Ekern, *Idaho Department of Transportation*

ORGANIZING FOR PERFORMANCE-BASED MANAGEMENT

Mark C. Larson

I appreciate the opportunity to summarize the conference resource paper that addresses organizing for performance-based management. Performance measures have been used at many transportation agencies for the past 15 to 20 years. The use of performance measures has been driven by a variety of external and internal factors. In talks with representatives from a number of state departments of transportation and metropolitan planning organizations (MPOs) in preparing the resource paper, some common elements emerged that appear to influence successful programs.

External groups, including state legislatures, commissions, and governors, helped promote the movement toward performance-based management. Internal factors include quality management programs, transportation planning requirements, and changes in leadership at many agencies. Performance-based management was well established in the private sector before it was introduced into public agencies. Freight companies, railroads, airlines, and public transit agencies have been using performance measures for many years.

External groups, especially state legislatures and governors, have become involved when there is a perceived lack of accountability at state transportation agencies. Our challenge is to move forward and set our own agendas. If we do not, the likelihood of outside forces doing it increases greatly.

As other speakers have noted, a number of states have tied increases in transportation funding to specific accountability measures. Examples include the 1980s gasoline tax increase in Florida, Vision 21 in Mississippi, the Nickel Tax in Washington, and the Cooper River Bridge project in South Carolina. Other examples are the 5-cent sales tax increase in Arizona, the dedication of increased bridge tolls for transit in the San Francisco Bay Area, and the Jobs and Progress Plan in Ohio.

The Jobs and Progress Plan in Ohio included a 6-cent increase in the state gasoline tax. The increase will provide an additional \$5 billion over the next 10 years for transportation projects in the state. The challenge to the Ohio Department of Transportation is to deliver the promised projects on time and on budget.

The resource paper outlines three stages of development in the application of performance measures at transportation agencies. The first stage focuses on establishing performance measures and monitoring progress. An annual report to the legislature represents a common reporting method during this stage. There may be system or process measures in this stage, but they are not usually connected. Agencies may also focus too much on trying to develop perfect performance measures during this initial stage.

The second stage focuses on a more real-time or future orientation. Performance measures in this stage are used in the planning process and in managing project delivery. This stage also includes setting targets, which can bring focus to a department and promote change. More analysis is conducted by using the performance measures. The third stage has a strong future orientation. Rather than

single measures, this stage uses a package of measures to optimize benefits.

The resource paper examines the current agendas of many transportation agencies. At least five common items seem to be prevalent at many transportation agencies. First, most states have project delivery reporting systems. Second, many states are reducing the number of performance measures in use and aligning key measures with the priorities of the state plan and the state administration. Third, states are improving decision support tools and models. Fourth, transportation agencies are focusing on more complex performance measures addressing quality of life, economic development, mobility, and safety. Finally, some states are expanding their measurement framework to encompass modal and intermodal measures.

The resource paper highlights examples of elements of successful practices. First, leadership and the attitudes of top management are keys to the successful use of performance measures. An ongoing commitment to improving the application of performance measures is part of this leadership. Second, regular monitoring and reporting are critical. Successful programs are based on a culture of accountability and regular monitoring and reporting. Third, policy-driven performance measures appear to be important factors at many agencies. The links between policy, programming, and monitoring establish the basis for performance measures in many states. Figure 1 illustrates the continuous cycle linking these elements at the Florida Department of Transportation.

A fourth element of successful programs is building ownership among staff and programs within the department. Fifth, the use of practical measures tied to compelling priorities can help build support. Sixth, ensuring that there is support from the legislature and other policy makers is important. Seventh, providing information to customers on the benefits of performance measures is important. Finally, setting targets is critical. If we do not set our own targets, we risk other groups setting them for us.

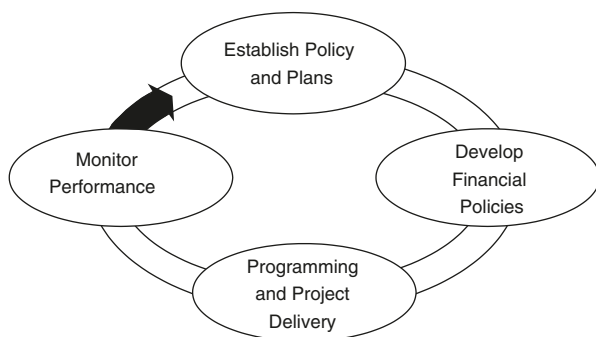


FIGURE 1 Performance measurement cycle of the Florida Department of Transportation.

Successful practice requires integration and institutionalization within transportation agencies. This integration encompasses legislative governance, executive initiatives, the budget process, and plans and programs. Incorporation of strategic plans, transportation plans, capital programs, and project selection and design into the process is important.

Montana's performance programming process provides one example of an integrated approach. It provides a method to develop an optimal funding allocation and investment plan based on strategic highway system performance goals and the continual measurement of progress toward meeting these goals.

The Minnesota Department of Transportation has established 10 policies in the statewide plan. Each policy has related performance measures and targets. The department is now working on establishing priorities among these policies. Twenty-year targets have been set for the various performance measures. The targets have been established on the basis of customer expectations, engineering, and other factors.

The Minnesota Department of Transportation's district planning process focuses on a 2008 to 2030 horizon. Two scenarios are included. The first is the performance-based plan, which includes the investments needed to meet targets by 2023. The second is the fiscally constrained plan, which includes priorities based on forecast revenues. System preservation is a top priority at the district level. Another priority is to allocate resources in constrained plans to meet pavement targets by 2014 and to make progress toward bridge targets by 2023.

The integration of performance measures into project delivery, maintenance, operations, and information technology projects and administrative support is also occurring at many transportation agencies. Examples of these approaches include Wisconsin's maintenance accountability program and Minnesota's operations and maintenance performance snapshot.

The resource paper identifies a number of emerging activities under way at transportation agencies. These activities focus on more proactive applications of performance measures. Examples of these approaches include forecasting, modeling, scenario planning, life-cycle costing and optimization targets, and trade-off analysis.

The future toolbox for performance measures will include a number of elements. First, we will see more use of geographic information systems to map performance gaps and other information. Second, dashboards and other measurement software will be enhanced. Third, auditing performance data will become more commonplace. Measuring cost and competitiveness will be a priority. Measures for performance-based contracting will also be developed, along with benchmarking.

A number of lessons can be identified from the experience to date with the use of performance measures at transportation agencies. First, it is important to keep performance measures simple and understandable. Second, take small steps, establish your system, learn as you go, and keep improving. Do not wait for perfect measures and data. Finally, policies must drive measures.

In closing, I would like to highlight a few of the challenging issues facing transportation agencies. Working to focus on a few critical strategic measures rather than accountability for everything we do continues to be a challenge. Linking agency performance measures to individual performance accountability is being explored at some agencies. Many agencies continue to struggle with vision and innovation versus day-to-day management. Finally, cooperation among state, regional, and local partners continues to be a challenge in some areas. Thank you.

INTEGRATING PERFORMANCE MEASURES ACROSS MULTIPLE JURISDICTIONS

Lisa Klein

I appreciate the opportunity to participate in this conference. I have been asked to talk about integrating performance measures across multiple jurisdictions. I will use two examples to highlight some of the experiences we have had at the Metropolitan Transportation Commission (MTC) in the San Francisco Bay Area with the use of performance measures involving multiple jurisdictions: a local pavement management system and a ferry boat fare box recovery measure.

The pavement management system in the San Francisco Bay Area is a successful example of integrating performance measures across multiple jurisdictions. MTC developed a pavement management software system in the 1980s to document aggregate funding needs for local street repair in the area's long-range planning process. The pavement management system provides an average score for pavement condition in each jurisdiction. It provides a numerical value from 0 to 100, with 100 equating to brand new pavement. There are 101 cities in the nine-county Bay Area. Most cities use MTC's pavement management system software.

Starting in 2001, the average condition score was published in the *Bay Area State of the Transportation System* report. The scores are reported by jurisdiction and ranked in order from highest to lowest. The local media report the results of the annual pavement management system rankings, especially the communities with the best and the worst average pavement condition scores. We have found that the annual results are discussed at the community level.

The city of Petaluma, which has had the lowest score for the past 2 years, provides one example of how the pavement condition index measure contributes to local discussions and actions. The city's low rating has been a topic of discussion among the city council, local interest groups, and other organizations. A year ago, the city council placed a measure on the ballot to increase the city utility fee to help fund pavement improvements. While the measure was not approved by voters, the city council has allocated additional funding for pavement improvements. City officials have been quoted in the local paper citing their new, improved pavement condition score. The city of Santa Clara is at the other end of the rating scale, ranking first in 2002. The Santa Clara city council formally recognized the public works department for achieving the top pavement rating.

A number of elements appear to contribute to the successful use of the pavement management system. First, the ability to contribute to the discussion of pavement needs is based on a substantial investment by MTC. A significant cost was involved in the initial development of the software. There is also a significant cost associated with its ongoing use and with providing technical assistance to communities. This support has established confidence among MTC, the MPO, and the local jurisdictions in the quality of the data used in the system.

Second, a state law aids in the use of the pavement management system. California law requires that MPOs certify that local jurisdictions have a pavement management system in order to receive federal and state funding. This ensures that we have access to the data on a regular basis. Third, the pavement management system measures a concept the customer understands. Although the pavement condition index is abstract, it is understood by community staff and policy makers, interest groups, and the public. There is some concern, however, that the focus on individual rankings may detract from the overall need to invest in pavements in the region. Fourth, the pavement management software and process provide a consistent measure that is accepted by technical staff. Timeliness is a problem, however, because there is a lag time between the reporting of data by communities, the time the data are available to MTC, and completion of the annual updates.

The second example of integrating performance measures across jurisdictions is the ferry boat fare box recovery measure. Funding for ferry capital and operating costs has traditionally come from bridge toll revenues, which are dedicated to transit. There has been concern recently about the cost-effectiveness of some of the ferry routes. In 2002 the commission established a 40 percent fare box recovery standard for ferry operators. A 3-year ramp-up period was provided. This fiscal year will be the third year of the ramp-up period, and

the next fiscal year will be the first when the fare box recovery ratio will be considered in allocating funding. In 2000 the fare box recovery ratio of the three ferry operators ranged from 40.5 to 73.2 percent, and the 3-year average from 1998 to 2000 ranged from 34.5 to 70.9 percent. There is also discussion of establishing a fare box recovery ratio and other operational performance measures for new transit projects funded through a recent increase in tolls.

It is too soon to tell for certain how the ferry boat fare box recovery measure will work out. It will probably not be as successful as the pavement management score in terms of integration across multiple jurisdictions. It appears that no service changes have been made in response to the measure. A number of factors may contribute to some of the push back from the three operators. First, there are unique elements or special circumstances associated with the different ferry routes. Second, compared with the pavement management example, the ferry box recovery measure lacks an established foundation. The operators would say that MTC is on dangerous ground when it comes to measuring transit operations. The stakes are also higher in terms of influence on future funding levels. Third, the measure may not be aligned with constituents' interests. Reducing ferry service that does not meet the fare box recovery ratio is certainly not in the best interests of residents who use these routes. Finally, with only three operators, compared with the 101 cities with pavement management systems, it is easy to make the case that each has somewhat special circumstances to be considered.

INVOLVEMENT OF CUSTOMERS IN PERFORMANCE-BASED MANAGEMENT

Sarath Joshua

I appreciate the opportunity to talk about the experience with involving customers in performance-based management at the Maricopa Association of Governments (MAG). The Phoenix area is experiencing rapid population growth and development. While improvements are being made to the freeway system, they are not keeping up with development. I will first describe the customers of an MPO. I will highlight what MPOs manage and discuss ways MPOs can measure performance. Finally, I will provide some examples of how MPOs can involve customers in developing and using performance measures.

It is first important to define the customers of an MPO. An MPO is primarily a regional collaboration of local governments. As a result, an MPO's primary customers are local jurisdictions and agencies. MPOs are in turn customers of the state and federal governments. MPOs

work with customers to develop regional solutions to critical problems. Examples of MAG plans addressing important issues include the regional long-range transportation plan, the 911 system plan, the air quality plan, the intelligent transportation system strategic plan, and the concept for a transportation operations plan.

While MPOs are typically not operating agencies, they are responsible for transportation planning and programming activities. MPOs are responsible for the development of a region's transportation plan identifying how state and federal transportation funds will be spent. MPOs are responsible for developing plans to meet air quality conformity requirements. MPOs also develop future growth scenarios for the region through extensive modeling to assist in decision making.

MPOs can use performance measures both internally and externally. Examples of internal performance measures include regional funds obligated on time and projects completed on time and on budget. Outcome measures can be established and program activity can be monitored. Measures from an external customer viewpoint might include maintaining pace with changing conditions, maintaining or improving the quality of life, improving safety, reducing traffic congestion, and maintaining or reducing travel times.

MPOs can involve their customers in developing and monitoring performance measures in a number of ways. First, decisions at MPOs are made in an open environment with direct involvement of customers. MPOs have formal committee structures involving all stakeholder groups. All MPO plans and decisions are subject to extensive public review.

The development of the regional concept plan for transportation operations at MAG provides a recent example of involving customers in developing performance measures. The plan focuses on improving transportation operations in the region. We asked representatives from the cities, counties, transit agencies, and other organizations to identify the current operation of the regional, local/regional, and local transportation systems. Participants were then asked their expectations of operations in 3 years and in 5 years if different improvements were made. The results of this assessment were used to help identify the goals of the operations plan.

The regional transportation plan includes performance measures for a number of areas. Maintenance and safety performance measures address cost and the number of crashes. Access and mobility performance measures focus on the level of service and delay. There are also performance measures related to sustaining the environment, accountability, and planning. The regional concept plan for transportation operations includes performance measures of freeway mobility, arterial mobility, incident duration, and integrated operations. For example, the 3-year goal is to reduce the duration of

incidents by 10 percent. The 5-year goal is to reduce the duration of incidents by 70 percent.

LINKING NATIONAL PERFORMANCE MEASURES TO EXTERNAL CUSTOMERS

Jeffrey Lindley

It is a pleasure to have the opportunity to share with you the Federal Highway Administration’s (FHWA’s) 3 years of experience in developing and tracking congestion performance measures at the national level. FHWA started an effort in late 2000 to develop metrics for its internal planning process. We were also interested in better understanding the causes of traffic congestion, being able to track congestion trends, and presenting this information to external audiences.

We now have a fairly extensive ongoing program of congestion monitoring, management, and research. The FHWA Office of Operations provides considerable information on congestion monitoring on its webpage, ops.fhwa.dot.gov. Congestion and reliability performance measures will be discussed in more detail at the Tuesday morning session. There is also a breakout session on congestion and reliability.

My comments focus on four general topics. First, I will discuss the number and the type of measures that were selected. Second, I will describe how the best measures were identified. Third, I will address the process of setting targets for the selection of performance measures. Finally, I will highlight the importance of communicating the results of performance monitoring to key external audiences, especially the public, the media, and policy makers.

FHWA uses congestion measures focusing on the average duration of congested travel, the travel time index, and the buffer index. There are two measures addressing the average duration of congested travel. The first is that for any 5-minute interval a trip is congested if its duration exceeds 130 percent of free-flow or uncongested duration. The second measure is that if more than 20 percent of all trips in the network are congested in any 5-minute interval, the entire network is congested for that time interval. The travel time index is defined as the ratio of congested and uncongested travel times averaged over all congested trips. The buffer index is defined as the ratio of total travel budget required for 95 percent on-time reliability over the uncongested travel time averaged over all congested trips. The buffer index provides a measure of not only how congested the system is but also how reliable the system is. It provides a performance measure from the customer’s perspective. The buffer index represents the amount of time commuters need to build into their trip to arrive at their destination on time 95 percent of the time.

Figure 2 illustrates the concept of the buffer index. The dashed line is the travel time index. It reflects the typical morning and afternoon peak periods, when congestion levels are highest. The buffer index is the solid line. While it tracks the travel time index, the buffer index line is higher, reflecting the extra time that must be built into a trip to arrive on time. As you can see, the buffer index for the afternoon peak period is about 100 percent higher than the travel time index.

Survey research indicates that travelers value reliability and that system unreliability is a major concern. Travelers, especially peak-hour commuters, are willing to put up with some congestion. What they do not like is when a trip takes 20 minutes one day, 40 minutes another, and 90 minutes on a day with an accident.

FHWA highlights these performance measures in a dashboard that is updated monthly. Figure 3 is an example of a page from the dashboard, which provides a summary of the current status of the three performance measures. A monthly urban congestion report is prepared and presented to FHWA management. This is currently an internal document.

I will highlight a few of the things we have learned in developing and applying national congestion performance measures. The first lesson relates to the number and the type of measures. We spent a good deal of time examining possible performance measures. We finally settled on the three I described previously. While one performance measure may not be enough for most measurement areas, focusing on a few key measures is important. Also, do not just select a measure because it is easy to get the needed data. It is important to identify measures that will be of use, not measures that have data available. We would not have developed the buffer index if we had focused only on easy-to-obtain data.

The second lesson addressed selection of the measures that best captured the most important aspects of a problem. The measures FHWA selected focus on the extent of

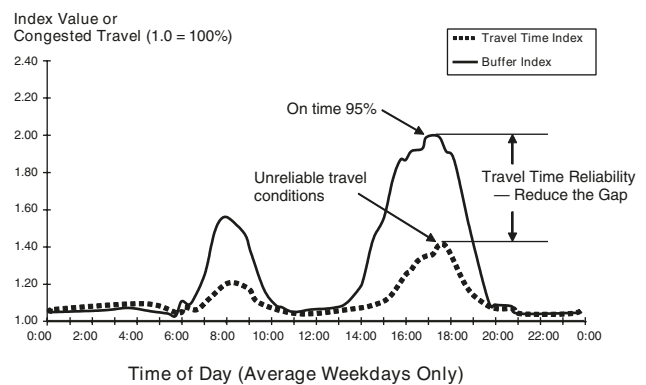


FIGURE 2 Performance measurement from the customer’s perspective: reliability—travel time index and buffer index by time of day.

NATIONAL CONGESTION INDICATORS									
	Cong. Travel Time/Day			Travel Time Index			Buffer Index		
NUMBER OF CITIES	DOWN > 5%	NO CHANGE	UP > 5%	DOWN > 5%	NO CHANGE	UP > 5%	DOWN > 5%	NO CHANGE	UP > 5%
Vs. Same Qtr 2002	3	2	5	4	3	3	5	2	3
UCR Composite	6.3 Hours ↑ 3.6%			1.50 ↓ 2.0%			2.04 ↓ 1.0%		
	Extent			Intensity			Reliability		

Dashboard Status: Yellow

FIGURE 3 Example of FHWA dashboard congestion measures. UCR = urban congestion report.

congestion, the duration of congestion, the intensity of congestion, and the reliability of the system. The third lesson focuses on selecting performance measure targets. Identifying appropriate targets may be more of an art than a science. One issue to consider is how aggressive the targets should be. FHWA's current congested travel target is simply to reduce the growth in congested traffic. This target has been kept simple until we have real-time traffic data.

It is also important to remember that how a target is defined may influence behavior. We are currently examining the targets being used in different areas for incident management. Some states, such as Washington and Florida, have set a target of clearing all incidents within 90 minutes. Other areas, including Dallas, have set a target of clearing incidents in an average of 15 minutes. While both targets use clearance times, the targets may lead to different behavior. Areas with a 90-minute target may focus more on clearing major incidents. Areas using an average clearance time might focus on clearing minor incidents more quickly.

The final lesson focuses on communicating with external audiences, which include policy makers, the media, and the public. Our experience indicates that while these groups may not understand everything about the buffer index, they do understand reliability. Measures can be as complicated as they need to be, but how we explain what they mean needs to be straightforward and easy to understand. It is important to provide a message that resonates with the audience you are trying to reach.

CEO PERSPECTIVE: WHAT DO YOU DO WITH THE MONEY

David Ekern

We have heard a number of common themes from speakers this afternoon related to the growing use of

performance measures by state transportation agencies. First, the intellectual capacity and the cultural changes in agencies are a critical aspect of initiating performance measures. Second, performance measures need to be tailored to the audience. Third, performance measures are being undertaken as part of a family of initiatives. Finally, in many ways, performance measures are all about translation, sales, and speed.

I have completed my first year as Director of the Idaho Department of Transportation. When I started there were a number of key elements influencing the department. First, funding focused on the remnants of a 4-cent increase in the gasoline tax that was approved in 1996 on the basis of a commitment by the department to improve the performance of the transportation system. Second, there was apprehension of a change in administration and a worry about shifting focus. Third, the department had disconnected initiatives. Finally, transportation funding in the state had been stagnant for the previous 4 years, with no new taxes.

The future transportation system in Idaho is international in scope, intermodal in form, intelligent in character, and inclusive in service. On the basis of recent dialogues with citizens throughout the state, I suggest that customers expect at least four basic things from the transportation system. First, customers want a multi-modal system that provides choices. Second, the transportation system should provide a quality of life that respects history and protects the environment. Third, transportation agencies should engage people in making decisions about the system. Finally, customers want a system that achieves goals within the bounds of reasonable funding. You will note the use of the term reasonable funding rather than adequate funding. Reasonable funding was the term we heard from our customers and policy makers.

We spent a good deal of time within the department talking about the transformation to performance-based

20th Century	21st Century
• Public works (output)	• Mobility (outcomes)
• Project- focused	• <i>Customer-oriented</i>
• Our jurisdiction	• System -focused
• 8-5	• 24X7
• Reactive	• Proactive
• Business as usual	• <i>Performance-driven</i>
• Do it our way	• Partnerships

FIGURE 4 Emerging changes in cultures at the Idaho Department of Transportation.

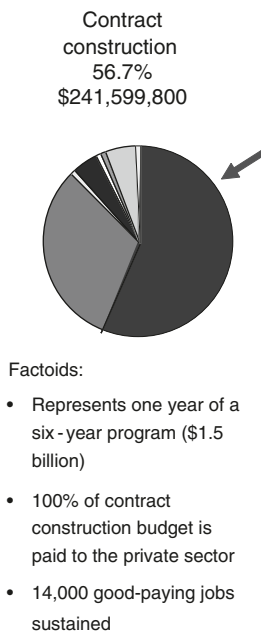
management and what is expected of department employees. We also made presentations to numerous groups and talked with customers throughout the state. Figure 4 highlights some of the emerging changes in culture within the department related to focusing more on performance-based management.

The department’s budget and funding request is presented to the legislature every year. We presented the state’s trend indicators, which include vehicle miles traveled, automobile registrations, driver’s licenses issued, population, and total fuel consumed. All of these indicators are increasing.

We use these trend indicators to help show policy makers and the public that Idaho is a growth state. The state does not experience the severe congestion levels and other problems facing many parts of the country. We will become more like those areas, however, if we do not deal with these issues. The flat budget over the past 4 years has not helped address these problems. Our challenge was to present these trends and the department’s performance measures to the legislature in a meaningful way.

Rather than just present the department’s budget in the normal way, we identified the six major products or services the department provides and highlighted the funding associated with each. A consistent format was used that focused on three messages. These messages were the funding amount, the output, and the context. This approach provides a consistent message for the annual appropriations process. Figure 5 provides an example of the information presented for contract construction services.

The department’s legislative approach built on positive factors. For example, we highlighted the fact that the department returns 94.5 percent of every dollar it receives in some type of product or service. It appears that this approach is working, because the legislature approved the department’s budget as presented for the first time in 22 years.



15 Bridge Projects (rehabilitation and improvement)	\$ 24.9 Million
79 Lane Miles of Major Capacity Projects	\$ 81.3 Million
1,141 Lane Miles of Preservation Projects	\$ 57.4 Million
47 Safety and Operations Projects Intersections, turn bays, guardrail, ports of entry, operations, bridge decks, planning and research, intelligent transportation systems, and training.	\$ 19.5 Million
86 Design and Right-of-Way Projects	\$ 25.1 Million
128 Local Highway Projects	\$ 33.4 Million
ECONOMIC INVESTMENT:	\$241.6 Million

FIGURE 5 Example of Idaho Department of Transportation’s legislative message: FY 2005 projected outputs for contract construction services.

Tying Together Performance-Based Program Development and Delivery

George Scheuernstuhl, Moderator, *Denver Regional Council of Governments*

Steven M. Pickrell, *Cambridge Systematics, Inc.*

Robert Romig, *Florida Department of Transportation*

Jeff Price, *Virginia Department of Transportation*

Brian Smith, *California Department of Transportation*

Gregory Selstead, *Washington State Department of Transportation*

PERFORMANCE CHALLENGE: LINKING PERFORMANCE-BASED PROGRAM DEVELOPMENT AND PROJECT DELIVERY

Steven M. Pickrell

Good morning. It is a pleasure to have the opportunity to present the resource paper on linking performance-based program development and project delivery. I acknowledge my two coauthors, Patricia Hendren and Lance Neumann, both from Cambridge Systematics, Inc.

I will start by describing performance-based program management and performance-based program development. I will discuss project delivery and performance measures and provide examples from state departments of transportation and other agencies. I will highlight the importance of linking performance-based program development and project delivery and some of the challenges that may arise in making this connection.

Performance-based program management is made up of three components: performance-based program development, performance-based project delivery, and system monitoring and reporting. The focus of our resource paper and my presentation today is on linking program development and delivery.

Application of performance-based program development varies across agencies. Examples include the Pennsylvania Department of Transportation's performance-based long-range transportation plan, which links objectives and actions to broad statewide goals; the performance-driven project prioritization approach to long-range planning adopted by the Arizona Department of Transportation;

and performance-based programming at the Montana Department of Transportation.

Possible benefits of performance measures in program development include linking statewide goals and projects and prioritization of the most effective programs and projects. Performance measures also enhance accountability and assist in allocating funds. Performance measures can be used in trade-off analysis and in benchmarking. The results of these efforts can be communicated to diverse audiences inside and outside an agency.

Performance-based program delivery applications also vary across agencies. Examples include a project delivery management group at the Arizona Department of Transportation and the use of performance-based interactive web-based tools at the Virginia Department of Transportation. The California Department of Transportation (Caltrans) uses a performance-based program delivery process in response to legislative mandates, and the New Jersey Department of Transportation uses a performance-based accounting system.

The real question addressed in performance-based program delivery is whether the expectations to deliver projects on time, within scope, and within budget are being met. There will invariably be changes in a state department of transportation's program as individual projects are delivered; what is needed is a better way to track and deal with changes in project scope and schedule. There is a need to understand, manage, and explain changes that occur to projects between the time the program is developed and the time projects are delivered. Many times there is not an explicit feedback loop in the process, so that the

benefits of the program, as actually delivered, are never compared with the expected or “promised” benefits that were used to sell the initial program.

Benefits of performance measures in program delivery include promoting efficient program management and program delivery. They can help minimize unnecessary or avoidable changes in scope, cost, and schedule and maintain the integrity and intended impact of the approved program. Performance measures can be used to track the number, extent, and cause of scope, budget, and schedule changes. This information can be used to identify process improvements. The results of these efforts can be communicated both internally and externally. They also demonstrate accountability to policy makers.

There are many reasons to consider linking performance measures for project programming and project delivery. With performance-based program development only, there is a chance that the most effective program of projects will be identified but then delivered inefficiently. With performance-based project delivery only, there is a chance that project delivery will be efficient but that the overall program will include marginal or suboptimal projects. When project programming and project delivery are linked, the most effective projects are selected and are delivered efficiently.

It is important to understand key objectives for using performance measures with planning and program development and with program delivery. A key objective in applying performance measures to planning and program development is allocating resources to programs and projects to achieve system performance goals. A key objective with program delivery is delivery of selected programs and projects as efficiently as possible with minimal impact on cost, scope, and schedule.

The types of performance measures used with project programming and project delivery are different. Performance measures with planning and program development address system condition and performance, such as pavement condition, congestion, and safety. Performance measures with program development typically address cost, scope, schedule, and work safety and quality.

Data are collected and reported over longer periods of time with planning and development performance measures, since the influence of selected programs and projects typically is not known for several years. Project and program delivery information is usually tracked on a regular basis, such as annually, quarterly, or monthly.

External factors that may influence planning and program development performance measures include driver behavior, demographic changes, and related factors. Unexpected changes in external factors may influence program delivery performance measures. Challenges related to planning and program development performance measures include selecting measures, data availability, analytic tools to predict performance, external factors, defining

expenditure impacts on system performance, and monitoring over time. Challenges related to program delivery performance measures include selecting appropriate measures, data availability, tracking project changes, external factors, and assessing the impact of program and project changes on system performance.

Figure 1 illustrates the performance-based management structure. The three major components include program development, project delivery, and monitoring and reporting. The feedback loops are important to determine whether the set of projects ultimately delivered had the desired impact on system performance and broad goals and objectives. Greater integration of the program development and delivery functions will help to improve outcomes, that is, efficient delivery of an effective program of projects.

Bringing program developers and project managers together early in the process can help establish ongoing coordination and operation. It is important to emphasize the value and importance of both processes, so that internal teams are equally committed to one another’s goals and to the ultimate objective, system performance. Applying the same criteria used in the original project selection to evaluate the impact of proposed scope changes at the project delivery stage will help determine whether the changes should be accepted and what the impact of the changes on overall program benefits will be. Posting construction management results internally and externally is also beneficial in keeping agency staff and stakeholders involved in the outcome. Sharing knowledge among all groups is important. The Washington State Department of Transportation’s Gray Notebook provides one example of sharing

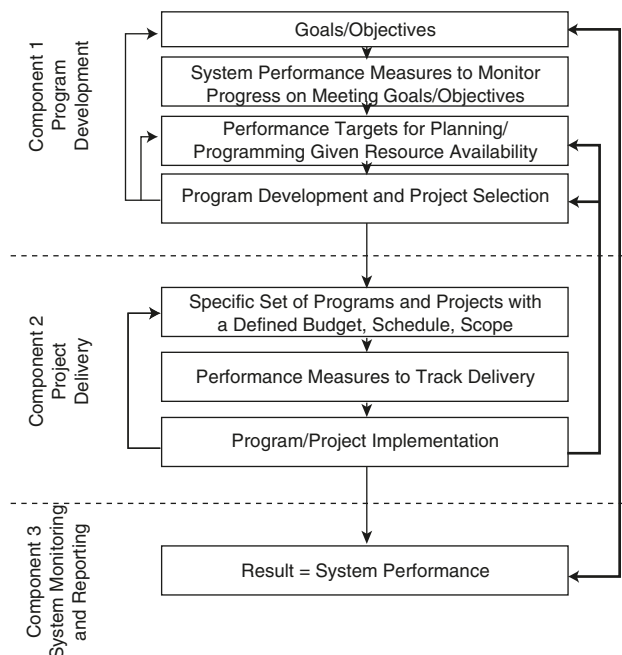


FIGURE 1 Performance-based management structure.

information among numerous groups. Project delivery becomes an agency goal, not just a department goal, with performance-based project development and delivery.

Agencies may face numerous challenges in the implementation and application of performance-based project development and delivery. Examples of possible challenges include time and resource constraints, internal organization restrictions, internal and external factors, and communication. The resource paper includes additional suggestions for improving the link between performance-based program development and delivery.

SETTING TARGETS AND MAKING TRADE-OFFS: PERFORMANCE-BASED RESOURCE ALLOCATION

Robert Romig

It is a pleasure to have the opportunity to talk about performance-based resource allocation at the Florida Department of Transportation. I will start by providing an overview of the department and then talk about Florida's asset management process and performance-based resource allocation.

The Florida Secretary of Transportation is the chief administrative officer of the department. The Florida Transportation Commission is the advisory board to the department. The Florida Department of Transportation is a decentralized agency, with a \$6 billion annual budget. The agency is trust funded. It currently has about 8,000 employees, which is down from a high of 10,300 employees in 1999. The department has moved toward more extensive use of the private sector over the past 5 years. Consultants are used for some 75 percent of planning activities, 82 percent of design, 100 percent of construction, and 80 percent of maintenance.

The department is responsible for major elements of the transportation system in the state. Approximately 12,000 of the 114,500 centerline miles of public roads are owned by the department. These state roads carry about two-thirds of all public road traffic. The department maintains 6,200 of 11,000 bridges in state. It also provides funding and technical support to 14 seaports, 22 commercial airports, 3,000 miles of rail, and 18 transit systems.

Florida's asset management process is policy driven. It is based on a strong statutory policy framework. Trade-offs between preservation and capacity programs are made at the policy level. There are both management systems and performance-based programming and budgeting systems. The asset management process provides a systematic approach to decision making. It represents a continuous cycle that includes evaluation and feedback.

Policy guidance for investment decisions comes from a number of sources at the federal, state, regional, and local

levels. Federal and state laws and regulations provide general guidance. The Florida Transportation Plan and the Strategic Intermodal System (SIS) provide more specific direction for investments. Regional policy plans, local comprehensive plans, and metropolitan planning organization (MPO) plans also provide detailed guidance.

The legislative direction provides the statutory policy framework for the process. Principles guiding investments include the preservation and maintenance objectives and the capacity objectives. Among the capacity objectives are that at least 50 percent of new discretionary funds will be allocated to the Florida Intrastate Highway System (FIHS) and that a minimum of 15 percent of state funds will be dedicated to public transportation. The planning and programming requirements provide program stability and help link statewide and local priorities.

Figure 2 illustrates the linkage between goals and program funding. It shows the links among the long-range transportation plan, the short-range component, and the short-range work program and list of projects. Figure 3 illustrates the elements under the general umbrella of asset management. Data collection, performance measures, management systems, and decision support tools are all part of the process.

The pavement management system is a major component of the preservation portion of the program. The department conducts an annual pavement condition survey that examines ride quality, crack severity, and rutting. The pavement management system objective is to have at least 80 percent of pavement on the state highway system meet department standards.

The bridge management system is another component of the preservation program. Bridges in Florida are inspected every 2 years. These inspections help determine the need for preventive maintenance, major or minor repair work, and replacement. The objectives are

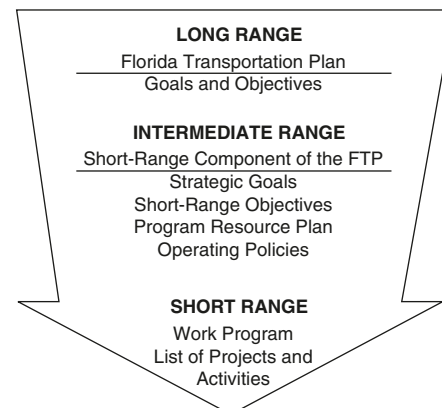


FIGURE 2 Funding directed by policy and program objectives identified in legislation and Florida Department of Transportation plans.

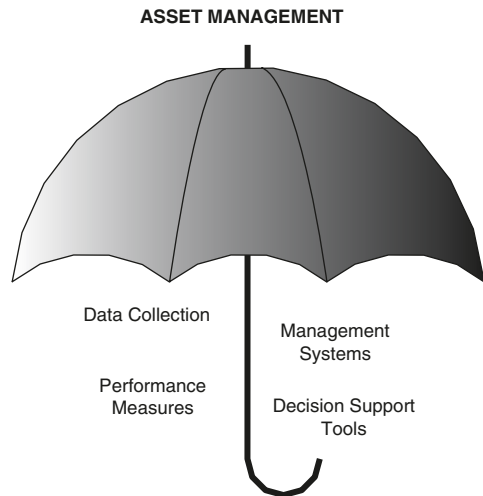


FIGURE 3 Components of Florida's asset management program.

that at least 90 percent of department-maintained bridges meet department standards and that all bridges open to the public be safe.

The maintenance program is the third element of the preservation and maintenance program. A maintenance rating program is used to evaluate field conditions. The following are elements of this program:

- Roadway—potholes and pavement joints;
- Traffic services—signs, lighting, and striping;
- Roadside—unpaved shoulders, fences, and sidewalks;
- Drainage—storm drains and ditches; and
- Vegetation/aesthetics—mowing, litter, and trimming.

The objective is to have 100 percent of roads on the state highway system achieve the maintenance standard.

The highway capacity program focuses on adding new facilities and expanding existing roadways as identified in the various plans. Improvements to the FIHS are needs driven on the basis of the 10- and 20-year plans and the 20-year cost-feasible plan.

The decision support system includes safety, congestion, intermodal connections, economic development, and pavement condition. Capacity projects on other arterials fund priorities of MPOs and counties.

There are capacity program performance measures for highways, public transportation, and the SIS. The highway performance measures include maintaining the rate of change in person-hours of delay on the FIHS in urbanized areas through 2007. The nonurbanized measure is presently under development. The transit performance measure is to increase transit ridership at twice the average rate of population growth through 2011. The SIS measures are being developed but will have a system focus and will consider efficiency, reliability, and economic impacts.

One issue of concern to all transportation agencies is monitoring project implementation. In Florida, the strong policy framework and program stability help ensure that plans are implemented. Also, financial planning helps support program objectives. The department uses monthly production management meetings, annual agency performance reports, and annual evaluations of work programs by the commission as part of an ongoing performance production-monitoring program.

A number of approaches are used to monitor and to report on progress. These approaches include the ongoing Transportation Commission productivity and performance review, the Florida Department of Transportation Executive Board annual program planning review process, the annual report on legislative-directed measures, and monthly reviews and monitoring by the Executive Board of dashboard measures and other information.

As do those of other states, the department faces a number of challenges in using and reporting on performance-based resource allocation techniques. The first challenge relates to communication and how the performance reports should be adapted to various users. A second is integrating large databases and management systems. A third is having consistent data over time, especially data from various sources. A fourth relates to developing performance measures for mobility and intermodal systems. A final challenge relates to accountability for performance measures outside the responsibility of the department.

In closing, I would like to highlight a few of the critical success factors in the department's approach. First, there is accountability due to a clear link between policy, programming, and performance monitoring. Second, there is strong decision-maker support and involvement. Third, the long-term and short-term cyclical process supports the program focus. Fourth, the program is based on credible data from solid data collection, quality control, and analysis techniques. Fifth, these data are converted into useful information.

The following websites provide additional information on the various programs and policies in Florida:

- Agency overview: www.dot.state.fl.us/financial_planning/AGENCY_OVERVIEW.pdf
- 2020 Florida Transportation Plan: www.dot.state.fl.us/planning/ftp2020/default.htm
- Short-Range Component and Annual Performance Report: www.dot.state.fl.us/planning/policy/pdfs/src.pdf
- Work Program Instructions: www.dot.state.fl.us/programdevelopmentoffice/Development/WP_instructions.shtm
- Florida Transportation Commission Performance Measures: www.ftc.state.fl.us/performance%20and%20production%20review%200102.pdf

Thank you for the opportunity to describe the Florida Department of Transportation's performance-based asset management program. I look forward to discussing your thoughts and ideas in the breakout session.

PERFORMANCE-BASED PROGRAM DEVELOPMENT AND DELIVERY

Jeff Price

It is a pleasure to participate in this conference and to have the opportunity to share our experience in Virginia with performance-based program development and delivery. During the 1990s and early 2000s, the public perceived the Virginia Department of Transportation as a poorly managed organization that did not fulfill its promises. In 2002 Governor Warner took office and appointed a commissioner with a "no-nonsense" business reputation to address problems the department was having with program development and delivery and to improve the department's credibility. Immediately upon his appointment, the commissioner began seeking ways to improve the situation.

The commissioner found that to assess the construction program, he had to meet with a room full of people. Even then he could not get a clear answer. Lines of responsibility were confused, and it was difficult to identify who was accountable.

The commissioner eliminated several executive positions, reassigned executive staff, and reorganized the department. He also set goals, clarified responsibilities, communicated that staff would be held accountable for fulfilling their responsibilities, and started examining ways to measure and manage performance.

The commissioner made a departmentwide announcement that the focus going forward would be on the flawless delivery of the 6-year improvement program. Virginia's General Assembly requires the Commonwealth Transportation Board to approve the program, which provides the development and funding schedules for all construction projects over a 6-year planning horizon.

To gauge how well the department is achieving this goal, measures that apply to both project development and delivery were developed. We track on-time performance in preliminary engineering and construction of each project. A project is considered developed on time if it goes to advertisement by the original advertised date, which is set following the initial scoping meeting. A project is delivered on time if the completed project is inspected and accepted by the original due date.

A project is delivered on budget if it is completed for 110 percent or less of the original award amount. We use 10 percent over the award amount to account for risks such as unexpected field conditions. This percentage is

being scrutinized, and we may change the definition to 100 percent of award amount.

We believe strict interpretation of on time, on budget sends a message that we will be accountable, we will be good stewards of the taxpayer's money, project scope should not creep, and we will deliver what we promised when we promised it. It forces us to do a better job of project scoping, design and plan review, cost estimation, contract development, and project management.

The Virginia Department of Transportation has changed in a number of ways. Performance measures were not new to the department. In 1986 we tracked 276 performance measures, none of which were paramount. While we still track performance in many areas, the focus under the current commissioner is on the core measures of on-time and on-budget program delivery. We have developed better tools and management information systems, including the dashboard, the watch list, and the quarterly report. In addition to improving our ability to monitor development and delivery of projects, the commissioner began conducting monthly meetings with all project managers to discuss performance of active projects.

The dashboard is a web-based tool used by the department, contractors, and the public to monitor the development and delivery of construction projects. It provided a series of web pages highlighting information on projects and their on-time and on-budget status as they progress from development to delivery. Users can search and select projects by location, type, or date and can then drill down to obtain more specific information. Users can also communicate with the project manager through e-mail.

The watch list is an internal tool used by the commissioner and project managers to monitor the status of active construction projects. The commissioner uses the watch list during the monthly videoconference to discuss the status of the program, performance in each district, and projects that are experiencing problems. The open format of the meetings provides project managers with the opportunity to speak frankly and directly to the commissioner and often generates suggestions for dealing with emerging problems.

Figure 4 illustrates the dashboard watch list. The top section shows the status of construction contracts. It compares the inspector's estimated completion date with the original completion date to determine the number of days the project is behind. The total also includes contracts not started on time.

The report card, illustrated in Figure 5, is published quarterly and can be downloaded from the department's website. It is the commissioner's report to the Commonwealth Transportation Board and the citizens of Virginia. It includes his statement of the accomplishments and shortcomings of the previous quarter with graphs depicting our on-time and on-budget performance.

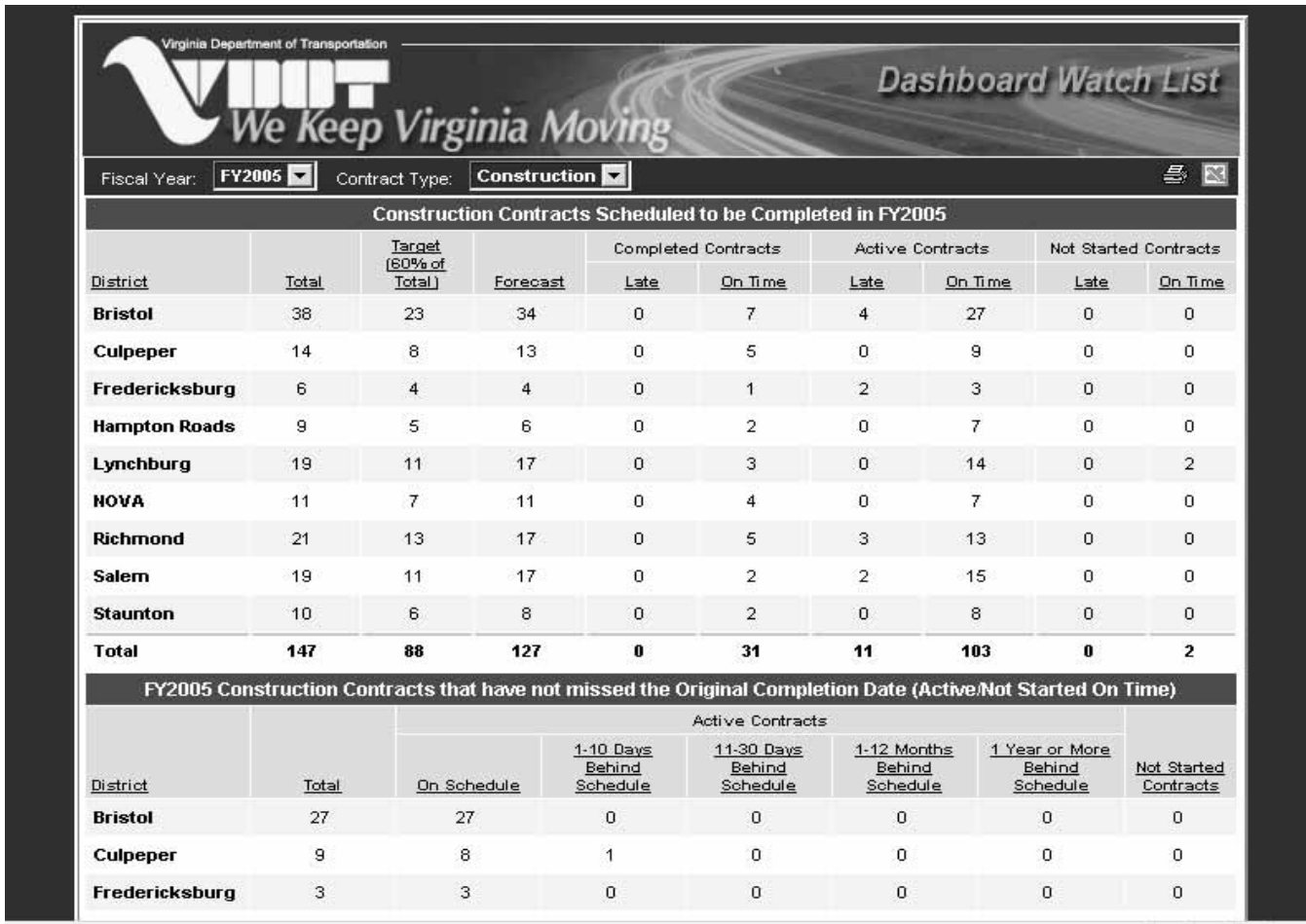


FIGURE 4 Virginia Department of Transportation dashboard watch list.

Figure 6 shows the improvement in the department’s on-time performance over the past 4 years for construction and maintenance projects. Performance has improved from a low of 20 percent of construction projects and 38 percent of maintenance projects being delivered on time in fiscal year 2001 to 36 percent of construction and 51 percent of maintenance projects in fiscal year 2004.

Figure 7 shows the improvement in the department’s on-budget performance over the past 4 years for construction and maintenance projects. Performance has improved from a low of 51 percent of construction projects and 59 percent of maintenance projects being delivered on budget in fiscal year 2001 to 73 percent of construction and 81 percent of maintenance projects in fiscal year 2004.

The bubble chart in Figure 8 illustrates both on-time and on-budget performance in fiscal year 2002. The size of the bubbles reflects the size of the project in dollars. The x-axis represents on-time performance, and the y-axis represents on-budget performance. All of the bubbles in the lower left quadrant were on time and on budget. All of those in the upper right quadrant were late and over budget.

Now compare the performance in fiscal year 2002 with performance in fiscal year 2003 and fiscal year

2004, as shown in Figures 9 and 10, respectively. These figures clearly show an improvement, as more projects have been completed on time and on budget.

Figure 11 illustrates overall performance for the past 3 completed fiscal years. Each bubble represents the center of gravity from all the projects shown in each of the previous three figures.

Part of our work in measuring performance involves identifying and analyzing factors that influence performance. We examined hundreds of work orders, which everyone believes is the main cause of projects being late or over budget. We found that generally work orders were written for a few reasons. These reasons included contract omissions, plan or design errors, utility and local government delays, force majeure, and unexpected site conditions. However, regression analysis indicated that while these are indeed significant factors, collectively they explain little of the variation in project delays and budget overruns.

So while the department addresses these factors, we continue to seek other factors influencing program development and delivery. It has become apparent that success depends on many factors working together.

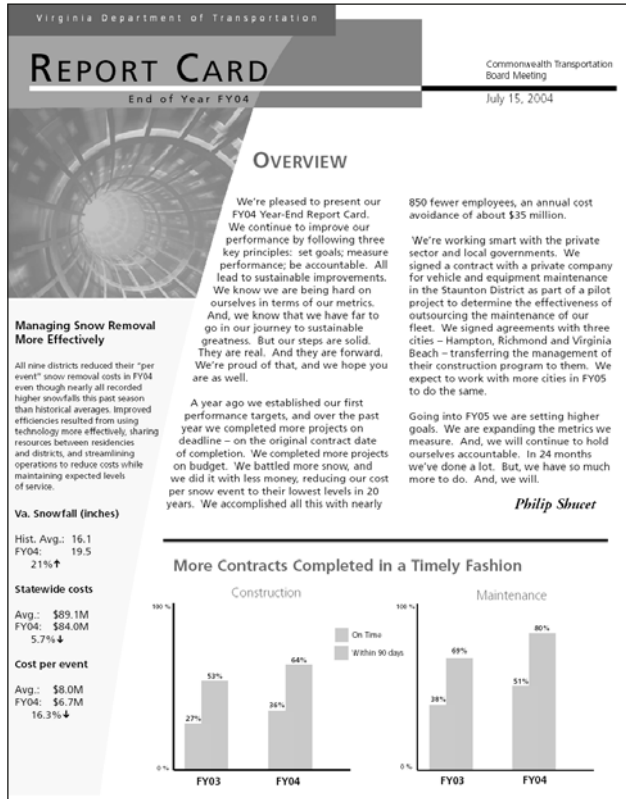


FIGURE 5 Virginia Department of Transportation report card.

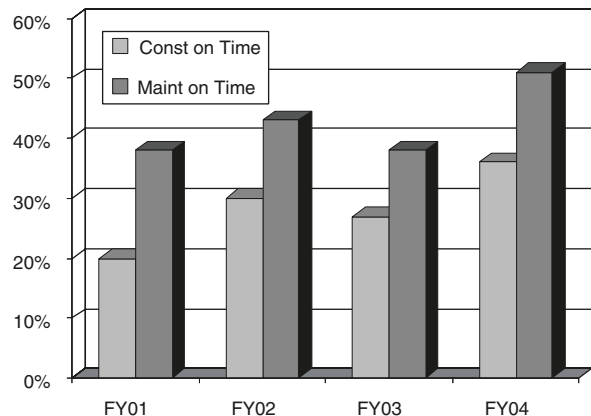


FIGURE 6 Virginia Department of Transportation construction and maintenance projects on time.

Creating tools that, in a very public way, show how you are doing and identify who is responsible has been a great motivator. Staff are more focused on achieving milestones and improving the processes they use to reach the targets set by the agency. We are examining contracts more carefully, with a focus on how we identify and allocate risk. We are taking a more systematic approach to risk assessment; we draw on data and experiences to formulate probabilities and contingencies for

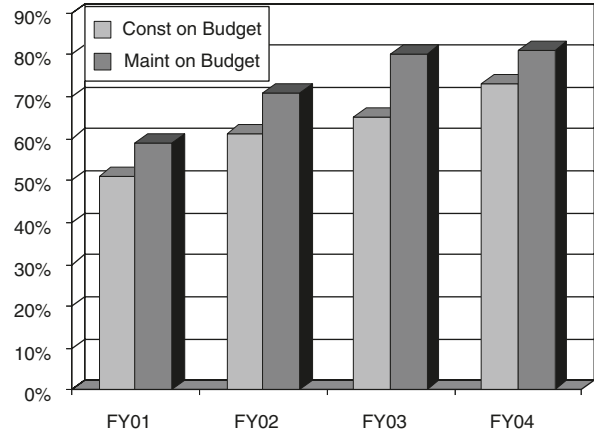


FIGURE 7 Virginia Department of Transportation construction and maintenance projects on budget.

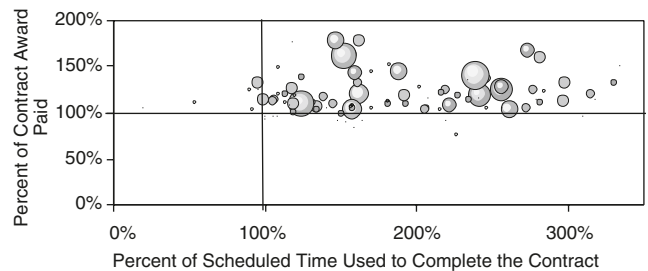


FIGURE 8 Virginia Department of Transportation contracts with final vouchers paid in fiscal year 2002.

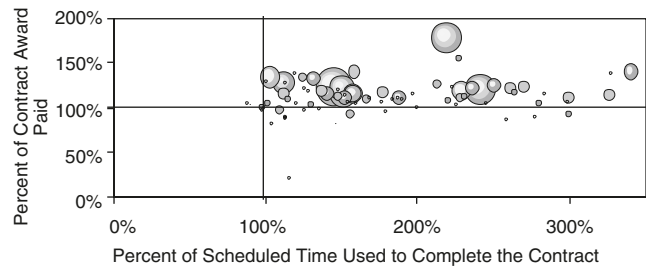


FIGURE 9 Virginia Department of Transportation contracts with final vouchers paid in fiscal year 2003.

risk events. We realize that utilities and local governments operate on their own schedules and that we must do a better job of coordinating our plans with theirs.

Again, our observation is that adopting an environment of accountability stimulates improvement. If you put the information out there and identify the people responsible, they will be more focused on achieving their targets. Tracking performance with the tools we have developed has focused people's attention on getting the job done. My office, which conducts process improvement studies, has seen a dramatic increase in requests for new studies. It is not enough simply to develop a performance measure, set a target, and tell people that

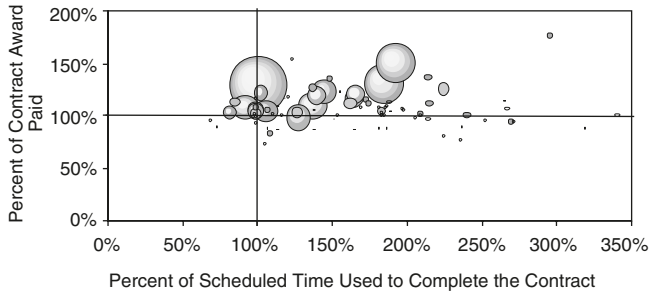


FIGURE 10 Virginia Department of Transportation contracts with final vouchers paid in fiscal year 2004.

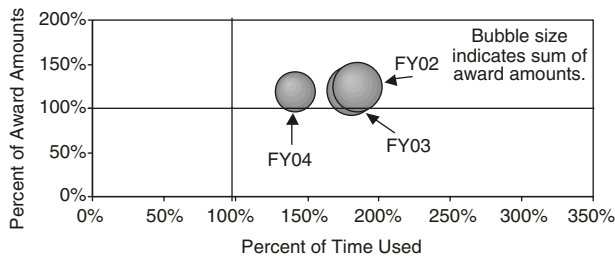


FIGURE 11 Center of gravity for projects in fiscal years 2002, 2003, and 2004.

by next month or next year you have to hit this target. You have to provide the means to get there. We now incorporate performance measurement in all process improvement studies.

Since data from several systems are used to measure performance, there has been a renewed interest in data accuracy. People who know they are responsible for specific data elements that influence what is seen on the dashboard are now much more careful about the accuracy, the completeness, and the timeliness of the data they enter. This has also led to discovering problems with projects sooner.

In addition, because getting a project to advertisement requires so many parallel functions and individual milestones, we are now examining the measurement of on-time performance in program development by the use of more than just the advertisement date. We are now considering measures of intermediate milestones, such as preliminary engineering approvals, environmental approvals, plan and design reviews, and right-of-way acquisition.

In conclusion, our experience has been that setting targets and demanding accountability have focused people's attention on the role they play in developing and delivering projects on time and on budget. Requests for assistance to improve business processes and performance have increased considerably. We are now incorporating performance measurement in all process improvement studies.

We have found that systems used to store information are of little value if that information is never used. The dashboard is simply a reporting tool. It contains no information. It retrieves information from other systems. When they were first implemented, we found that these other systems contained many errors and gaps. Staff advised us that we could not rely on these systems to provide accurate information about the status of projects. However, we found that once it was understood that project performance would be based on information in the underlying systems, the quality of data in those systems improved tremendously. Implementing the dashboard, the watch list, and other performance-reporting systems enables us to discover and address project problems sooner. Thank you.

LINKING SYSTEM PERFORMANCE MEASUREMENT TO DECISIONS—PROGRESS SINCE THE FIRST NATIONAL CONFERENCE

Brian Smith

At the conference 3 years ago, Caltrans's then Chief Deputy Tony Harris described California's activities related to performance measures. I will not repeat his comments related to California's use of performance measures to drive programming decisions. Instead, I will describe some of the progress the department has made since the first conference in 2001.

First, to set the stage, you have to remember the size of California. The state has 36 million people and is still growing. California has the world's fifth-largest economy. The annual gross state product is \$1.3 trillion. Approximately 37 percent of U.S. international trade flows through California. The 50,000 lane miles of state highway carry some 255 billion vehicle miles of travel annually out of 322 billion vehicle miles of travel statewide. There are 160,000 lane miles of local streets and roads. These figures indicate that the freeway system has to perform many different functions and serves local, regional, intrastate, interstate, and international traffic.

The transportation system in California is institutionally complex. Many parties are individually or mutually responsible for providing transportation in the state. Hardly any one agency can unilaterally say yes to transportation investments, but many agencies can say no. Responsibility and accountability are diffused among numerous agencies.

Federal and state agencies share responsibility with 19 MPOs, 26 regional transportation planning agencies, 58 counties, and 478 cities. There are 218 transit providers carrying 1.1 billion transit trips per year. The state also

has major ports; commercial airports; and light rail, commuter rail, and intercity heavy rail operators.

The state transportation funding and programming process has several unique characteristics. The California Transportation Commission decides on the approved level of funding for safety, operation, and preservation projects. This amount comes off the available funding for new projects. The remaining funding is divided uniquely, with 75 percent going to regions and 25 percent going to the state for interregional projects and rail system investments. By state law, all projects must be in the regional plans.

I will briefly summarize the background to the current use of performance measures by Caltrans. The development of the Intermodal Surface Transportation Efficiency Act of 1991 required state plans in the mid-1990s and led to a follow-on effort to start developing performance measures. The California Transportation Plan 1 Performance Measures Module developed in 1997 and 1998 included nine outcomes, indicators, and decision-making linkages. It established the need to integrate performance measures and long-range planning supporting decisions. It also noted that transportation improvement plans should demonstrate progress toward outcomes. The plan established the need for periodic monitoring and reporting.

Tony Harris's presentation at the 2001 conference focused on the development of performance measures between 1998 and 2001. An external system measures working group and policy advisory committee helped with the effort. Attempts to increase performance measurement resources were not successful. A system performance measure prototype was developed focusing on safety and security, mobility and accessibility, reliability, and environmental quality. At the same time, some MPOs in the state, primarily the Metropolitan Transportation Commission (MTC) in the San Francisco Bay Area and the Southern California Association of Governments (SCAG) in the Los Angeles area, began using both quantitative and qualitative performance measures independently.

Since the first conference in 2001, Caltrans staff have continued the development of performance measures and monitored the national experience and research. During this time, performance measures entered the day-to-day activities in the traffic operation and the maintenance divisions. Strategic goals focused on safety, reliability, performance, flexibility, and productivity were developed to drive internal performance agreements.

Some of the challenges from previous efforts included the lack of resources and the lack of management commitment. Linkage to real-world decisions was also unclear. In some cases, technology development and deployment issues had to be addressed.

A number of factors influence the current efforts. The California Transportation Plan 2 provides the vision,

goals, and policies that set the framework for performance measures. A number of external stakeholder groups were involved in the development of this plan.

As you know, California went through a change in governor recently, with corresponding changes in appointed agency officials and agency directions. The new leadership has brought more of a business orientation to the department. The Business, Transportation, and Housing Agency undertook a Performance Improvement Initiative. The initiative involved an expert review panel, whose recommendations included expanding relationships with external stakeholders and developing system performance measures.

The primary intent of the current effort is to optimize transportation's impact on the economy, the environment, and equity by providing a framework for improved decision making by system managers and system users. There is a focus on improving collaboration and accountability and management of transportation systems and modes. Another intent is to streamline and improve business practices.

A system performance measure team was appointed by the Secretary of the Business, Transportation, and Housing Agency in May 2004. The team is composed of public- and private-sector interests and state, regional, and local governments. The team focused first on outcomes and then on indicators. The team identified outcomes and indicators to pursue immediately, as well as others needing further development. The final report was delivered to the secretary on July 30, 2004.

The following nine performance measures and definitions are included in the report:

- Mobility, accessibility, and reliability: Minimize time and cost and maximize choice and dependability. Reach desired destinations within reasonable time and cost with choice, dependability, and ease.
- Productivity: Maximize throughput or efficiency systemwide.
- System preservation: Preserve the publicly owned transportation system at a specified state of repair or condition.
- Safety: Reduce fatalities, injury, and property loss of system users and workers.
- Environmental quality: Maintain and enhance the quality of the natural and human environment.
- Coordinated transportation and land use: Ensure that transportation decisions promote and support job and housing proximity.
- Economic development: Contribute to California's economic growth.
- Return on investment: Benefit-cost analysis or best return on investment, including life-cycling costing.
- Equity: No person shall, on the grounds of race, color, or national origin, be excluded from participation

in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving federal financial assistance. Avoid disproportionate impact based on income and ethnic groups. Ensure equitable sharing of benefits. Ensure accessibility for people with disabilities.

The plan also contains the following system performance measures or outcomes:

- Mobility, accessibility, and reliability: Travel time in key corridors, on-time performance of various modes, trip time reliability, and accessibility for workers within specific minutes of jobs, and proximity to transit.
- Productivity: Throughput for persons, vehicles, and goods movement, and effective use of capacity.
- System preservation: Asset condition of highways, streets, and roads. Condition of transit and passenger rail facilities and rolling stock. Condition of airport runways and pedestrian and bike facilities.
- Safety: Traveler safety, transportation worker safety, and crime statistics at transportation facilities.
- Environmental quality: Air quality, noise, energy consumption, ecosystem health, and water quality.

Performance measures or outcomes are still being developed for coordinated transportation and land use, economic development, return on investment, and equity. We are proceeding with the next steps including working with stakeholders to develop an initial version of a performance measures report by January 2005.

A number of factors appear to have influenced the success of the department's efforts to date. First, executive management support has been critical. Second, the experience at MTC and SCAG, among others, helped support Caltrans's work. Third, the 4 years of development work has started to pay off. Fourth, there was a recognition of the power of performance measures in making good programming decisions.

Recognized support for business-to-business relationships was an important factor. There was also a realization that shared responsibility for reporting is critical, since no one agency can or should do it all. Caltrans is now working on organizational performance measures tied to strategic goals and system measures and regional strategies tied to outcomes.

A number of challenges remain. First, technology and resources continue to be a challenge. Second, there is a cultural reluctance to deliver bad news. There is also some resistance to constraining local decision making. Transportation in California is a huge system of many modes and service providers. Maintaining a customer focus, not a technician focus, is important because public support is critical. It is important to report on performance measures that matter to the customer in a way the

customer can understand. Keeping measures outcome-based and ensuring that the right projects and services are delivered efficiently and effectively are also critical.

THREE DIMENSIONS OF PROJECT DELIVERY MEASUREMENT AND REPORTING

Gregory Selstead

I appreciate the opportunity to provide additional information on the use of performance measures at the Washington State Department of Transportation. Yesterday, Douglas MacDonald, secretary of the department, shared his perspective on using performance measures in the political decision-making process. My presentation focuses on the internal use of performance measures in the department.

After 12 years of no new revenues, the department now has an ambitious program based on the recently passed Nickel Tax. With these additional resources it becomes even more critical that the department deliver projects on time and on budget. Accountability within the department focuses on implementation and delivering on the commitments made to the public and the legislature.

The department's Gray Notebook and *2003–2007 Business Directions* outline the performance expected within the department. Staff within the department are taking ownership of the performance measures included in the documents. It is important to set understandable goals. We also need to clearly show tangible benefits. Finally, performance measures need to be understandable, simple, and sustainable.

The first section of the *2003–2007 Business Directions* presents the department's mission and management principles. One of the management principles addresses delivery and accountability. This principle focuses on providing taxpayers and the legislature with the highest possible return of value.

More detail is provided on defining delivery and accountability in the published measures section. Examples of measures include planned versus actual expenditures, cost comparisons for contracts awarded, and cost comparisons for contracts completed. There is also an emphasis on the safety program.

There is a statement advocating "frequent exchange and support between headquarters and regional staff to overcome obstacles to program delivery." This statement supports the need to be proactive in addressing issues that may arise. Every quarter a team of headquarters staff meets with regional staff to stress the commitment to the performance measures and to identify and address any issues.

The first section of the Gray Notebook contains a report to the transportation commission, citizens, other

officials, and the legislature on achievements, shortcomings, and challenges in the department's performance. This statement initially caused concern among some groups within the department. It acknowledges that the delivery of transportation projects is difficult and that the department will be forthright in discussing any shortcomings and challenges.

The Gray Notebook contains the universe of projects in the 10-year capital construction program. This program presents all the capital projects, including the preservation program, the improvement program, ferries, rail, facilities, advanced technology, local programs, and special projects such as the Tacoma Narrows Bridge. A summary of advertised projects, awarded projects, and completed projects is published every quarter. Projects that are delayed or deferred are noted, along with an explanation of the reasons for the delay. Construction highlights are presented for every project.

There is also a section on project delivery addressing proposed and potential adjustments to delivery plan-

ning. In the past, the legislative appropriation was by program. With the passage of the Nickel Tax, a line-item appropriation process is now used. Each project now has a fixed funding amount and fixed milestones in the 10-year plan. This section presents any problems or issues, such as change orders, that may come up on a project. The opportunities and options section presents proposals that require legislative guidance.

The Gray Notebook provides more detailed information on scheduled project advertisement dates. We have incorporated the construction season into this report. Previously, a project was listed as late if the advertised date was missed. Now, projects are not considered late if the advertised date is missed but the targeted construction season is met.

The Gray Notebook is an important document for internal department use and for communicating with the legislature and the public. I look forward to further discussion at this conference on performance measure reporting. Thank you.

Data and Tools Required to Support Decision Making

Sandra Straehl, Moderator, *Montana Department of Transportation*

Louis H. Adams, *New York State Department of Transportation*

Anthony Pietropola, *GeoDecisions*

Jeff May, *Denver Regional Council of Governments*

Mark Wolfgram, *Wisconsin Department of Transportation*

Leonard Evans, *Ohio Department of Transportation*

ISSUES AND CHALLENGES IN USING EXISTING DATA AND TOOLS FOR PERFORMANCE MEASURES

Louis H. Adams

It is a pleasure to have the opportunity to participate in this conference. I thank the two coauthors of the resource paper, Frances Harrison and Anita Vandervalk of Cambridge Systematics, Inc., for their assistance.

The purpose of this presentation is to highlight some of the technical issues associated with using existing data and tools for performance measurement at transportation agencies. Agencies rarely have the luxury of embarking on completely new data collection efforts and acquiring new information systems and analysis tools. Most agencies typically must rely on existing data and tools. This is not necessarily a hardship, however, since most agencies collect data on system condition, performance, supply, and demand. The challenge is to take advantage of existing data flows and tools. The resource paper identifies common challenges and offers recommendations to allow agency staff to anticipate and address these challenges in a proactive manner.

My presentation focuses on five topics. I will begin by providing some suggestions for agencies just getting started in using performance measures. Second, for seasoned practitioners, I will highlight a continuous improvement strategy. Third, I will cover issues associated with specific types of performance measures. Fourth, three business processes will be examined. These business processes are defining measures, gather-

ing data, and using information flows to make decisions. I will close by highlighting a few additional resources available to practitioners.

If you are just starting the process of performance-based planning and budgeting, you have the luxury of learning from the experience of other agencies. Implementing data collection need not be costly, time-consuming, or resource intensive. A simple initial program can be established by using a single indicator that is of interest to an executive-level sponsor. Targets can indicate whether a performance rating is satisfactory or needs improvement. The program can evolve incrementally over time as the agency learns from the initial experience, and more performance measures can be added. Improvements in the sophistication of measures can also be incremental, as can further integrating the use of the measures into strategic and tactical decision-making processes and communicating results to a wider group of customers, partners, and stakeholders. This evolutionary model of performance measurement improvement is typical in agencies that have successful programs.

Agencies experienced in performance-based planning and budgeting face challenges in the area of business process refinement. Typically, their continuous improvement strategy will require effort on multiple fronts:

- Measuring the right things at an appropriate level of detail;
- Taking advantage of current technologies and tools for data collection, processing, and analysis;
- Making the best possible use of existing data and legacy systems;

- Enhancing tools over time to provide better decision support; and
- Building the staff capability and commitment required to ensure that quality information and analyses are actually used to make decisions.

Infrastructure preservation measures are used by most state transportation agencies. A condition inventory is fundamental for this measure. Condition inventories provide a comprehensive summary of the number, age, and condition of capital assets by asset class. A simple condition rating scale that is consistent across asset classes and agency programs is typically used. The scale identifies compliance with current standards, in-service failure rates, and annual maintenance requirements for each asset.

Measures of functional deficiency are used to describe how well transportation facilities are serving their intended purpose. Measures of backlog or need can be derived on the basis of standards for condition or functional deficiency, or both. For these types of measures, it is important to establish precise criteria for what constitutes a need, so that identification of such needs can be an automated process. Varying definitions for what constitutes a deficiency should be accommodated, however, because agency policies change over time.

Using remaining life as a performance measure is one approach that allows agencies to compare performance across different classes of assets. This approach requires reasonable estimates of the expected life of different types of assets under varying circumstances such as traffic, environmental conditions, construction methods, and maintenance practices.

Monetary valuation indicates how well the agency is preserving the substantial investments that have been made in the infrastructure. Service improvements form another grouping for measuring performance. Examples of safety measures include number and rate of fatalities, injuries, and run-off-the-road crashes. The timeliness and accuracy of police crash reports are improving rapidly as paperless methods replace hard copy documents.

The establishment of reliable accident locations that can be correlated to highway design and condition attributes is becoming more widespread as a result of Global Positioning System technology. Increased attention to safety data requirements and new levels of data integration will need to be pursued before the 2008 implementation target of a new federal strategic goal to reduce the number of annual deaths attributable to highway crashes by 9,000.

Examples of mobility measures include the travel time index, which focuses on the average congestion level; the planning time index, which focuses on arriving on or ahead of schedule 19 times out of 20; and the aver-

age travel rate, which was recommended by *NCHRP Report 398*. A reliability challenge is processing extensive data flows to determine the locations, magnitudes, and durations of disruptions to expected travel time patterns. A reliability recommendation is to use simulation and theoretical understanding to estimate performance.

Most existing performance measurement efforts have focused on performance from the facility or supplier point of view. Interest in reflecting the customer point of view is growing, including measurement of customer perceptions concerning transportation services.

Transportation user advocacy groups frequently use customer-related performance measures in their publications. The Road Information Project and the American Highway Users Alliance express the backlog of needs in terms of excess cost of travel per highway user on an annual basis. The costs attributed to condition and performance shortcomings are likened to a hidden tax, which acts as a drag on regional and national economic efficiency in a globally competitive marketplace.

Deciding how to measure performance should be based on what an agency is attempting to accomplish, the framework of policy goals and objectives that has been established, and the expectations of customers and partners, rather than the data now being collected. Consideration should be given to the information and the tools already being used to make decisions. I would not suggest suddenly replacing a well-understood measure with a new measure. Rather, use the old measure alongside the new measure until comfort with the new measure is established.

Knowing whether goals are met is insufficient information for a leader to use in making decisions about how to improve agency performance. It is helpful to define a quantitative performance rating scale for each goal, with upper and lower bounds and ranges such as excellent, satisfactory, and needs improvement. It also is helpful to track whether the current performance rating is better or worse than an expected value and the value for the prior reporting period.

Agencies have tended to rely on output-type measures rather than outcome measures. Completing 500 lane miles of paving raises the question, "So what?" A better measure might be that this year 82 percent of customer travel is on smooth pavement, which is 4 percent better than last year and on target with our plan.

Agencies need to demonstrate how expenditures of public tax dollars are in fact making things better for customers than they otherwise would have been. The availability of trend data for the measures that are selected and the data sources to be used is also important, as is assuring that changes in measurement or computation methods have not affected the validity of trend lines. Consideration should be given to the impact of changing data collection methods or schedules on the agency's ability to maintain valid time-series information.

Where existing data sources are to be used, it is important to evaluate their accuracy, precision, timeliness, and consistency. If data quality improvements are warranted, it is suggested either to make incremental enhancements or to develop a strategic data plan for the agency.

Ensuring the accuracy and consistency of fundamental measures such as system mileage and vehicle miles of travel (VMT) is important. Before combining or comparing data from different analysis tools or data sources, basic consistency checks on fundamental measures should be conducted.

Location referencing and temporal integrity are essential in thematic mapping for project development. Spatial relationships among pavement condition, crash rates, and congestion hot spots must be valid.

Temporal integrity is particularly important in mapping current deficiencies from dated condition inventory records, because projects and work orders that have been completed since the condition survey act to remove current deficiencies from the map. An example of data integration is the calculation of accident rates, which are derived by matching accident records with VMT.

Challenges in data collection, processing, analysis, and distribution can seem either mundane or overwhelming, depending on a manager's background and interests. However, addressing the challenges is critical to support performance-based decision making.

Performance data must be managed as an enterprise asset. Data elements must have a data owner, a data element definition, a schedule for updating, and a fixed amount of precision. Precise data definitions are particularly important where data from secondary sources are being used to derive performance measures.

Processes should be developed for quality checking the raw data and turning the data into an aggregated and value-added information asset accessible to the whole enterprise. When data are collected from multiple pieces of equipment, by way of multiple methods or from multiple sources, consistency of the measurement must be ensured. Location and temporal validity and integrity control systems for all enterprise-level data elements must be compatible.

Many data elements are commodities and can be procured from private-sector vendors by low-bid methods at unit costs that are competitive with costs for provision of the same services by a public-sector work group. Examples include automated pavement condition surveys, periodic bridge inspections, and highway traffic counting programs.

When the performance data are in place, they must be disseminated to decision makers in an effective manner, and analytical tools must be available to assist in development of performance targets and investment analysis. Most agencies focus on a small set of performance measures for external reporting and strategic

budgeting. More detailed information is needed for decision making at the staff level. Ideally, the few high-level performance measures can be derived from more detailed measures for presentation to policy makers. Technical staff still have access to the detailed data and assumptions behind the aggregate measures.

Use of a desktop geographic information system (GIS) application by well-trained staff can be an efficient means of preparing input data for a legacy system to process. The same is true for use of a desktop database application. Minor modifications to legacy system source codes are usually worth the effort to enable the system to produce comma-separated variable (CSV) output files of legacy system results. CSV files can be easily read into desktop spreadsheets and GIS applications, which can then be used for analysis, presentation, and printing.

Tools that predict future conditions should reflect work that is scheduled or programmed. Keeping infrastructure management systems in synchronization with program and project databases is often a challenge. Efforts are needed to ensure that data structures are consistent, so that information can flow between the management systems and the program and project databases. At a minimum, specific work flow processes should be defined to update management systems as the program and project databases change.

Tools that provide the capability to predict system performance as a function of investment levels use a variety of methods for identifying needs and determining how the available budget is allocated. These methods should be well understood in selecting or configuring a tool and in determining how to make the best use of an existing tool in the performance target-setting process.

It is important to pay attention to costs in using tools to perform investment versus performance analysis. Tools and inputs should reflect proper use of discounting methods and should account for inflation. Budgets and work costs should be consistent. For example, if work costs do not include indirect costs, the budgets should be reduced accordingly.

Fact-based what-if analysis of alternative funding scenarios and policy choices is a fundamental part of performance-based planning and programming. For many types of performance indicators, simulation tools can be used to help provide an understanding of how future performance may be affected by the quantity, timing, and type of agency interventions and by variations in factors outside the agency's control, such as growth patterns. Ideally, a technical champion should be designated to run the simulation model and to make sure that it is producing reasonable results.

In closing, I encourage you to read the resource paper. It includes examples focusing on each of four critical cat-

egories of measures: infrastructure, mobility, safety, and customer service. The examples highlight the use of readily available data and standard tools including GIS, desktop applications, and management systems. In each case, the key to success is the way in which different data sources and tools are used in combination and the processes for establishing priorities and allocating resources.

The resource paper is intended to help agencies successfully navigate the wide array of technical, process, and organizational issues that can be anticipated in using performance measures. A systematic approach to performance program design that considers the interrelated issues involved in measure definition, data management, and decision support can help agencies avoid major roadblocks and anticipate the nature and extent of the effort that will be required for success. Chapter 4 of *NCHRP Report 446: A Guidebook for Performance-Based Transportation Planning* provides additional guidance on the use of data and tools in performance-based planning.

Thank you for your participation.

TECHNOLOGY AND TOOLS TO ACCESS DATA FOR DECISION MAKERS: CASE STUDY OF STATE DEPARTMENTS OF TRANSPORTATION

Anthony Pietropola

It is a pleasure to discuss some of the approaches state departments of transportation are using to present performance measure information at this conference. My presentation will cover some of the lessons learned, as well as the historical perspective and the current experience with the use of different techniques for presenting information on performance measures. I will describe the approaches being used at four state transportation agencies.

I will highlight what I think are five lessons that have been learned from presenting performance measure information. First, keep it simple. Second, it has been suggested that if a picture is worth a thousand words, then a map is worth a thousand pictures. Using graphics to present key information appears to be effective. Third, everyone wants to use technology to enhance performance. Fourth, develop a good website or other communication method and people will use it. Finally, a catchy name and logo appear to help people find and remember your information.

From a historical perspective, many state transportation agencies began using route logs in the 1950s during the development of the Interstate system. The route logs were initially drawn by hand. During the 1980s, many route logs were converted to computer-aided drafting systems. Route logs have been coordinated or replaced by

management systems within a number of transportation agencies.

Route logs typically contained a lot of information on the roadway system. Information on road surface types and depths, widths, curves, grades, structures, intersecting roads, and railroad crossings was included. Data on traffic volumes, accidents, traffic counter locations, and other elements were also included.

The development and use of management systems required a lot of information. Many states have management systems for bridges, pavements, and other system components. Unfortunately, many management systems were developed around what I call islands of data—that is, the data in the different management systems are not integrated.

Some states have developed information portals to integrate available data. Information portals provide business layers from many department of transportation divisions and can be used as decision support tools. Some states have automated their road logs as part of their information portals, which allows many attributes of a road segment to be displayed.

Information portals may also provide GIS-enabled intranet applications. They allow users to access many different types of data from multiple business functions simultaneously. Information portals also allow users to query, view, map, analyze, and report on data within the system. Information portals provide consistent information quickly so that more informed decisions can be made with regard to the transportation network.

A number of benefits may be realized by using information portals. First, the decision-making process may be improved and accelerated through easier access to reliable data. Information portals may also improve consistency in responses to internal decision makers, the public, other state agencies, and legislators.

The Information Network for Online Resource Mapping (INFORM) at the Delaware Department of Transportation provides an example of an information portal. INFORM contains data on the road inventory, pavement conditions, highway safety improvement program, average annual daily traffic (AADT), projects, bridges, environmental factors, and storm water conditions. Figure 1 illustrates the home page of the INFORM Internet site. Figure 2 highlights the layering capabilities of the INFORM system. As illustrated in Figure 3, the INFORM system provides users with the capabilities to drill down for more detailed project and site-specific data.

The INFORM system is used for a variety of applications. Future plans include providing additional reporting and video logging capabilities. The department also plans to integrate the system with intelligent transportation system elements including cameras, routing, and geocoding. Other future efforts include adding Highway Performance Monitoring System (HPMS) data reporting

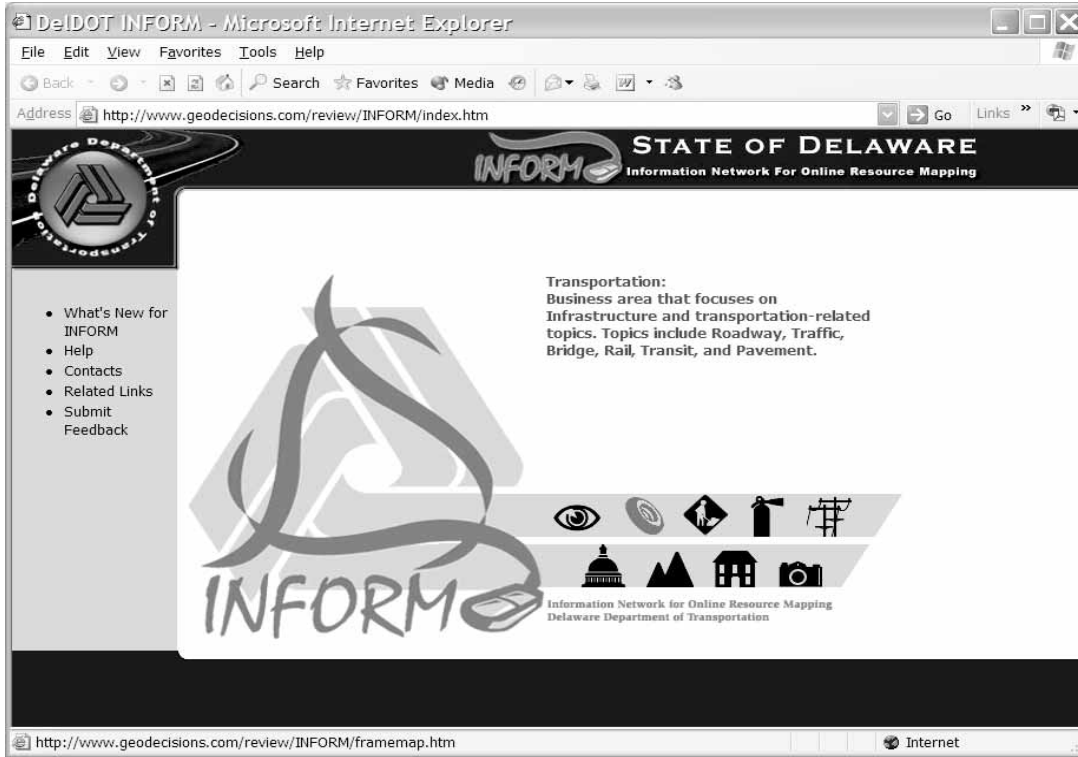


FIGURE 1 Delaware INFORM home page.

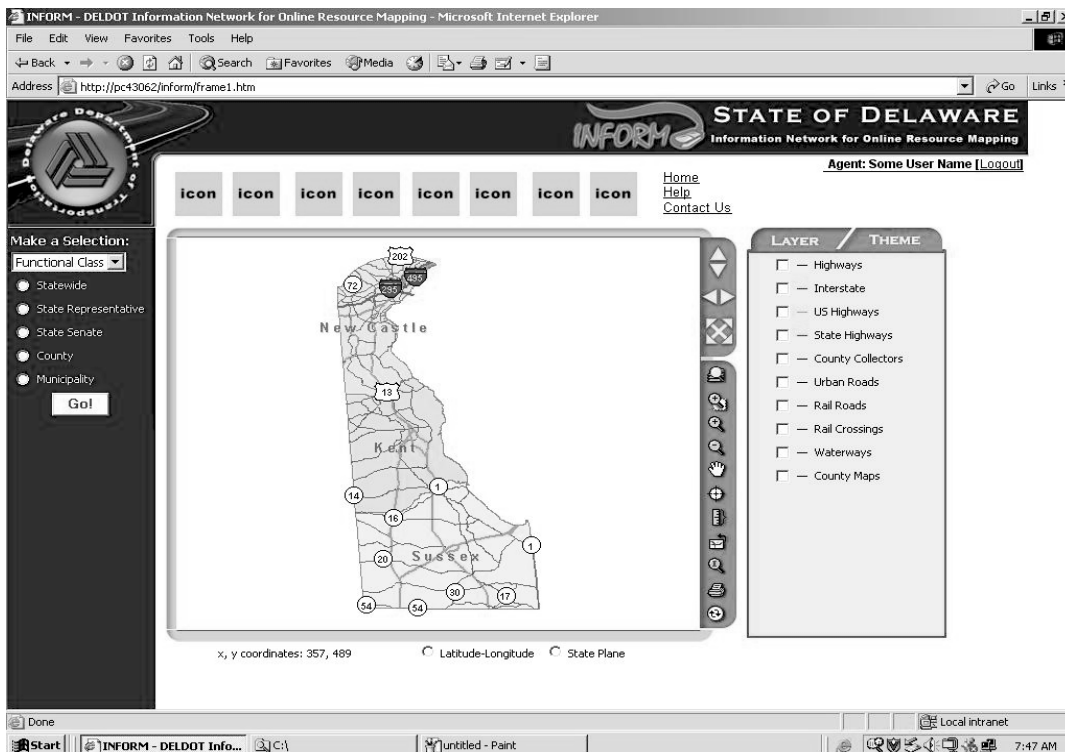


FIGURE 2 Delaware INFORM layers.

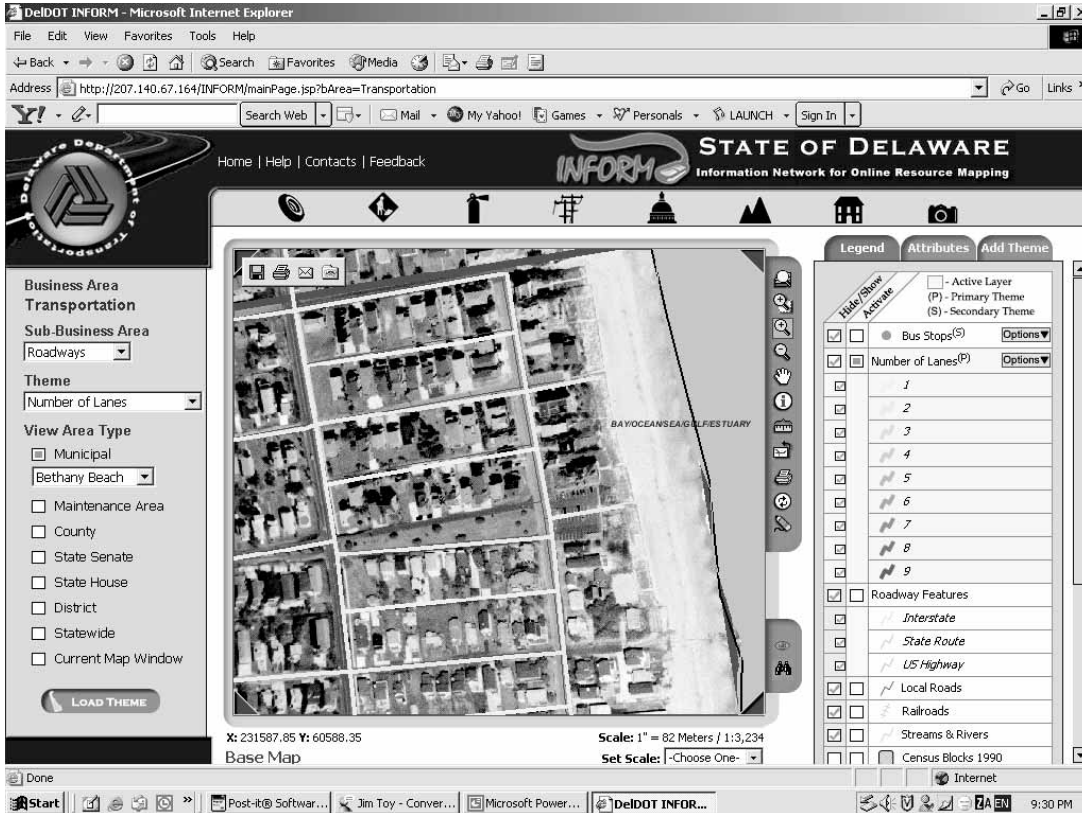


FIGURE 3 Example of INFORM drill down capabilities.

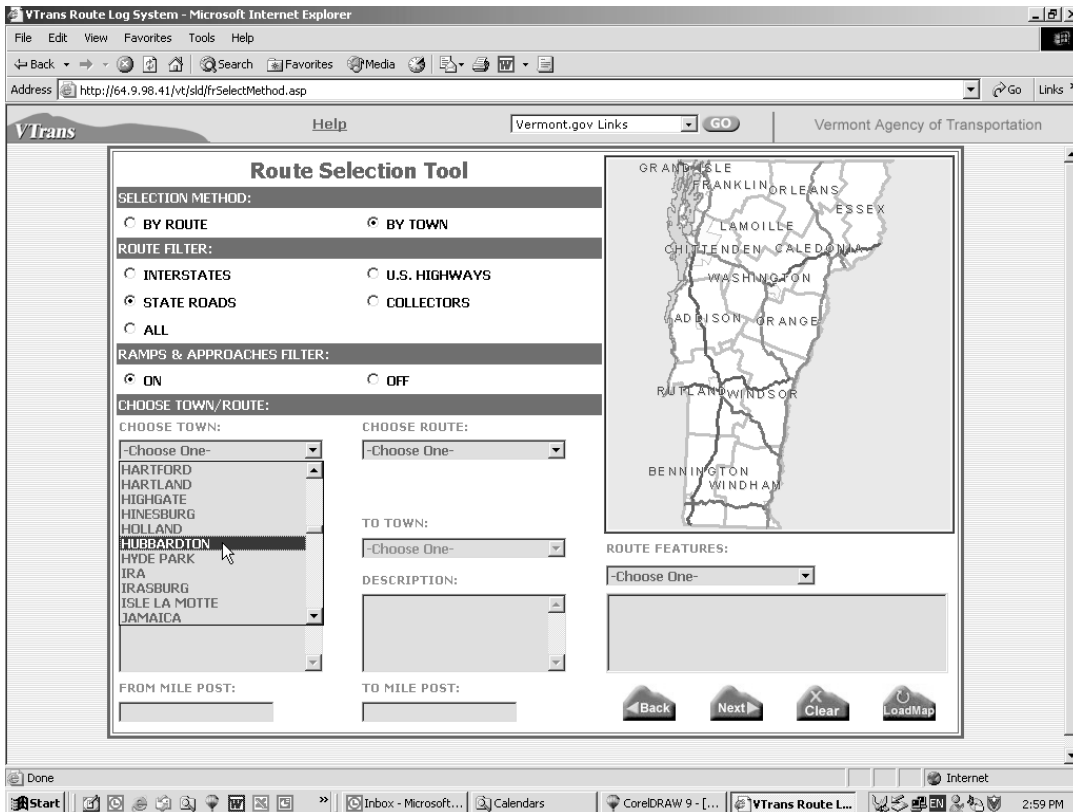


FIGURE 4 Example of Vermont Agency of Transportation's route selection tool.



FIGURE 5 Pennsylvania Department of Transportation's TIP home page.

and transit ridership and linking digital documents to the mapping layer.

The Vermont Agency of Transportation's automated route log system provides a second example. This Internet site provides a tool to create and view route logs for the entire state. The agency uses scalable vector graphics software and a GIS server. The system provides map view and selection and data linkages. Figure 4 illustrates an example of available route selection tools on the system. The agency also provides drill down capabilities for more detailed information.

The third example is the Oklahoma Department of Transportation's Geographic Resource Intranet Portal (GRIP). GRIP contains a wide range of data. Thematic maps and reports can be developed for surface type, AADT, access control, functional class, number of lanes, terrain area type, and many other variables. Condition information includes surface condition rate, capacity adequacy, shoulder condition, foundation

condition, total condition rate, total design rate, and total sufficiency rate. Data on accidents, pavement condition, bridge condition, and a number of other elements are included. GRIP provides drill down capabilities for users. Information can be mapped. GRIP includes photographs of different elements of the transportation system.

Finally, I will give a live demonstration of the Pennsylvania Department of Transportation's Transportation Information Program (TIP) Internet site. Figure 5 shows the home page of the TIP Internet site. TIP has many of the same features as the systems just described.

In summary, tools are available to link available data on the transportation system to provide agency technical staff, as well as policy makers, with useful information. As I noted at the start of my presentation, keep the presentation method simple, use graphics, match technology to need, develop a good website, and develop a logo and catchy name. Thank you.

ROLE OF REGIONAL TRAVEL MODELS IN DEVELOPING PERFORMANCE MEASURES FOR CONGESTION

Jeff May

It is a pleasure to have the opportunity to talk about the role regional travel models can play in developing and using performance measures. I will share some of our experience in the Denver area and describe the process we used.

The Colorado Department of Transportation is responsible for the statewide performance measures and management systems. Two management systems—pavement and bridge—are well advanced and have been used for a number of years. The safety management system is in the intermediate stage of development and is beginning to show some results. The mobility or congestion management system is just in the initial stages of development. Like other states, Colorado has focused primarily on fixing and maintaining the existing transportation system, with expanding the system a lower priority due to lack of funding.

Traffic congestion is a concern in the Denver metropolitan area. Congestion is the major transportation problem identified by front-range residents, including those in the Denver area. Traffic congestion results in lost time and lost productivity. Residents and businesses have made policy makers aware of their concerns about increasing levels of traffic congestion.

The Colorado Department of Transportation and the Denver Regional Council of Governments (DRCOG) have been working on developing a funding allocation process for mobility projects for a number of years. In July 2004, the department and DRCOG agreed on a congestion measure for allocation of mobility funding to regions. For the urban areas, VMT on congested roadway segments will be used. Congestion is defined as a volume-to-capacity (V/C) ratio greater than 0.85 based on design hour, which is the 30th-worst hour of the year.

The agreement also states that both agencies want to move toward more sophisticated performance measures. The measures may include traveler hours of delay, freight delay, duration of congestion, and travel time reliability. There was also agreement, however, to move toward more sophisticated measures only if significant funding becomes available to address congestion problems. Currently, the Colorado Department of Transportation has allocated \$8 million statewide for congestion projects. More sophisticated measures would be used only if they would change decisions significantly. Finally, more sophisticated measures would be explored with a target of additional data collection and analysis costs being less than 1 percent of mobility

funding dollars. The 1 percent figure reflects the amount spent on data collection for the pavement and bridge management systems.

The challenge facing both agencies is how to improve Colorado's mobility performance management system with existing or low-cost sources of information and analysis tools. We first examined available data and tools that could be used. The department's files contain information on every link of the state highway system. Information such as AADT by state highway segment statewide is included. In the case of freeways, the average daily traffic is based on a few permanent traffic counters extrapolated to estimates for the whole system, while arterial roadways are actually counted every 3 years. The department calculated the capacity of roadways in the 1990s. These calculations have not changed, with the exception of links where lanes have been added.

Another available tool is the four front-range urban areas' regional travel models and the department's I-70 model. These models cover the most congested locations in the state. DRCOG also compiled samples of hourly traffic volumes from local and state sources. Data on speeds and vehicle classification counts are available.

The Denver regional travel model was initially developed in the 1960s for use in planning the Interstate system. In the 1970s and 1980s, the model was expanded for use in planning rapid transit. In the 1990s it was used for air quality analysis. In the 2000s, I see the model becoming a multimodal land use decision-making tool. Almost \$1 million has been allocated by the DRCOG board to improve the model to support multimodal decision making.

The current four-step model calculates travel between destinations by mode and route. The model is calibrated through household travel surveys, external station surveys, and traffic counts and HPMS VMT estimates. Over the past year, additional speed and delay studies were conducted. Speeds and traffic counts were used to calibrate the model.

Model outputs include estimates of traffic volumes and speeds on 25,000 highway segments by 10 time periods of the day. The model calculates peak-period weekday V/C ratios. The model also provides congested hours of travel for current days and future year estimates.

The model only deals with recurring congestion, not incident-related congestion attributed to crashes and vehicle breakdowns. Applying the Federal Highway Administration (FHWA) methodology to Denver freeways results in estimates of incident delay of about 110 percent of recurring delay. There is a good deal of variation among areas, ranging from 80 percent to 250 percent.

The model focuses on the average weekday congestion levels. Weekend congestion associated with special

events, shopping, and recreational opportunities is not modeled. We are working to improve the model credibility with Colorado Department of Transportation staff. Department representatives have been included in the long-range planning process and the process to enhance the model.

The model produces estimates over time and shows geographically where congestion occurs. It can also be used to assess the impact of various improvement programs. The model can reflect evolving definitions of congestion. The current definition of congestion used at DRCOG is $V/C > 0.95$ for 3 or more hours.

Traffic congestion was not a major problem in the Denver area during the 1970s. In the 1980s, traffic congestion became a major issue on most freeways and roadways in the area. This trend continued in the 1990s. The changes in congestion levels can be displayed graphically by using GIS.

In conclusion, travel models can play a part in the development of performance measures for congestion. We need to do more work to supplement the model with other elements. Examples of these elements include being able to identify incident-caused congestion and weekend congestion. The Colorado Department of Transportation is also exploring enhancing data collection and analysis tools for rural areas. Thank you.

USING PERFORMANCE MEASURES TO IMPROVE HIGHWAY PROGRAM EFFECTIVENESS

Mark Wolfgram

I appreciate the opportunity to participate in this session and to share some of the Wisconsin Department of Transportation's experiences with the use of performance measures for highway program effectiveness. My comments will touch on some of the topics discussed during this morning's session and will describe what we have accomplished since the first performance measures conference in 2001.

Figure 6 illustrates the department's highway asset management process. The process is similar to those used in other states and is based on the department's policies, goals, priorities, and highway program budget. The process begins by forecasting highway performance and needs. A program of projects is then developed to address the identified needs. After development of the program, the projects are constructed, and in turn they influence future highway performance and needs.

The asset management process is guided by the department's policies, goals, and priorities. High-level policies address conditions requiring pavement and bridge improvement as well as capacity, safety, and other elements of system performance. Our long-term

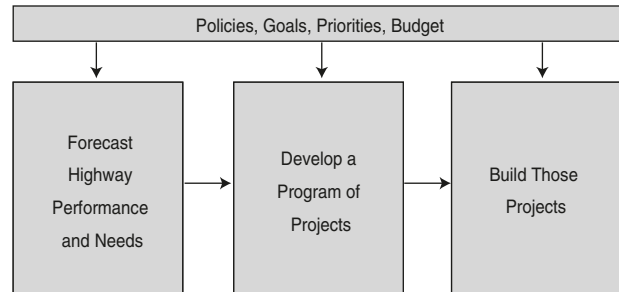


FIGURE 6 Wisconsin Department of Transportation asset management process.

goals focus on reducing pavement, bridge, safety, and capacity deficiencies. Infrastructure condition and safety are our two top priorities.

Forecasting highway system performance and improvement needs requires a lot of data. Information on the system inventory, system condition, traffic volumes, and crash locations is needed. Such forecasts also require performance models. Our pavement management, bridge management, safety management, and congestion management systems provide this modeling capability and, together, form what we refer to as our metamanagement system. The metamanagement system helps answer numerous program development questions. It helps identify pavements that must be improved, bridges that are deficient, and safety and capacity issues that must be addressed, and it helps identify the appropriate way to address them.

Once improvement needs are identified, the next step is to develop a program of projects. At the Wisconsin Department of Transportation, developing the project program is a biennial process. The goal of the program is to focus funding on delivering the right projects, in the right place, at the right time, to meet priority improvement needs. In Wisconsin, as elsewhere, our improvement needs greatly exceed the resources available.

The program development process begins by allocating highway improvement funds to two subprograms within our overall highway improvement program. The first subprogram is designed to address needs on what we call our Backbone highway system. This system includes Wisconsin's Interstate highways and other high-volume, multilane routes. The second addresses needs on all other state highways. The metamanagement system is used to identify priority needs across the state and the cost of addressing them appropriately. The distribution of priority needs (i.e., budget-constrained needs) between Backbone and non-Backbone routes determines the allocation of resources to the Backbone and non-Backbone subprograms. The distribution of non-Backbone needs by district determines district allocations for addressing the needs on those routes. The Backbone subprogram is then developed and managed centrally, while the non-Backbone subprogram is developed and managed at the district level.

This process has evolved slowly over many years. The overall vision was there from the beginning, but district understanding and acceptance were critical to success. Although the effort was led and staffed centrally, each step in developing the process was taken in partnership with district staff. District champions were identified, and the process was developed and implemented as everyone became comfortable with both the steps and the outcomes.

Using the process to influence the allocation of resources between subprograms was accomplished early on. Next, the degree of influence was increased until it was direct and immediate. Finally, since our last conference in 2001, several program performance measures were developed for program development staff in the central and district offices. The measures are focused on ensuring that funding is actually used at the right time, at the right place, to do the right thing.

There are performance measures to address each of these three program goals. First, we consider whether funds are actually being allocated to projects in the right place. Performance data, policies, and goals are used to divide the transportation system into “needy” and “not needy.” We also identify priorities within the needy parts of the system. Currently, 74 percent of available funding is being spent on segments that are high-priority needy portions of the highway system, 1 percent is being spent on lower-priority needy segments, and 25 percent is allocated to segments that, according to our data, are not needy. Our performance goal is to move toward spending at least 80 percent of available resources on high-priority needy projects.

The 80 percent target was selected rather than a 90 percent or higher target for a number of reasons. First, there are limitations in the data and the models. Second, all portions of a logical project segment may not reflect the same high priority, which reduces the measure as currently implemented. Third, in some cases, other factors may call for a project at this time.

We also examine the timing of needs to determine whether projects are being undertaken at the right time. Approximately 75 percent of the current program focuses on projects that are needed right now, 19 percent addresses projects that are needed within a short time, and approximately 6 percent addresses distant needs. To help ensure that we focus resources on immediate needs, a performance measure was set calling for no more than 2 percent of available funding to be used for distant needs.

To determine whether we are doing the right thing, we compare the project scope suggested by the metamanagement systems with the scope of the projects actually developed. Currently, some 55 percent of available funding is going to projects with scopes very close to those identified by the metamanagement system.

Approximately 16 percent of our funding is going to projects that are overscoped, and 3 percent is going to projects that are underscoped. We have a goal of limiting resources for overscoped and underscoped projects to not more than 10 percent each.

If central or district program managers develop programs inconsistent with any of these goals, a peer-review process with other program managers is used to review the reasons for the decisions being made. Any group using funds on unjustifiable projects is violating the principles of accountability needed in program development and delivery.

To help program managers improve their performance, geographically referenced data are made available to them. By using GIS, they can easily identify projects on nonneedy portions of the highway system and focus on projects suspected of being improperly scoped. This allows them to explore the reasons for these potential discrepancies before the peer-review process is engaged.

The use of performance measures is helping us meet program goals. Currently, 22 percent of our pavements are below the desired thresholds. Our models indicate that some 39 percent of pavements would be below the desired thresholds in 2008 without the program. With the program, 23 percent of pavements will be below thresholds.

We still have a number of challenges in the use of performance measures. As with other state departments of transportation, we are working to link consequences to performance. These links might include an impact on future funding allocations for each district and an impact on compensation for key managers. Over time, it is our intention to improve our data and modeling processes, slowly raise the bar for program managers, and increase the performance delivered by our highway improvement program.

Thank you.

TRAPPED KNOWLEDGE, UNLOCKING KEY INFORMATION: WORKING WITH LEGACY DATABASES AND MANAGEMENT SYSTEMS

Leonard Evans

It is a pleasure to participate in this session and this conference. My topic addresses legacy databases and management systems and how they can be used to support performance-based decision making. I will share some of our experiences in Ohio with the use of legacy databases to support performance measures.

What is a legacy database? A simple definition of a legacy database is that once a system has been put into service, it becomes a legacy system.

Legacy systems are constantly being created. During development, the programmer has complete control over data structures. After deployment, however, the programmer loses control as other systems interface with the database. We need to be aware that changes to data structures may alter dependent systems, so legacy databases should be continuously monitored.

Numerous systems provide transportation data and support the transportation decision-making process. These information sources provide data on road inventories, bridges, pavements, signals, crashes, and speed limits. Other systems provide data on traffic control devices, detours, congestion levels, safety locations, and planning. Information on project design, construction, and accounting is also available. Most of these data sources were not originally designed to support asset management and performance-based decision making, however.

The Ohio Road Inventory or road log is the base of the transportation information system. It was developed between 1947 and 1958. The road log includes the county, route, log mile, and physical roadway attributes. The road inventory includes data on roads in all 88 counties, 1,309 townships, and 942 corporations in the state.

Ohio is the 35th-largest state in the nation. The State Roadway System includes 20,000 miles; the County Roadway System, 30,000 miles; the Township Roadway System, 43,000 miles; and the Municipal Roadway System, 25,000 miles. The total roadway system in the state covers approximately 118,000 miles.

One of the key challenges with any information system is maintaining the data. A process to update and maintain data is needed. With more than 50 years of information on the transportation system in Ohio, it is critical that we maintain the integrity of the data. We do not want to make investment decisions on the basis of incorrect information.

In Ohio, formal roles and responsibilities have been defined through legislation and other policies. Ohio is a home-rule state, and the Ohio Revised Code (ORC) establishes the highway classification system in the state and the naming of the roads and bridges. The ORC also defines the duties and responsibilities of county engineers, county commissioners, and township trustees.

Obviously, a critical element for a roadway log is a standard method to define transportation locations. The Base Transportation Referencing System (BTRS)

provides the standard for identifying transportation locations in the state. The system links the GIS to different databases. We encountered problems when we initially tried to map the locations of projects. The maps showed projects in the wrong locations. We organized a team made up of representatives from various departments and districts to examine the problem. We found that we did not have all the necessary data or a standard method to map projects in the GIS correctly. The team developed a system that uses a 14-character Network Linear Feature identification and a three-digit decimal mileage reference. The latitude and longitude are also identified.

The system provides the capability to integrate databases, which are used to develop mobility measures and performance measures. The BTRS link number provides the connection to information in other databases and management systems. Using computing power and storage readily available, we created an integrator file that breaks information down to log points at every 0.01 mile. This file has some 2.1 million records for the state system.

Once the data are integrated, we can analyze a wide range of data. For example, our sufficiency index includes information on functionality geometrics, lane width, shoulder widths, curves, bridge and pavement conditions, and accidents. It has been an excellent tool for developing, analyzing, and monitoring performance measures.

The system was a great benefit in the recent development of *Access Ohio*, the long-range transportation plan. We were able to access and map a wide range of information easily. We also used the system in scoring priority projects.

In closing, I would like to note two research studies that have reports and information available on the Internet. The first is the FHWA-sponsored study *Review of Data Integration Practices and Their Application to Transportation Asset Management*, which was completed in 2003. It is available at www.fhwa.dot.gov/infrastructure/asstmgmt/diindex.htm. The second is NCHRP Project 20-64, XML Schemas for Exchange of Transportation Data (TransXML), which is under way. Information on this study is available at www4.trb.org/trb/crp.nsf/All+Projects/NCHRP+20-64.

I look forward to discussing legacy databases and management systems in more detail in the sessions this afternoon. Thank you.

International Use of Performance Measures

Michael Meyer, Moderator, *Georgia Institute of Technology*
Michael Halladay, *Federal Highway Administration*
Takayuki Oba, *Ministry of Land, Infrastructure, and Transport, Japan*
Douglas MacDonald, *Washington State Department of Transportation*
Connie Yew, *Federal Highway Administration*
C. Michael Walton, *University of Texas at Austin*
Bob Arnold, *Federal Highway Administration*
Ken Philmus, *Port Authority of New York and New Jersey*
Randy Halvorson, *Minnesota Department of Transportation*
Jeff Price, *Virginia Department of Transportation*
Gary White, *Federal Highway Administration*

SESSION INTRODUCTION

Michael Meyer

The session this evening focuses on the results from the international scan on performance measures. Mike Halladay from the Federal Highway Administration (FHWA) will provide an overview of the international scan program sponsored by FHWA and the American Association of State Highway and Transportation Officials (AASHTO). We will then hear from Takayuki Oba of the Japanese Ministry of Land, Infrastructure, and Transport, whom we met during the international scan. Mr. Oba is responsible for the performance management office in the transport bureau of the ministry and has been instrumental in implementing a comprehensive performance management program for Japan's highway program.

We are fortunate to have nine individuals who participated in the performance measures scan here this evening. Each scan member will highlight what he or she considers the most important observations and experiences from the scan.

The international performance measures scan occurred in spring 2004. The primary purpose of the

scan was to learn about the experiences of other countries in using performance measures and performance management in planning and programming decision making for all modes of transportation. The scan team first visited Vancouver, British Columbia, Canada, and then traveled to Tokyo, Japan. In Australia we visited Brisbane, Queensland; Sydney, New South Wales; and Melbourne, Victoria. The scan ended in Wellington, New Zealand.

During our visits, we met with representatives from national ministries of transportation, other transportation agencies, and provincial or state departments of transportation in each location. We also were able to meet with representatives of the Victoria Department of Infrastructure; rail and transit planning organizations in Vancouver, Queensland, Victoria, and Japan; and the police department in Victoria. Although the time was limited, the breadth of contacts provided the scan team with a good understanding of how other countries have adopted performance management in their investment and system management decision-making processes. A summary report on the scan will be posted on the FHWA Office of International Programs webpage international.fhwa.dot.gov.

FHWA AND AASHTO INTERNATIONAL TECHNOLOGY SCANNING PROGRAM: PERSPECTIVE ON HIGHWAY SAFETY

Michael Halladay

It is a pleasure to participate in this session and to share information with you on the FHWA and AASHTO international technology scanning program. I will briefly describe the purposes and process of the scanning program and implementation efforts associated with it. I will also highlight key topics from the safety-related scans, including the findings and implementation activities.

FHWA and AASHTO have been operating the scanning program for about 10 years. There are four major scanning program objectives. The first is to discover and explore technology used successfully in other countries and to learn from their experiences. The second is to increase our awareness of underlying policies, processes, and capabilities. The third is to determine the applicability of technologies and tools for use in the United States. The final objective is to foster implementation of appropriate tools, technologies, procedures, and policies in this country.

FHWA and AASHTO established a biennial program of 10 scans. Five priority topics per year are selected for scanning tours. The program began with a technical orientation, but the scanning tours conducted to date have covered a wide range of topics, including the use of performance measures. Topics of the 2004 and 2005 scans include infrastructure, operations, safety, and organizational issues. I have had the opportunity to participate in a few of the scanning tours.

A lot of work goes into selecting the team members, arranging the countries and cities to visit, conducting the scan, and summarizing the results. Each scan includes a chair or cochair, a recorder, and team members. One key to selecting members is to include individuals who can help champion the implementation of findings from the scans. Objectives and amplifying questions are developed. Host countries are selected, contacts are established, and logistics are finalized. The trips are conducted and the experiences are documented, including possible implementation actions.

The core of a scan tour is meeting with representatives from agencies and organizations in the host countries. Detailed questions are provided to the representatives before the trip. Detailed presentations are given on the scan topic, along with site visits and field observations of technologies, operations, and research activities. Figures 1 and 2 provide examples of scanning tour presentations and site visits. There is a rich dialogue among scan tour members and representatives of host countries. I gained a much better appreciation for the different transportation structures and cultures as a result of participating in



FIGURE 1 Example of scanning tour presentation.



FIGURE 2 Example of scanning tour site visit.

the scanning tours. The culture and organization structures, especially in the safety area, really set the countries we visited apart from the United States.

Safety-related scanning tours have focused on policy, organizations, leadership, tools, and technologies. Other topics include bicycle and pedestrian safety, intersection safety, highway safety, and intelligent transportation systems and safety. Most European countries make managing and organizing for highway safety a top priority. Highway safety information systems are a key part of this focus. The transportation system is also designed and operated with safety as a key element. Signalized intersection safety is a priority, as is examining human factors in research and implementation.

The signalized intersection safety scan in 2002 identified five major implementation priorities. The first was developing a model photo-enforcement process and program. The second was identifying and implementing demonstration projects for enhanced dilemma zone detection. The third was developing a policy project to control speed through intersections by using a combination of European practices. The fourth was to promote single-lane roundabouts as alternatives to signalized intersections. The fifth was developing guidelines and identifying pilot projects to enhance pedestrian crossings.

The human factors in research and implementation scan in 2004 identified practices that could benefit the U.S. transportation system. Human factors practices identified for implementation in the United States included the use of interdisciplinary research teams, simulator research and field validation, and cognitive models. Human factors-based initiatives include self-explaining roads, the “2 plus 1” road configuration, and speed management strategies.

The managing and organizing for the highway safety scan in 2002 covered Sweden, Germany, the Netherlands, and the United Kingdom. I had the opportunity to participate in the scan that focused on national safety goals and plans; processes, policies, and procedures to prioritize 3E (engineering, education, and enforcement) decisions; resources, tools, and legislative policies that guide and support 3E decisions and priorities; and examples and results of successful safety programs and activities.

A number of themes emerged from this scan. First, highway safety is viewed as a public health issue in the countries visited. Second, national comprehensive and coordinated plans address safety. The plans provide a proactive approach, measurable and deliverable targets, leadership and financial support at the national level, and clearly identifiable safety slogans and philosophy. There is local participation in setting national targets. Local plans and targets are keyed to national plans, and monitoring and evaluating of effectiveness of plans occur at all levels.

The plans contain a number of common elements. Among them are required seat belt use, low blood alcohol content levels and zero tolerance, and speed management. Other common approaches include conducting road safety audits and addressing vehicle crashworthiness, vulnerable road users, and novice driver training and licensing. Other supporting activities include significant data collection and analysis efforts, along with strong research capabilities and technical expertise focusing on safety.

The highway safety information systems scan in 2003 also identified a number of themes. First, safety drives the organizational structure in the countries visited. Data-driven strategic approaches, safety goals, and accountability permeate the organizational structures. Leadership supports safety, and needed resources are allocated for safety projects. Second, information on safety is shared among all agencies. Third, tools are available for efficient, accurate, and timely analysis support. These tools include technology applications and human resources and brainpower that are dedicated to safety.

I believe these scans have helped enhance the consideration of safety in planning, designing, and operating transportation facilities in the United States. We have seen action toward safety as a business driver through data-driven strategic safety programs, improved tools and tech-

niques, and legislative proposals. I believe there is also leadership awareness and support for safety programs. Planning for the Safety Summit II is under way.

The scanning team members really become the implementation champions. You will hear from members of the performance measures scan later this evening. They will share their enthusiasm and commitment to helping promote implementation of the best practices they encountered during the scanning tour.

PERFORMANCE MANAGEMENT OF ROAD ADMINISTRATION IN JAPAN

Takayuki Oba

I greatly appreciate the opportunity to participate in this session and the conference. I will share with you some of the experiences with the use of performance measures at the Ministry of Land, Infrastructure, and Transport in Japan.

My presentation focuses on three main elements. First, I will highlight the history of outcome-based road administration management in Japan. The use of performance measures in Japan includes analyzing the effectiveness of implemented policies and projects and using the analysis results to improve future projects, identify new approaches, and enhance budget projections. Second, I will describe the process for developing performance plans for each prefecture, which is coordinated with local governments. Finally, I will discuss recent initiatives to enhance accountability.

In August 2002, the Infrastructure Development Council provided a number of recommendations that resulted in the movement toward the use of performance measures. The council's view was that it was important to shift to an outcome-based road administration. The council recommended the establishment of an evaluation system that uses outcome indicators.

A number of activities were undertaken in fiscal year 2003 to start the process of road administration management. These activities included establishment of an advisory committee for public management of road administration and establishment of the Performance Management Office in the Road Bureau of the Ministry of Land, Infrastructure, and Transport. The 2003 performance plan for road administration was released, and performance plans at the regional level were developed. Finally, the cabinet approved the long-term plan for the development of social infrastructure in Japan.

The cycle of management was put into practice in fiscal year 2004. Key activities included linking budgets to outcomes through the introduction of performance-based budgets. The 2003 achievement report and the 2004 performance plan were also released.

The Performance Management Office, which I represent, was established in 2003. The office is located within the Planning Division. This organizational structure allows the division to work directly with individuals developing future plans and budgets.

The performance plan for road administration includes numerical targets for 17 performance indicators associated with five policy themes. Five-year midterm numerical targets were established for each indicator in the Key Plan for Infrastructure Development. This plan was authorized by the cabinet in October 2003. The scope of the plan includes more than just highway projects to help ensure the integration of all infrastructure plans. The first performance plan was issued in July 2003, and the 2003 achievement report was issued in June 2004. The results were used to develop the budget request for 2005. In April 2004 we began the performance-based budgeting process.

I will now highlight cooperation with regional governments in the use of performance measures. First, we discuss background data, such as the status of congestion, with each prefecture or state. This information is used to formulate a performance plan for each prefecture. The plan indicates the numerical targets and measures and the projects for achieving these targets. It includes the projects undertaken at the national level.

Many prefectures have worked out a succession of performance plans to disclose their numerical targets, as well as the measures and projects that address the unique features and needs of each region. For example,

the Tokyo performance plan was developed by a council composed of representatives from national and metropolitan governments. Beginning in 2003, an outcome plan was published to meet the national goals and targets. The plan links the policy targets to outcome indices and major projects.

As of December 2003, the 22 prefectures had set up nearly 160 indicators. Approximately half of the indicators are original ones for the regions concerned and are different from those in the nationwide performance plan. For example, a prefecture in the northern part of Japan has an indicator addressing the ratio of sections of road where the driving speed is reduced during the winter.

The Road Bureau holds regional road management workshops or hearings twice a year to discuss road management strategies in each region. The first workshops were held in February 2004. Future workshops will be held in February and June of each year.

In terms of accountability, the Road Bureau is working to establish a system that is useful in actual management of the roadway system. It is also important for policy makers and the public to know what we are doing. Figure 3 provides a map of time lost due to congestion in the Tokyo area. Figure 4 illustrates examples of trouble spots on National Route 16, which is an arterial highway around Tokyo. The trouble spots are the interchanges with the national highways. We have found that three-dimensional maps like these are an excellent tool to communicate with policy makers and the public.

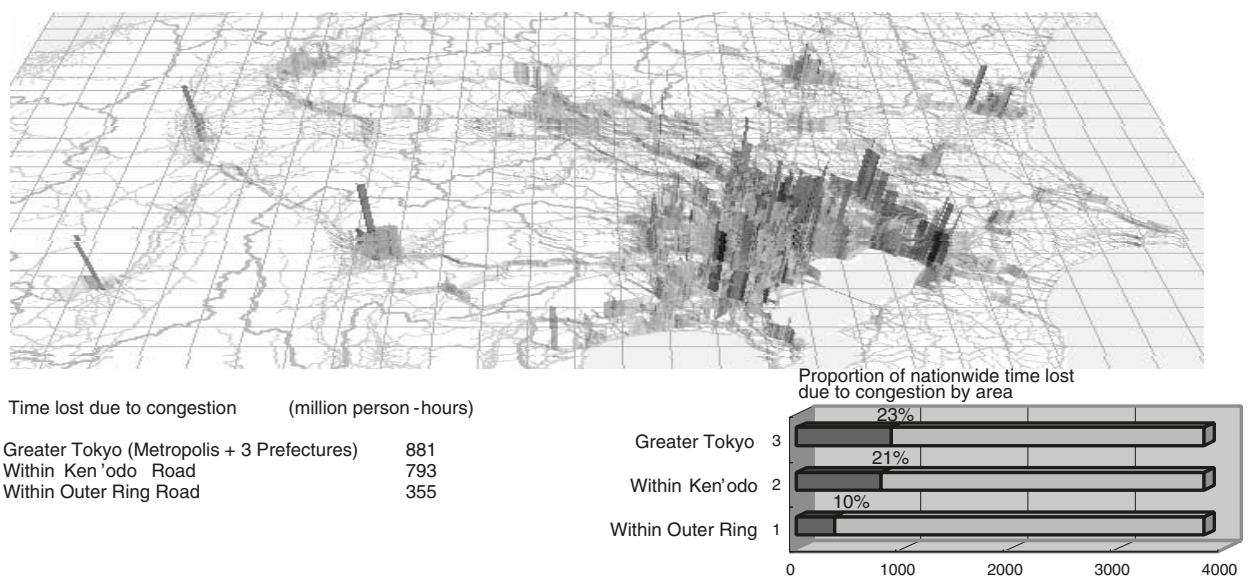


FIGURE 3 Example of finding trouble spots by means of congestion loss data, Kanto area: time lost due to congestion by area (nationwide 3.81 billion person-hours; Kanto 1.239 billion person-hours).

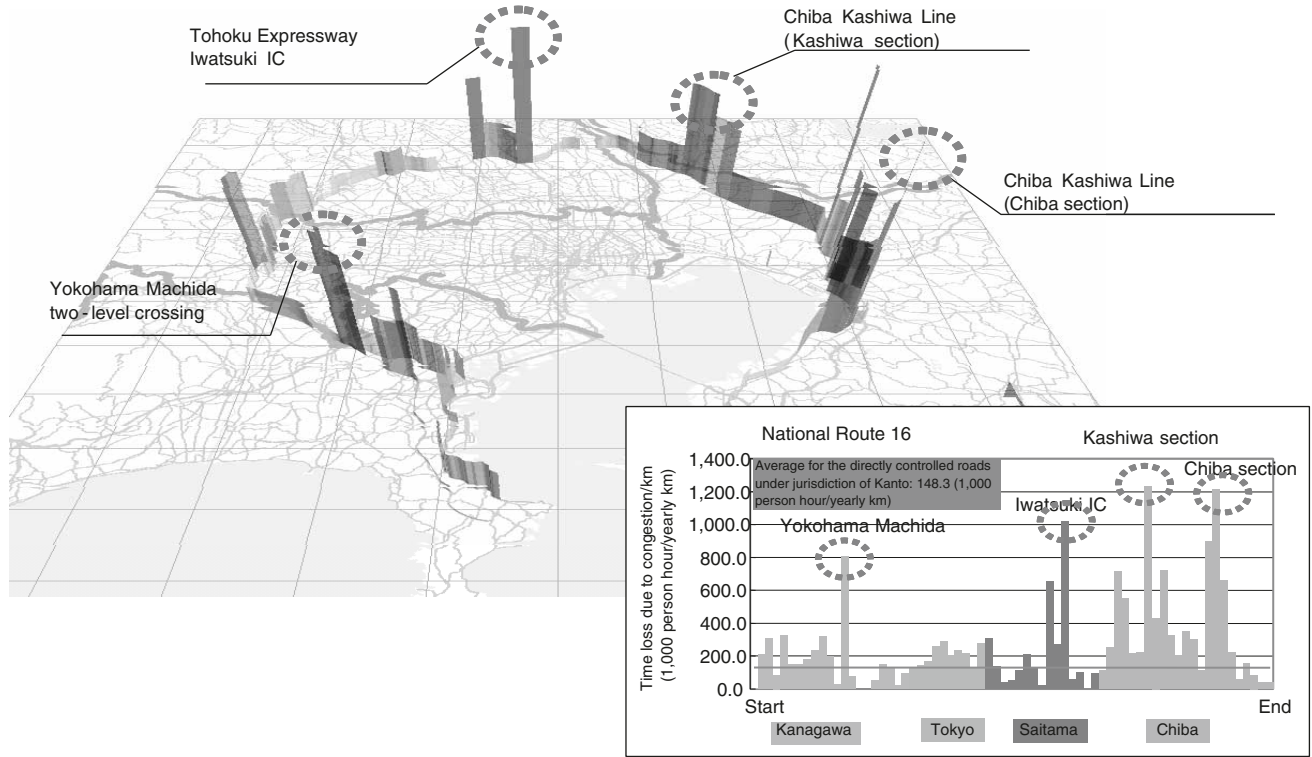


FIGURE 4 Example of finding trouble spots by means of congestion loss data, Kanto, National Route 16.

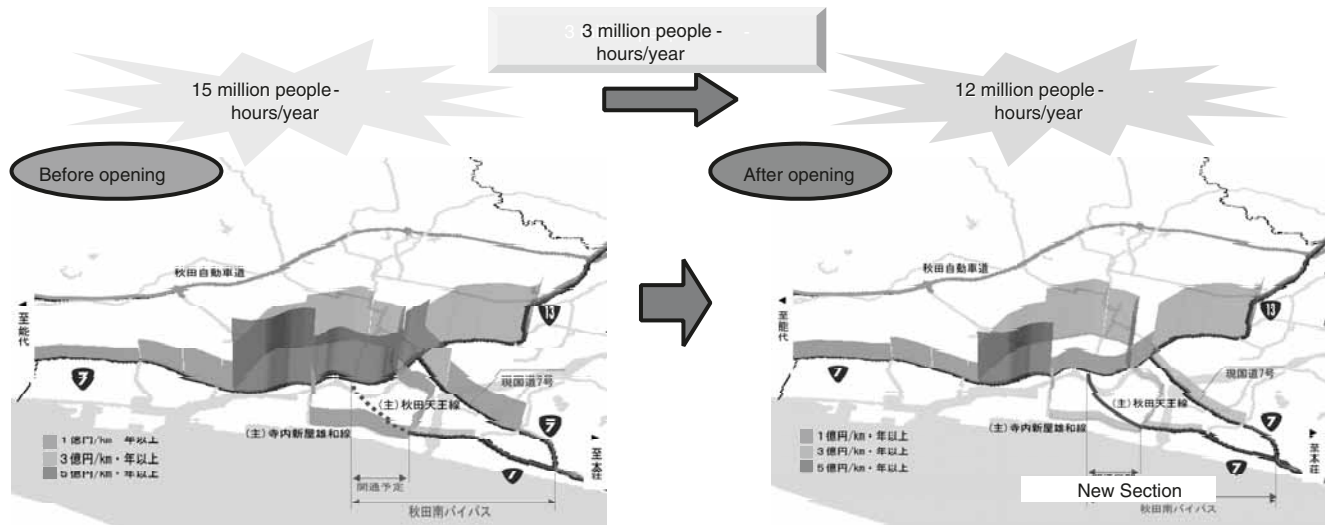


FIGURE 5 Analysis of the effect of an individual project in which data were used: change in congestion time loss.

Figure 5 provides an example of a map illustrating the benefits derived from a project. It shows the conditions on a national highway before construction of a new bypass and the conditions after the bypass was open. We use these types of graphics to illustrate the benefits of projects and policies.

We are still in the early stages of using performance measures and performance-based management in Japan. I look forward to learning more about the approach in use here in the United States during this conference.

INTERNATIONAL SCAN ON PERFORMANCE MEASURES

Douglas MacDonald, Connie Yew, C. Michael Walton, Bob Arnold, Ken Philmus, Randy Halvorson, Jeff Price, Gary White, and Michael Meyer

Douglas MacDonald: The scan tour was an intense and interesting experience. We visited a number of cities in Canada, New Zealand, Australia, and Japan over a 2-week period. The report to be distributed by FHWA on the scan will help share what we learned.

Transportation agencies in the countries we visited seem to have used performance measures more effectively in their highway safety programs than we have. New Zealand and Australia have seen dramatic improvements in highway safety performance as a result of this focus. Safety-related performance measurement plays a major role in achieving these results. Performance measures are important to identify targets, analyze needed changes, and track results. I believe most of us came back with a sense that the United States can do more in this area.

In Tokyo, the scale of transportation systems is huge. We visited with representatives from Japan Railway and toured the Central Train Station, which is being rebuilt. Four million people travel through this station on a daily basis. A multibillion-dollar infrastructure replacement project is also under way at the station. Work on this project is done between 1:00 and 4:00 a.m., when trains are not operating.

In New Zealand we visited an agency charged by the central government with producing a plan to cut road use by 20 percent. The agency was struggling with how to accomplish this goal while meeting other goals related to mobility and sustainability.

I found the scan to be beneficial, and I greatly appreciated the opportunity to participate. There is much to learn from the experience in other countries. I believe all the team members came back a little changed by the experience.

Connie Yew: One of the themes we encountered at many of the agencies we visited was an interest in providing greater accountability and visibility to the public. This interest in communicating performance measures with customers relates directly to many of the topics discussed at this conference and was the focus of a breakout session earlier today.

A few agencies we visited are fairly advanced in the use of performance management. These agencies link planning, decision making, and project delivery. Agencies in Queensland, Australia, are using sophisticated planning and reporting methods. Planning in Queensland is more accountable and visible to the public. The agency prepared five reports to document the status of

planning and project delivery. The first presents a top-level policy plan that identifies the desired outcomes. The second is a strategic plan that outlines the performance measures and the strategies to accomplish the desired outcomes. The third presents a 2-year road investment plan. The fourth highlights the annual accomplishments. This annual report presents financial performance measures and major activities during the year. The final report addresses the management and performance of Queensland's roads. This report presents performance measure results in an easy-to-understand way. I found this final report interesting and useful. It provides a model for transportation agencies in the United States to consider.

I also found interesting a report published by Austroads, an organization similar to AASHTO, on national performance indicators for Australia and New Zealand. The report has been published annually for the past 7 years. It provides important time-sensitive information to the transportation community and the transportation industry. The report acknowledges the differences in performance measures, data collection techniques, and operations in the various states in the two countries. Supporting information is provided to explain and address these differences. The report provides a benchmark to facilitate discussions at the local, state, and national levels in Australia and New Zealand.

I believe we can learn from these and other examples from the scan on enhanced methods to communicate performance measures with the public and policy makers. The agencies are interested in being more accountable and visible. The examples also highlight the connections among the various reports. The examples can be used as models to enhance the way we reach out to the public, which is important in communicating our message. The priority placed on safety was also evident. We can learn a lot about the approaches used in the countries we visited to improve safety on our roadways and other transportation facilities. Thank you.

C. Michael Walton: I greatly appreciated the opportunity to participate in the scan tour. The composition of the team provided an excellent mix of expertise and areas of interest. The chemistry among team members was outstanding and made the entire experience more rewarding and enriching. Mike Meyer did an excellent job as the reporter and was responsible for developing the final report. I thank everyone who participated in the tour, especially Mike for his work on the report. I believe everyone takes pride in it.

I have a few observations. First, as noted by other team members, safety is clearly a high priority in the countries we visited, and the results from the implementation of various strategies in reducing the number of fatalities are impressive.

Another issue that struck me as important was the ongoing organizational and institutional changes in many government agencies. Agencies are separating policy and management from the delivery of services and projects. The changes occurring within most agencies are a top-down process being driven by financial concerns and budget limitations. These changes are resulting in a dramatic reduction in public forces. The issues of accountability and transparency are key drivers of change. A related point was the transition of the culture at many public agencies, given the changing role of public institutions.

I had the privilege of visiting some of the countries 5 years ago and noted the progress, or at least the changes, that have occurred during the intervening period. There is a greater recognition of the importance of data—quality and quantity—in the ultimate choice of performance measures. This is particularly important for agencies undergoing significant changes in outsourcing, privatization, or downsizing. Knowing what you are getting for your investment is deemed critically important.

Many of the agencies we visited are moving aggressively toward design–build–finance–operate, design–construct–maintain, and build–operate–transfer approaches. There is a growing realization that data are critical in gauging how well these approaches are working. The agencies recognize that it is important to have a strategy to collect needed data and to maintain these systems. Stewardship was another term used frequently by representatives at many agencies we visited.

Intelligent transportation systems are another major focus among many of the transportation agencies visited. Technology is being considered to enhance the operation of the transportation system. For example, alternatives to loop detectors are being explored and tested in Japan. Reliance on loop detectors has become problematic given their maintenance experience, reliability issues, and the high traffic volumes on the Tokyo expressways. Alternative technologies, such as the use of probe vehicles, are at various stages of deployment. Another procedural requirement is the use of cost–benefit analyses and before-and-after studies in the evaluation of alternatives and in determining the effectiveness of an investment in achieving expected results.

Finally, the agencies we visited are interested in defining environmental performance measures. However, they are struggling to identify appropriate measures, data collection techniques, and reporting methods, as are transportation agencies in this country.

Bob Arnold: I enjoyed the opportunity to participate in the scan. I believe all of the team members learned a lot from the countries we visited. There were a number of things that I found of interest in the site visits and in our meetings with agency personnel.

First, performance measures are being used by transportation agencies and are being monitored in the coun-

tries we visited. Many of the performance measures are similar to those in use by transportation agencies in the United States. There were some differences, however, especially in the areas of safety, the environment, and quality of life.

Second, I was surprised that the insurance industry is active in transportation in many of the countries we visited. The insurance industry is involved in transportation projects and uses performance measures to select and fund some projects, particularly in the safety area.

We can learn from the experience with the use of performance measures in some of the difficult-to-measure areas in the countries we visited. Many transportation agencies in the United States are struggling with this. Certainly, we can learn from the performance measures used in the safety area.

Ken Philmus: I appreciated the unique opportunity to participate in the scan. I also appreciate the recognition by AASHTO and FHWA of the importance of tolling as a method of raising funds not only for added improvements and capacity but also for traffic and congestion management. We saw this approach in the four countries we visited.

One of the things I noted was the involvement of the public in the transportation performance measures process. The public is our customer, and it was interesting to see how agencies in other countries involved the public in developing performance measures and reporting the results of ongoing monitoring efforts. Too many times managers and policy planners in this country think we know and understand what the public wants without asking. We are often surprised that we really do not know what the public wants when we actually ask for opinions. In all of the countries we visited the public was involved in some way, either through user satisfaction surveys or participation in meetings to help develop performance measures. I believe we can learn from the methods used in the countries we visited to involve the public in setting performance measures more directly.

Coming from New York City, I deal with major traffic congestion on a regular basis, and I was not totally overwhelmed by the traffic in Tokyo. I must admit that I was overwhelmed by the multimodal approach in Tokyo, however. I am responsible for one of the busiest bus terminals in the world, and it pales in comparison with the Central Train Station in Tokyo. The Tokyo station was busier at noon than our station is during the peak periods. It was just an amazing place to see.

The agencies we visited are using congestion performance measures and reliability performance measures. These measures were not focused solely on passengers. Too often we think of the commuter and travel in personal vehicles, but the movement of freight and goods is equally important. Trip-time reliability is also important. We all will put up with a certain amount of con-

gestion. While we want to reduce congestion levels, most commuters tell us that trip-time reliability is more important. Trip-time reliability and other related measures are being used in other countries, in addition to measures addressing congestion.

It was also interesting that tolling is used in the countries as a way to reduce congestion as well as to raise funds. Not only is electronic tolling used, but open road tolling is used in some areas and is planned in other areas. Open road tolling means there are no tollbooths and enforcement of toll payments is done through the use of cameras and other advanced technologies.

I was also interested in regional and local agency involvement in the state performance measures. I believe it is critical that local entities and state agencies be aligned. We saw some good examples of coordination among state, regional, and local agencies in the development and use of performance measures. We still struggle with this type of coordination, especially in coordinating transportation and land use.

Finally, there is one thing that I did not see in the countries we visited. As you know, the Port Authority of New York and New Jersey was terribly disrupted by the events of September 11, 2001. We constructed, owned, and operated the World Trade Center. Our offices were in the World Trade Center, and when those buildings collapsed our agency came to near collapse. We have been rebuilding our agency ever since. My job has changed from being a transportation expert to being more of a security expert.

As are agencies in the United States, those we visited are struggling with how to measure security. How do you know that you are spending the right amount of funds in the right places to accomplish the right kinds of things when the only measure you have is that a terrorist attack did not happen? I did learn that the risk and vulnerability studies we are conducting at the Port Authority seem to be on the cutting edge, as are the changes we are implementing to reduce risk and vulnerability. No one in the world is using these approaches, and I answered numerous questions about our efforts. Thank you.

Randy Halvorson: I believe all the team members, myself included, greatly appreciated the opportunity to participate in the scan. We joked why people in their right minds would agree to travel 25,000 miles on 12 flights over 18 days, however. The answer is found in the 21 observations contained in the final scan report. I will highlight four of the observations. I will note how these observations relate to what we are doing at the Minnesota Department of Transportation and how some initiatives that are under way have already been influenced by the scan.

The first observation relates to safety. As other speakers have noted, safety is given a high priority in the

countries we visited. The breakthrough in reducing fatalities in Australia is especially dramatic. Minnesota's first comprehensive highway safety plan was still in the development stage when I returned from the scan. We were able to use some of the information from the scan in the development of the final plan.

I am pleased to say that the highway safety plan includes 10 emphasis areas—four in infrastructure and six in behavior. Before we incorporated what we learned from the scan, the emphasis areas probably would have been eight in infrastructure and two in behavior, and the behavior performance measures would have been included as an afterthought. The lessons we learned in Australia showed the power of behavioral interventions in reducing fatalities on the transportation system.

The second observation relates to the power of performance measures in educating both elected officials and the public. I would take that one step further. I believe performance measures can actually be used to change the nature of the public debate.

The third observation relates to the use of visualization. How we present performance measure information and display data to elected officials is important. There is a new National Cooperative Highway Research Program (NCHRP) project in the 8-36 series called Effective Organization of Performance Measures. Part of this project will examine visualization techniques for presenting performance measures. It will include best practice examples.

My final observation relates to benchmarking, which is being used extensively in Australia. An NCHRP panel in the 20-24 series is currently examining the use of benchmarking in this country. I believe we have a lot to learn about benchmarking in the United States. While some groups are concerned about the use of benchmarking, I believe it is worth pursuing.

I appreciated the opportunity to participate in the scan and look forward to helping champion these and other observations. Thank you.

Jeff Price: Many of the things that I found most interesting during the scan have already been mentioned by other members of the scan team. As other speakers have noted, the scan provided a wonderful opportunity to visit with staff from the different agencies and to see the various transportation facilities. The same basic principles and approaches to performance measurement that we have been talking about at this conference are being used in many of the agencies we visited. It was interesting to see how they are taking the same principles and applying them to their circumstances. I believe many of the differences in areas of interest and different applications of performance measures reflect differences in the culture and in the political structure or the current political agenda.

For example, it was interesting to see the different approaches being used to address customer satisfaction,

especially those aimed at providing a pleasant and satisfying experience for public transportation passengers. In Tokyo, passengers are alerted when a bus is approaching a congested area. In Melbourne we saw variable message signs that gave the expected travel times for automobiles versus buses. In combination with bus-only lanes and a bus priority initiative, showing expected travel times has been a good stimulus for people to use public transportation. In general, I was impressed with the emphasis placed on encouraging the use of public transportation. While this trend is in part due to many of the organizations we visited either owning or operating the transit systems, it also reflects the different attitude they have toward public transportation.

I believe you will find the final report to be of great value and use. It is well done and contains the observations from the team. As other speakers have noted, we can learn from the experiences in the countries we visited.

Gary White: I greatly appreciated the opportunity to participate in the scan. As other speakers have indicated, the use of safety performance measures was one of the most notable observations from the scan. The safety performance measures in these countries provide examples that are transferable to the United States.

Another important point that we heard several times related to starting small and building on success. Rather than waiting for the perfect performance measure to emerge, develop an initial set of performance measures, adjust them as needed, and learn as you monitor and evaluate performance over time. If you wait for the perfect measures, it will never happen.

Another observation concerns keeping the use of performance measures simple. Rather than starting with too many performance measures, identify a few key measures in the beginning. Focus on collecting the data needed to monitor and evaluate these key measures, and expand to more measures as appropriate.

There were a few performance measures that I found of interest. One internal performance measure was the percentage of employees who had professional development plans. The Virginia Department of Transportation has a similar internal performance measure, but what I found of interest was the use of a percentage of the agency payroll allocated to a strategic training plan. Another performance measure that I found of interest related to the percentage of projects that include the provision of walking and cycling.

Michael Meyer: My colleagues have covered many of the highlights from the scan. As the last speaker, I will focus on a few observations that I consider to be important, without repeating what we have already heard. In particular, I want to emphasize lessons learned that relate to this conference.

Many of you have heard me talk previously about the importance of vertical integration in information

flow and decision making within organizations. The paper I presented at the first national performance measures conference in 2001 included a figure that helped illustrate this concept. The figure was a triangle that had different tiers of decision making with arrows going up and down connecting these different levels, representing the important connections in information flow and decision-making accountability that need to occur within an organizational decision-making structure. The arrows illustrated how performance measures could cut across different levels of decision making and provide important information for decisions made at different levels in an agency.

I was greatly surprised and impressed that we saw this concept of performance measurement in Australia and New Zealand. Using a pyramid diagram, agencies in the Australian states and in New Zealand portray performance measures as starting at the highest level of an agency's decision making and flowing down. Performance measures are also used to provide consistency in decision making among other agencies, traffic management centers, and private contractors. The cases studied provided excellent examples of vertical integration. Performance measures need to be placed in the context of a performance management structure that integrates an organization's decision-making process.

I was also impressed with the widespread use of before-and-after studies in the countries we visited, especially Japan and Australia. Before-and-after studies are conducted on 10 to 15 percent of all the projects implemented in some of the Australian states every year. The results of these studies provide a feedback loop to help evaluate the benefits of the projects and the usefulness of specific performance measures. Most transportation agencies in the United States do not conduct extensive before-and-after studies of projects. I believe we can learn about the benefits of these types of studies from the countries we visited.

Benefit-cost analysis was used both before project implementation and after projects have been in place for 2 years. The before benefit-cost analysis is compared with the after benefit-cost data to develop what is called an achievement index. If the achievement index varies, which indicates that the benefit-cost analyses do not match, or in other words that the initial attempt at benefit-cost analysis was faulty, an assessment is conducted to determine what factors caused the difference. The results of this assessment are linked to the initial assumptions and performance measures.

As other speakers have noted, agencies in the countries we visited are struggling to develop performance measures for environmental quality and other hard-to-measure features. Performance measures addressing environmental quality tend to be similar to those used in the United States. While there is an interest in develop-

ing better measures, most agencies have not progressed any further than have agencies in this country.

We did see an emphasis on rural transportation issues in a few areas. Brisbane is the major population center in Queensland, Australia. However, the transportation needs of the rural parts of Queensland, especially isolated communities, are considered to be an important equity issue for the Queensland government. Providing truck and rail transportation to these communities is the means of providing connections to the rest of the state, and performance measures are used to determine how effective these rural transportation services are.

Some agencies in the four countries had performance measures focusing on quality-of-life issues. For example, in Japan one performance measure relates to ensuring that pregnant women are within a threshold travel time of a maternity hospital. In other words, the performance measure focuses on making sure that women having babies can get to the hospital quickly. It was interesting to see the use of performance measures to address issues such as this.

Finally, it was interesting to see the link between performance measures and the political process in the countries we visited. In most of the countries visited, performance measures are developed at the government level first and then flow down to agencies. For example, the national parliament in Japan provides the initial direction on performance measures. The state governments or parliaments in Australia also provide direction to state transportation agencies. These general policies are used to develop more specific agency performance measures. My sense is that in the countries we visited there is less concern about trying to get the attention of the politicians because they are already actively involved from the beginning.

I greatly appreciated the opportunity to participate in the scan. Team members who were not able to be here tonight include Hal Kassof from Parsons Brinckerhoff, Doug Rose from the Maryland State Highway Administration, and John Baxter from the FHWA Office of Highway Safety. Tony Kane from AASHTO also participated in part of the scan tour.

Measuring Performance in Difficult-to-Measure Areas

Michael Meyer, Moderator, *Georgia Institute of Technology*
Timothy Lomax, *Texas Transportation Institute*
Randy Halvorson, *Minnesota Department of Transportation*
Barbara Ivanov, *Washington State Department of Transportation*

CONGESTION AND RELIABILITY PERFORMANCE MEASURES

Timothy Lomax

It is a pleasure to have the opportunity to talk about performance measurement issues related to traffic congestion. My comments focus on the types of decisions congestion measures might be used with, possible congestion and reliability performance measures, data considerations, and research needs.

It is important first to examine what we are trying to measure and why we are trying to measure it. Performance measures should be considered within the context of a variety of urban goals. Goals addressing improved mobility might include lower travel times and more reliable travel conditions. Mobility goals may focus on the movement of both people and freight. Consideration may be given to a variety of time-of-day periods and to regular and special events. Urban and rural situations should be considered, as should different modes and possible pricing structures.

It is also important to remember that congestion performance measures are of interest to a wide range of groups, including the public, travelers and shippers, the business community, elected and appointed officials, agency leaders, and agency staff. We need to be able to communicate with all these groups. Different communication techniques and messages are typically needed with these various groups.

We also need to look at the potential actions or end results with the use of congestion performance mea-

asures. Influencing changes in travel might be one outcome. Actions by agency staff to address problem areas identified through the use of specific measures may be another result. Business location decisions may be influenced by congestion levels in a corridor or an area. Travelers and freight shippers may make routing decisions on the basis of congestion.

Survey results from around the country indicate that the public is aware of congestion issues and congestion levels. Figure 1 tracks the results of an annual public perception survey in Houston, Texas, and the hours of delay per peak-period traveler in Houston. The line with the square boxes indicates the percentage of survey respondents ranking traffic congestion as Houston's major problem. The line with the diamonds shows the delay per traveler value for Houston.

As Figure 1 indicates, congestion was a major problem in Houston until the mid-1980s, when the city experienced a major downturn in the economy at the same time that there was a significant expansion in transportation system capacity. Congestion levels began to increase in the mid-1990s as Houston's economy recovered. The public's perception of congestion, as recorded through the annual surveys, mirrors the trends seen in the traffic data. I believe that the public does understand congestion-related performance measures. The challenge is to match measures to issues of interest to the public.

We also need to think about the types of decisions agencies and travelers can make on the basis of information from performance measures. Those related to congestion and reliability might influence decisions

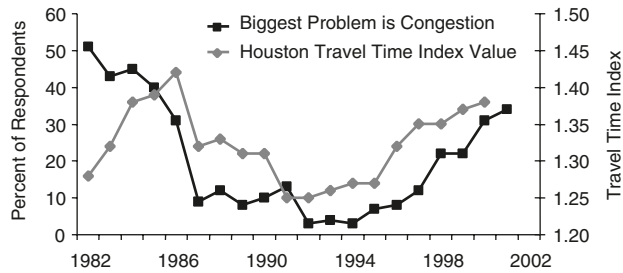


FIGURE 1 Congestion and public perception in Houston. (Source: Stephen Klineberg, Rice University.)

about what to do, what to spend, when to act, and what to change. We also need to consider how important or immediate the decisions and related actions are.

Congestion performance measures are related to a variety of other measures and issues associated with the quality of life in an area. Some of these issues are accessibility, air quality, business productivity, economic development, safety, schools, health care, libraries, and housing. It is important to think about congestion performance measures in a competitive sense. Congestion-relieving projects are not just competing with other transportation projects for limited funding; they are also competing with other urban priorities.

We need to have performance measures that work in real time. We need short-term or day-to-day performance measures and long-term measures for annual reporting and future estimates. We also need to set targets for the various performance measures. We can anticipate that these targets will change as people's expectations change. The targets will also change by location and by time of day. Most people do not expect to be able to drive 50 mph on a freeway in the morning peak hour, but they do on a weekend. It is important to talk about the benefits as well as the costs of various strategies.

There are a number of sources of unreliability related to travel time and trip reliability. The Future Strategic Highway Research Program Reliability Research Project identified seven sources of unreliability: traffic incidents, weather, work zones, traffic variation, special events, traffic control problems, and bottlenecks. Transportation agencies can address many of these sources of unreliability and may have more success in reducing the day-to-day differences in travel time than in reducing average congestion levels.

Performance measures have been used with pavement quality and bridges for many years. Applying performance measures to operations is a recent activity. Operations performance measures should be related to the goals and the vision of the region and the various parts of the transportation system. They should be easy to use and easy to communicate to stakeholders. They should be based on cost-effective data collection that is compatible

with legacy data to the extent possible. Measures should allow for use of estimating and modeling future trends. They should also allow for modal and program trade-offs. There may be some good private-sector examples that can be used.

Another topic of discussion is how to measure improvements or successes. Lower travel times and less congested time and space are two approaches that have been used. Given the variability in travel time from day to day, focusing on acceptable travel times may be a more realistic measure. Providing more options for travelers may be appropriate. We might also be able to do a better job of predicting travel times.

A number of factors should be considered in selecting appropriate mobility measures. For example, being able to show the effects of potential solutions is important. Performance measures that respond to land use changes are needed. Performance measures should address both person and goods movement. Targets for measures should be based on realistic expectations.

Consideration needs to be given to what we should measure. I believe we need to measure trip and segment travel times and link, section, and route speed. We need to be able to identify variations. Some people have suggested that we measure bad days or days that are worse than normal. The value of travel and delay allows us to place a monetary value on congestion. Matching expectations and schedules is another possible measure. Measures are needed that focus on a single mode, but we also need measures addressing multimodal and intermodal trips.

A number of measures are appropriate for consideration. Measures that appear to resonate with the public and policy makers include travel time, travel time variation, and delay. The travel time index at the area level also appears to be understood by these groups. The buffer index that Jeff Lindley talked about on Sunday and the misery index that is targeted toward the number of bad days are two other possible measures. Being able to place a monetary value on delay and variation is also important.

Research indicates that there is a strong relationship between congestion and reliability. As congestion increases, reliability decreases. In metropolitan areas that have implemented more aggressive operations strategies, unreliability does not appear to increase as sharply.

Figure 2 illustrates the buffer index measure. The buffer index, which is the difference between the average travel time and the planned travel time, can be used in a number of ways. We can also match the results of customer satisfaction surveys with reliability performance measures. We know intuitively that travel conditions vary greatly on a daily basis. Graphing daily values shows that there is wide variation in the upper and lower bounds.

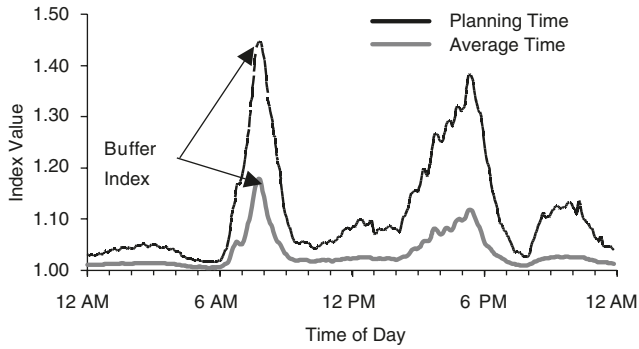


FIGURE 2 Planning time and buffer index.

The influence that turning off the freeway entrance ramp meters in the Minneapolis–St. Paul, Minnesota, area had on delay at the entrance ramps has been examined. Congestion levels increased and travel reliability declined significantly during the period the ramp meters were turned off.

It is appropriate to consider different performance measures to address a range of needs. Real-time maps of urban traffic may be related to specific trips. Measures addressing average travel times, historic travel times, and variation in travel time are also needed. Performance measures for annual strategic decision making might include the different indices, elements covering all travel, average and actual travel time, and condition-specific reporting.

A wide range of data sources may be available for use with performance measures. Point detectors and travel time collection are two of the most common approaches. It is important to identify the critical data collection elements and to maintain them over time. Travel time studies, data from private firms, and continuous Global Positioning System–based data collection may all be used. Key data collection resources should be identified and maintained over time. It is difficult to maintain 2,000 loop detectors or 2,000 radar microwave detectors.

As illustrated in Figure 3, we are seeing a migration to direct monitoring over the long term. Other potential data sources will be needed, including legacy data systems and customer satisfaction, travel behavior, and goods movement surveys.

Surveys of travelers, truckers, and bus riders can be an important source of information. Surveys of high-occupancy vehicle (HOV) lane users over the years indicate that they report greater travel time savings than are measured by travel time runs or other data collection techniques. It could be that these commuters are indicating that they do not need to plan on a longer travel time, since they can depend on the trip-time reliability provided by the HOV lane.

In using congestion performance measures it is important to have an understanding of other factors

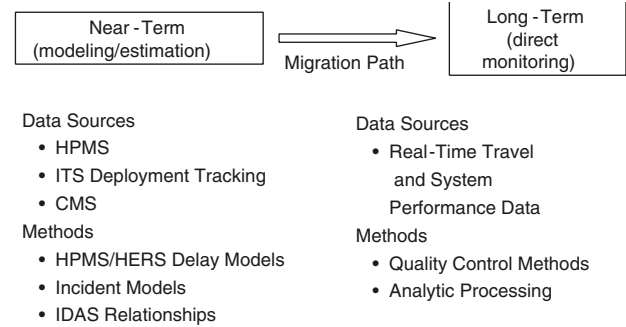


FIGURE 3 Migration to direct monitoring for data collection. (HPMS = Highway Performance Monitoring System; ITS = intelligent transportation system; CMS = congestion management system; HERS = Highway Economic Requirements System; IDAS = ITS Deployment Analysis System.)

that may influence the performance of the system. These factors include weather, collisions, breakdowns, malfunctions, traffic or loading variation, new development, and special events.

The limitations of data collected through various means should be recognized. Understanding the different data collection devices and maintenance needs is critical. Data quality issues, as well as other uses of data, should be understood. Partnering with other agencies can reduce the cost of data collection and can increase the availability of data.

In conclusion, I believe the strategies being considered in most urban areas focus on both providing more transportation system components and increasing choices for system users. Agencies are examining ways to improve the implementation process and to provide better products and services. Performance measures have a role to play in these strategies. Performance measures can help provide linkages between choices, funding, and actions. We also need to continue to experiment with both performance measures and strategies to improve the transportation system. Thank you.

TOOLS FOR UNDERSTANDING CUSTOMERS IN MAKING INVESTMENT DECISIONS

Randy Halvorson

I will start my presentation with a story about linking customer satisfaction, performance measures, and incident management, and communicating with elected officials. Three years ago, the Minnesota legislature was facing a significant budget shortfall. A legislator suggested that the Minnesota Department of Transportation's budget could be reduced by eliminating the Highway Helper Program. It was suggested that people could change their own tires.

The department was able to show the legislature both the importance of the program to congestion management and the importance travelers place on it through ongoing customer surveys. The result was that the legislature increased the budget for the Highway Helper Program that year.

The department has conducted annual omnibus surveys of citizens since 1987. The department was also one of the first state transportation agencies to employ market research personnel. It adopted a statewide performance-based plan in 2003. Performance measures are being integrated into the budget process. We are communicating with members of the legislature concerning the key elements of the plan and the performance measures.

The Minnesota Department of Transportation collects and analyzes information on customers in a variety of ways. First we use market research techniques, such as surveys, focus groups, and other methods, to collect quantitative information about customers with scientific sampling techniques. Our public involvement processes also collect information on our customers. These forums, especially public meetings, do not scientifically sample or randomly select participants. Nevertheless, they are an important source of input from citizens and stakeholders.

The department is in the process of converting an 11-mile HOV lane on I-394 into a high-occupancy toll (HOT) lane. The department used market research when the HOV lanes were being developed in the mid-1980s. We are also using market research, including focus groups, as part of the HOT lane project. Issues discussed by the focus groups included the hours of operation and the tolls for HOT lane users.

Finally, user impact analysis measures the effects of our investments on roadway users in terms of travel time savings, accident reductions, and vehicle operating cost savings. These assessments are typically performed through techniques such as benefit-cost analysis or life-cycle cost analysis.

My comments today focus on using market research information for investment decision making and performance measurement. Developing performance measures requires three steps. First, an outcome statement describing the result we hope to achieve for our customers is developed. An example of an outcome statement is reasonable, predictable travel times between regional trade centers. Second, a quantitative measure of that outcome or objective is developed. These measures may be proxies for the outcome, on the basis of existing data. Several measures may be needed to capture a single outcome. An example of a quantitative measure for an objective is a specific average travel speed in miles per hour. Third, a quantitative target or goal is set for each time period. An example of a goal is achievement of an average travel speed of 60 mph on 88

percent of miles of high-priority interregional corridors by 2005.

In developing performance measures by using customer information, the importance of transportation services to our customers should be understood first; only then should we examine how satisfied they are with these services. Understanding the reasons for their satisfaction or dissatisfaction is also important. Performance measures and targets combine this information, with more aggressive targets set for the most important services. Products that are not important may not be tracked with performance measures or may be selected for a reduction of resources.

Figure 4 illustrates how the Minnesota Department of Transportation analyzes customer information on the importance of and satisfaction with specific products and services. We focus resources on those products and services that customers rank as most important. If they are already satisfied, we try to maintain that service. If they are dissatisfied, we try to improve the service.

Figure 5 provides an example from the department's market segmentation study of how customers assess the importance of our roadway maintenance activities and their satisfaction with those services. As shown in the upper right corner, our customers rank snow and ice removal as very important, and they are satisfied with those services. In the upper left corner, customers are also very satisfied with our roadside planting, but these services are not highly valued by our customers. The department may be able to reduce resources in this area and still maintain customer satisfaction.

The lower right corner identifies areas that customers value but where they find the department's current level of service unsatisfactory. Road striping is important to customers, but they are not satisfied that the stripes are clearly visible. The department may place increased effort in this area. Finally, as noted in the lower left cor-

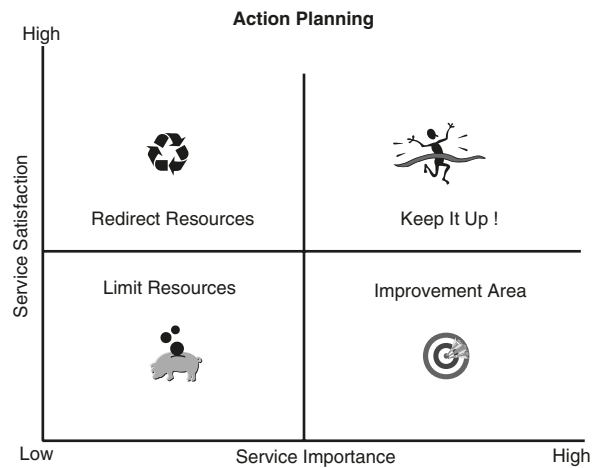


FIGURE 4 Customer satisfaction with products and services.

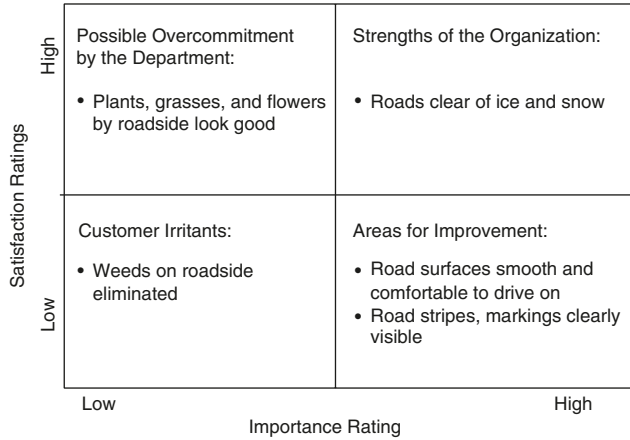


FIGURE 5 Customer satisfaction with roadway maintenance activities.

ner, customers think our roadsides are too weedy, but they do not rate this as an important roadway feature.

This information provides a clear picture of which products and services are of more importance to our customers. Those services directly provided on the roadway are consistently ranked most important by all of our customer segments. These services include salting, sanding, maintaining roads and bridges, building roads and bridges, removing debris, creating and maintaining speed and road signage, managing traffic, and providing features such as lights and striping. The two highest-ranked services are snow and ice removal and road smoothness.

The Minnesota Department of Transportation uses customer satisfaction information in conjunction with importance rating data to set a limited number of performance measures directly. We make limited use of these direct satisfaction measures for a number of reasons. First, budget limitations do not allow us to satisfy all customer priorities. For example, we know our customers are dissatisfied with traffic congestion. The department does not have the funds to reduce this growing problem significantly, however.

Second, many of the services we measure are not visible to customers, so they would not have a sound basis for reporting satisfaction or dissatisfaction. For example, the structural condition of bridges is important to the safety and efficiency of the highway system. The department measures and reports on the number of structurally deficient bridges each year. However, we do not ask customers whether they are satisfied with our performance, since bridge structural problems are not typically visible to drivers. We do use customer satisfaction measures directly in the areas of roadway maintenance, including snow and ice removal, and reliability of department information.

The Minnesota Department of Transportation conducted focus groups several years ago to obtain a better

idea of customer satisfaction with different levels of snow and ice removal. The focus group participants were shown different photographs of roadways after a snowfall. Participants were asked whether they would be satisfied if the road looked like the photographs after different lengths of time. The focus groups were stratified to provide feedback by roadway type, from high-volume urban freeways to low-volume rural two-lane roads. Targets were established on the basis of the focus group results for the number of hours after a snowfall a roadway should be cleared for each roadway type. Figure 6 shows the systemwide average. The bars are the department's actual performance for the past 5 years.

The department also conducts an annual survey of customer satisfaction with roadway maintenance. Figure 7 illustrates the overall satisfaction ranking from the surveys. While the department's snow and ice removal times are good, the survey results indicate that satisfaction levels are declining.

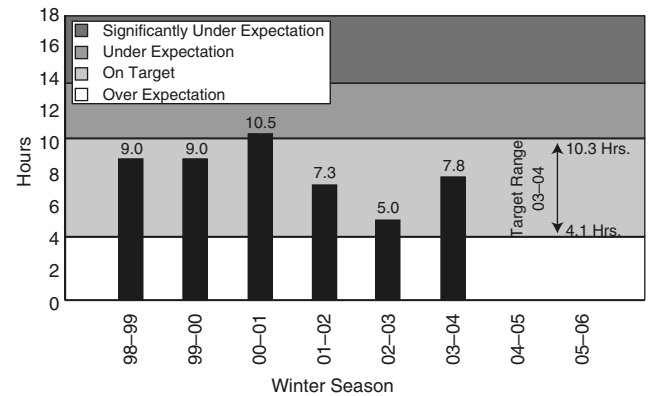


FIGURE 6 Snow and ice removal: statewide annual average hours to achieve bare lanes after a snow or ice event. (Source: Office of Maintenance, Minnesota Department of Transportation.)

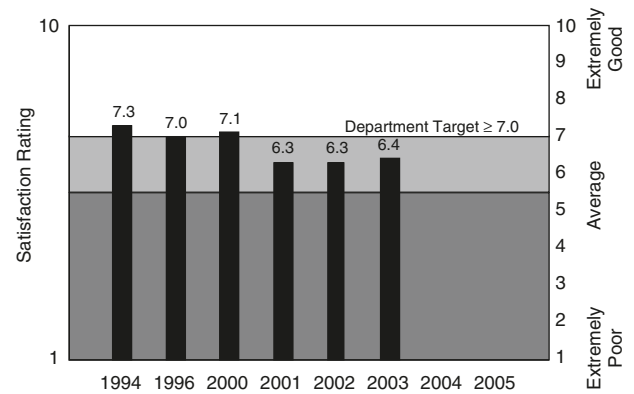


FIGURE 7 Minnesotans' satisfaction with maintenance of roadways: state highways—average on a 10-point scale. (Source: Omnibus Study 2003/2004, Minnesota Department of Transportation.)

dimensions, including both snow and ice removal and roadway smoothness. Ratings of road smoothness have declined as pavement conditions have deteriorated in the past 4 years. This trend has overshadowed our performance in snow and ice removal.

Customer satisfaction with the department as a reliable source of information is also measured. Customers consistently rank providing timely and accurate information as one of our most important services. Each year through our omnibus survey, we ask citizens if they are satisfied with us as a reliable source of information. As illustrated in Figure 8, we have been below our target of 60 percent of customers regarding us as a reliable source of information for the past 4 years.

The department uses market research information on customer satisfaction indirectly to validate some of its performance measures. For example, the department sets a target for pavement smoothness rating (PSR) at the level that minimizes the life-cycle cost of maintaining the pavement. However, we use customer satisfaction information to validate that target.

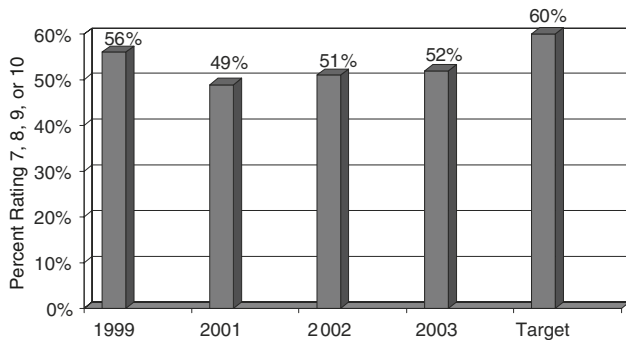


FIGURE 8 Customer regard for Minnesota Department of Transportation as a reliable source of information.

Figure 9 shows the department’s PSR data. We have set a target that 70 percent of roads will have a PSR rating of 3.3. Keeping pavements at that rating minimizes the cost to maintain them over their life.

Figure 10 shows customer satisfaction with road smoothness. When the department was meeting the pavement targets, the average satisfaction score was 6.7 to 6.6 on a 10-point scale. When pavement conditions started to decline in 2000, however, so did customer satisfaction with road smoothness.

The department’s investment decisions have changed in reaction to customer information. On the basis of roadway maintenance information in 2000, the department reduced expenditures on roadside mowing and weed control. These resources were redirected to snow and ice removal, which our customers value more. The department has recently directed districts to increase pavement preservation investments to reverse declining PSRs and to help districts meet pavement targets by 2014.

The Minnesota Department of Transportation has learned a number of things from these efforts. In the private sector, market research is either implicitly or directly related to product price. In contrast, we do not directly price highway services, with the exception of toll roads. As a result, it is important to structure questions carefully to get at customer preferences and priorities. We often ask customers to rank a series of services or features. Another technique we use is to ask customers to allocate \$100 among different transportation investments or services. These approaches help eliminate the tendency of the average citizen to say “I want it all.”

All of our major customer segments generally report similar priorities for services, with those tied directly to

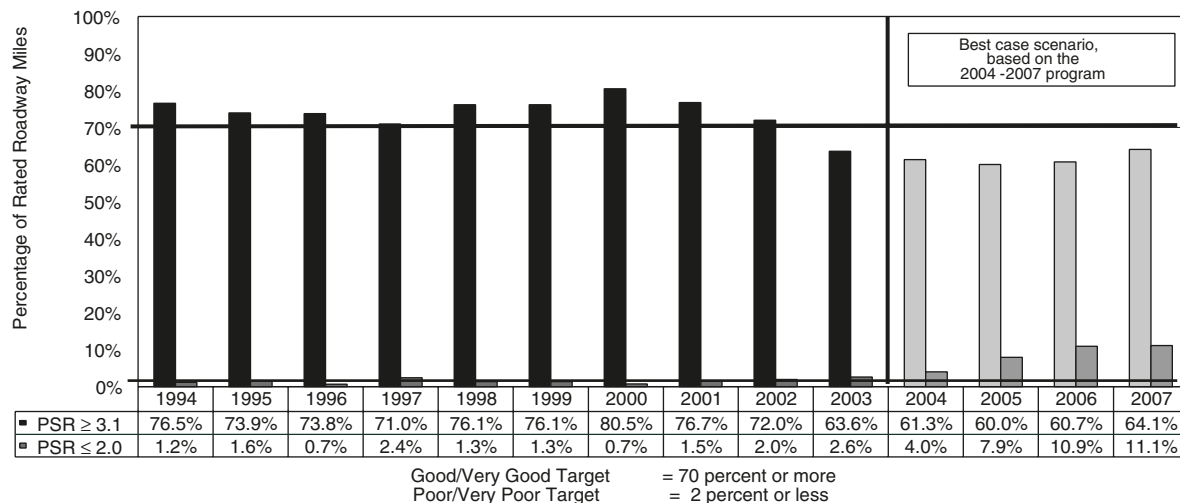


FIGURE 9 Customer ride quality serviceability rating and pavement smoothness rating. (Source: Office of Materials, Minnesota Department of Transportation, February 17, 2004.)

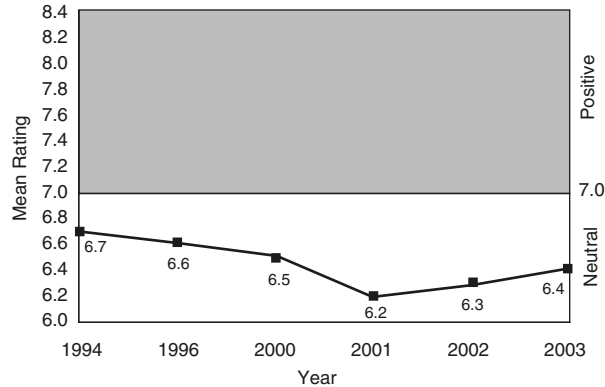


FIGURE 10 Customer satisfaction with road smoothness: rating on a scale of 1 to 10. (Source: Office of Investment Management, Market Research, Minnesota Department of Transportation, February 2004.)

the roadway ranking highest. The segment in Minnesota with significant differences is farmers. This group tends to rate roadside services higher than other groups because farm equipment frequently uses the shoulders.

We have found that our customers are perceptive and accurate about changes in road conditions. For example, in 2002 our customers reported that congestion was improving. This response surprised us until we examined the annual extent of congestion data. Congestion actually did decline that year. The state was in a recession in 2002, with a loss of some 45,000 jobs. The 45,000 fewer commuters made a measurable, although short-term, impact on congestion.

In conclusion, customer information is important to the Minnesota Department of Transportation in prioritizing investments and allocating resources. The department uses customer satisfaction ratings for performance measures only in limited areas, however. The lack of resources and price signals makes it difficult to satisfy customer needs fully. Also, many important measures are not directly assessable by our customers, such as bridge conditions.

Customer satisfaction measures alone do not provide enough information for investment decisions. We need to make sure that we are working on the products and services that are most important to customers—and focus our investments on improving satisfaction in those areas.

In the 1980s, a decision was made to enhance the department's market research capabilities. The department currently has two full-time staff, which is down from a high of five in the late 1990s. The department spends about \$250,000 annually on market research projects. There is strong management support for market research within the department. While market research is used throughout the department, the Minneapolis–St. Paul metropolitan district probably uses it the most.

PERFORMANCE MEASURES FOR FREIGHT SYSTEMS

Barbara Ivanov

It is a pleasure to provide a perspective on freight performance measures at this conference. Performance measures for freight can assist state departments of transportation in making program and investment choices. Performance measures are part of a data-driven, problem-solving approach at the Washington State Department of Transportation. Freight performance measures focus on customers and are grounded in data and analysis. They attempt to find root causes of issues and concerns.

Freight performance measures should be based on customer requirements. In 2004, the department's Freight Office methodology included the following elements:

- More than 150 one-on-one interviews with high-volume shippers and freight carriers,
- Focus groups with key public and private partners,
- Voice surveys of another 350 statewide customers,
- Literature reviews of freight-dependent industries' requirements,
- Truck surveys providing origin–destination data on major statewide corridors, and
- Additional existing regional research.

Performance measures help show the benefits of various programs and services. For example, the department is able to document the time and cost savings from the Commercial Vehicle Information Systems and Networks program and the Weigh-in-Motion program. This information is directly related to motor carriers' interest in on-time performance.

To create state-level performance measures, we first examined how the freight system supports three major customer groupings in Washington. First, it supports international and national trade through Washington ports, airports, and other gateways. Second, it supports Washington State's own producers and manufacturers. Finally, it supports distribution, wholesale, and retail functions.

Washington producers and manufacturers are important customers of the freight system because they generate hundreds of thousands of jobs and make a significant contribution to the gross state product. Food and agricultural products accounted for \$5.6 billion in revenues in 2002. Transportation is especially important for Washington agriculture because the state produces about three times as much food—and for some commodities up to 20 times as much on a tonnage basis—as it consumes. The state is also separated by long distances from the majority of the nation's consumers.

Manufacturing gross business revenues were \$88.3 billion in 2003. This figure accounted for 21.3 percent

of the total state gross business income. Manufacturing is thus a key freight-dependent industry.

Washington's regions have distinct economies based on industry and agriculture, and freight customers' problems vary from region to region. Documenting customer requirements of the freight system is critical. To develop state freight performance measures, we began by analyzing current freight system performance in terms relating to customer requirements.

Here are two examples of how the Washington State freight system serves regional economies. The first is southeast Washington, and the second is the central Puget Sound region.

Southeast Washington is predominantly rural and is known as a wheat producer for the world. Washington ranks third among U.S. wheat-producing states, with 130 million bushels grown on 2.7 million acres. Approximately 85 percent of the wheat grown in the state is sold to international markets. Wheat contributed \$1.8 billion to the state's economy in 2002, mostly in eastern Washington. By tonnage, food and food products outweigh other waterborne outbound commodities shipped from the state.

About 53 percent of growers say that the price of freight service matters most to them, and 20 percent say adequate storage at the right location is the most important element. Only 50 percent of wheat growers are highly satisfied with the current performance of the state freight system. There are a number of significant transportation issues in this part of the state. Maintenance and preservation of the Columbia River and Snake River channels and locks are critical. Second, improvements are needed on I-90 at Snoqualmie Pass to avoid winter weather closures. Third, year-round freight corridors on the county-state road system are needed. Fourth, adequate grain storage is needed at the right locations.

The Columbia River and Snake River transportation system is important to wheat growers because 92 percent of southeast Washington wheat is shipped to Columbia River ports. Approximately 51 percent is transported by truck/barge, 19 percent moves by bulk rail, and 30 percent travels by truck to storage facilities or nonbulk rail. Risks face each of these modal choices. Barge traffic may be influenced by environmental issues and federal policies. Truck weights are restricted on local roads during the spring thaw. Rail branch lines and short-line rail with low volumes often cannot recoup capital costs, and service may be curtailed or the line abandoned.

The central Puget Sound region is urban and is the center of the state's manufacturing sector. In 2003, 4,434 manufacturing firms were located in the region. Survey results indicate that 65 percent of south Puget Sound region manufacturers and 63 percent of eastside manufacturers are very satisfied with current freight system performance. However, only 50 percent of central Puget Sound trucking companies are very satisfied with the current performance of the freight system.

The survey also provides important information on freight customers' goals. Some 56 percent of eastside manufacturers rate on-time performance as most important, while 20 percent rate predictable trip times first, and 17 percent identified price as most important. In comparison, 52 percent of South Sound manufacturers rated on-time performance, 31 percent rated price, and 7 percent rated predictable trip times as most important. Customer deliveries are mostly made by truck.

The state transportation system is also important for wholesale and retail distribution. Up to 80 percent of truck trips are operated on the local distribution system, which handles an enormous variety of goods. Products include food and groceries, fuel, pharmaceuticals and medical supplies, office supplies and documents, trash and garbage, and retail stock, from furniture and appliances to clothing and books.

Survey results from the Washington State distribution sector indicate that on-time performance is the main goal of about half of the respondents. About 35 percent identified price and 12 percent identified reliable trip times as most important. On-time performance is critical to this sector, with 100 percent of high-volume distributors requiring delivery in less than a 3-hour window. Approximately 25 percent defined it as less than a 1-hour delivery window, while 63 percent defined it as within 1 to 2 hours of the appointment time, and 12 percent identified a window of 2 to 3 hours.

A freight congestion data pilot test was conducted in the central Puget Sound region by the Transportation Research Center at the University of Washington to obtain a better idea of the influence of congestion on truck travel. Trucks of volunteer firms were equipped with Global Positioning System devices, and their movements were tracked to travel times on different routes at different times of the day.

Freight industry performance is achieved through efficient and effective logistics. State departments of transportation need a better understanding of logistics and should acquire a skill base in this area. The Council of Logistics Management defines logistics as "that part of the supply chain process that plans, implements, and controls the efficient, effective flow and storage of goods, services, and related information from the point of origin to the point of consumption in order to meet customers' requirements." Operational improvements require multiple data points at short time intervals to adjust a system, guide strategic investment, and analyze supply chains to determine and influence drivers of performance.

Both short-term fixes and longer-term solutions are needed to address freight transportation system issues. Remedies include preventing customer dissatisfaction while a problem is being solved, addressing symptoms, and focusing on detection. Long-term solutions include ensuring customer satisfaction, reducing or eliminating root causes, and preventing problem recurrence.

Closing Comments

Lance A. Neumann, *Cambridge Systematics, Inc.*

Thank you all for participating in this conference. The past 2 days have been productive. My closing comments focus on a few summary observations from the sessions; the conference follow-up activities; and opportunities for continued involvement with performance measures research, technology transfer, and outreach.

As I noted in my introductory comments on Sunday afternoon, the first observation is that the use of performance measures has become widespread in many transportation agencies. We have learned a great deal about the application of performance measures since the first conference in 2000. The speakers over the past 2 days have reinforced this point. Clearly, we have moved from performance measures as a concept to performance measures as a practical management and decision-making tool. We have seen a tremendous maturing in the use of performance measures to guide transportation investment decisions.

The final session this morning added another dimension. That dimension is including our customers in the process of developing performance measures and in identifying where investments should be made. Obtaining the perspective of our customers in defining performance and priorities is important.

The second observation is that while using performance measures to guide budget and program decisions is a critical step, we miss the mark if we do not also focus on program delivery. Once we decide where funds should be allocated, we also need to monitor program delivery and ensure that funds are spent appropriately. The practical reality is that agencies are never able to

deliver 100 percent of the promised program. Performance measures can help determine the factors influencing the delivery of the program. So the second observation is the recognition that we need to extend the use of performance measures to include program delivery. At many agencies, it is the pressure to deliver projects on time and on budget that drives the use of performance measures.

The third observation relates to the three critical stages of overall program management. These three stages are program development, program delivery, and program monitoring. The discipline to monitor the impacts of what is actually delivered and to compare the actual impacts with those estimated during the planning process is an important step. As noted during the Monday night session, before-and-after studies are routinely conducted in many other countries. Many speakers discussed the notion that the program management cycle is not complete until we learn what performance was actually generated. We need to realize that some projects will not generate the anticipated results for a number of reasons. We should acknowledge both our successes and our failures in estimating project impacts.

Another observation relates to the notion of performance measures as a communication tool. The effectiveness of performance measures as a decision-making tool is dependent on our ability to communicate effectively with policy makers, the public, and staff at other agencies, as well as internally. The point was made that performance measures can be a powerful tool in helping integrate an agency vertically as well as in building partnerships with other agencies.

The final observation relates to the data, tools, and analysis techniques needed to support the use of performance measures. While data and tools are needed to maintain and analyze performance measures, a strong message was presented that the lack of data should not be a barrier to starting to use performance measures. Clearly, better tools and data collection techniques are needed, but it is encouraging that it is possible to start using performance measures with available tools and data and expand to more sophisticated measures. The difficulty of developing meaningful performance measures related to environmental quality and social concerns was also noted.

In closing, I would like to thank all of the sponsors—the Transportation Research Board (TRB), the Federal Highway Administration (FHWA), the Federal Transit Administration (FTA), and the American Association of State Highway and Transportation Officials (AASHTO).

The conference planning committee did a great job, as did the TRB staff. All of you participating in the conference deserve thanks. Your participation and willingness to engage in discussions and share your ideas determined the success of the conference.

I look forward to working with you on future conferences and other activities of the TRB Performance Measurement Committee. The committee will use the results from the breakout groups to help develop research problem statements and identify opportunities for technology transfer and information sharing. The committee will also work with FHWA, FTA, AASHTO, and other groups to coordinate these efforts and other outreach activities. Thank you all again for participating in this conference. Please continue your involvement in ongoing activities of the Performance Measurement Committee and other groups.

Breakout Session Summaries

George Gerstle, *Colorado Department of Transportation*
Kristine Leiphart, *U.S. Department of Transportation*
Joe Crossett, *TransTech Management, Inc.*
Craig Secrest, *Wilbur Smith Associates*
Gregory Selstead, Keith Cotton, and Barbara Ivanov, *Washington State Department of Transportation*
Robert Romig and Brian Watts, *Florida Department of Transportation*
Leonard Evans, *Ohio Department of Transportation*
Mark C. Larson and Randy Halvorson, *Minnesota Department of Transportation*
Anthony Pietropola, *GeoDecisions*
Kent Barnes and William Cloud, *Montana Department of Transportation*
Robert Winick, *Motion Maps, LLC*
Jeff May, *Denver Regional Council of Governments*
Louis H. Adams, *New York State Department of Transportation*
Riju Lauanya, *University of California at Irvine*
Timothy Lomax, *Texas Transportation Institute*
Steven M. Pickrell, *Cambridge Systematics, Inc.*
Michael Meyer, *Georgia Institute of Technology*
Mark Hallenbeck, *Washington State University*

MAKING IT WORK: OVERCOMING INTERNAL ORGANIZATION CHALLENGES

George Gerstle, Moderator
Kristine Leiphart, Recorder

Topics Discussed

Participants discussed a wide range of topics associated with building internal understanding and support for using performance measures and performance-based management. Participants provided examples from their agencies and organizations of techniques to introduce performance measures, change organizational culture to focus on performance, overcome staff concerns, and incorporate performance measures into day-to-day management.

Participants discussed the need to obtain input from staff in the field and throughout an agency, to explain goals and performance measures, and to obtain their buy-in. Suggested topics were meeting with field teams and showing them how the measures would help solve problems and help with their responsibilities. Performance measures must be conveyed to an array of audiences, including new staff and those who have been with an agency a long time.

Planners, administrators, and elected officials represent the three levels of cultures. Working with each level to coordinate outcomes is important. One approach to building support is assigning a high-level champion, assigning the champion three or four staff members, and providing ongoing support to the champion. For example, the Minnesota Department of Transportation made numerous presentations tailored to the location, time, and need of the audience

to communicate the importance of meeting performance targets. Staff are frequently excited to have a strategic plan, but they are not necessarily committed to implementation.

Participants discussed the need to provide adequate resources to support the development and use of performance measures. A critical mass is needed, with enough people to carry out the change and affect every level of management. There must be top leadership support, but support and understanding must trickle down to all staff levels, including maintenance and field workers.

Participants noted that performance measures at some agencies were developed a number of years ago and may no longer be relevant today. Performance measures should be kept current with changes in the transportation systems and modifications in the roles and responsibilities of transportation agencies. Leadership is key to these outcomes.

Participants noted that some state departments of transportation and city agencies are beginning to link management pay and bonuses to strategic directives and agency performance. The British Columbia Ministry of Transportation has linked its performance target goals to individuals' development plans. There can be a disconnect between where the funding is being allocated and agency objectives. It is important to link short- and long-term objectives. With limited resources, priorities are often set for the measures that are most important. Performance is not always linked to the amount of funding a program receives. If additional funding is available, it is important to show what can be delivered with the additional resources. Tension may come from unmet expectations. Agency staff may believe that they are being monitored for performance they cannot reach.

The example in Portland shows that higher performance can be achieved even when less funding is available. Although agencies track where funds are spent, the follow-up of the benefit received is sometimes lacking. The need to assess performance measures periodically was discussed. In most cases, agencies will not meet every performance goal. Tracking performance measures is important, as are periodic discussions of their status. Feedback along the way is a key reason for using performance measures.

Making the measures important and understandable for staff at all levels is also critical in obtaining and supporting performance measures. Celebrate successes and revisit shortfalls.

Participants discussed the need to move from the theoretical phase of performance planning to the empirical level. In the public sector, there may be a lack of command and control to meet performance measures that may be more evident in the private sector. Keeping things simple and measurable and showing that man-

agement has confidence in what agency staff are doing are important practices.

Participants discussed how some police departments use performance measures effectively. Personnel are targeted toward the outcomes they want to accomplish. For example, the police put more resources into decreasing murder rates, and a decline in murder rates was accomplished. Transferring best-case scenarios from other organizations to transportation is a good approach. Leadership is important in meeting performance targets. The law enforcement society has leadership that drives the performance of the top two to three performance measures. Obtaining a consensus is not the primary focus for meeting performance in the law enforcement society.

Research Needs

- Identify and document methods to measure organizational capacity to meet performance targets.
- Identify and document methods agencies have used to communicate with staff concerning the use of performance measures. Provide examples of best practice case studies.
 - Examine models from nontransportation agencies and businesses for addressing internal barriers to the use of performance measures. Document best practice case studies.
 - Examine how changes in the governor's office or the state legislature have influenced the use of performance measures for planning and project delivery by the state transportation agency and the specific measures used by different agencies. Provide approaches state transportation agencies may consider in communicating performance measures and performance-based management to new elected officials.
 - Identify and document analytical tools to help implement agency goals and to encourage managers to enhance agency performance.
 - Examine approaches to making the monitoring and feedback loop more effective, and ensure that resources are being allocated to meet performance targets. Document practice case studies and identify other possible approaches for agencies to test.
 - Conduct a study to assess how states, counties, and cities are currently aligning performance measures to coordinate project delivery. Identify methods to standardize performance measures so that what is being measured is common across state departments of transportation and local transportation agencies.
 - Examine methods and techniques to engage policy makers proactively in the project delivery process and in establishing performance measures. Document best practice case studies and identify other possible approaches.

TURNING EXTERNAL BARRIERS INTO OPPORTUNITIES

Joe Crossett, Moderator
Craig Secrest, Recorder

Topics Discussed

Participants in this breakout session discussed a range of external influences that affect the use of transportation performance measures. The discussion focused on the following questions:

- Who or what are potentially significant external influences and barriers to performance measurement?
- In what ways may external forces create barriers to the development, selection, or implementation of measures?
- What successful examples, lessons learned, or ideas do participants have about how to address external performance measurement barriers?

Participants discussed additional research needs to address these issues.

Participants discussed sources of external influences and barriers. It was generally agreed that items on the following list, developed in advance by the moderator and recorder, represented most of the external influences or sources of barriers to various aspects of performance measurement:

- Interest groups,
- Other state agencies,
- Local governments,
- Metropolitan planning organizations (MPOs),
- The public,
- The state legislature,
- The federal government, and
- Media.

There was general agreement that none of these groups stand out as a major external influence; rather, they are all influential.

Participants discussed the types of external influences and barriers. They generally agreed that items on the following list, developed in advance by the moderator and recorder, represented the general types of external influences or barriers to various aspects of performance measurement:

- Management of performance measures,
- Balancing needs and demands of nontechnical and technical audiences,
- Negative ramifications,
- Timing issues, and

- Other considerations.

Some participants were interested in how the performance measurement activities of departments of transportation are interrelated with external stakeholders concerned with environmental issues. Environmental groups were perceived to have a powerful influence over the project development process, and failure to develop project solutions that respond appropriately to their concerns may create barriers to attaining mobility, accessibility, and other performance targets. Some participants suggested that measurement results for mobility and other performance measures can be skewed because of events and activities that transportation agencies cannot control. Participants identified the following potential strategies to address the impact of environmental delays on performance measurement:

- Build in longer project development time frames based on assessment of delay risks.
- Identify potential sources of project development delays as early as possible in the project development process—build relationships and establish clear expectations to help avoid delays.

Several participants indicated that states with unique demographic compositions often face particular challenges in meeting performance targets that are influenced by driver behavior, such as alcohol-related accident and fatality rates, or unique concerns of such groups. Potential strategies participants identified to address the impact of these issues on performance measurement were as follows:

- Develop dual sets of measures to deal with different populations.
- Sift through performance-related data to eliminate outliers and prevent them from skewing performance results.

Participants discussed how state legislatures, state executive offices, and state and local agencies can impose performance measures on an agency that are redundant or that conflict with the agency's existing or desired measures. Potential strategies participants identified for handling negative implications of externally imposed measures were as follows:

- Work with the outside parties to educate them about the agency's internal performance measurement needs and to find mutually satisfactory measures.
- Maintain a broader set of measures that meet both internal needs and externally imposed mandates.

Participants discussed how stakeholders often tend to be "balkanized" in their desire for performance mea-

asures—they only want performance measures that relate to their particular areas of interest and neither understand nor care about the need for trade-offs between competing performance targets. This can make it difficult for state departments of transportation to arrive at measures that appeal to all external audiences. As a solution, participants emphasized the importance of closer coordination with external groups in establishing measures, but they recognized that this may be difficult to achieve in practice.

Some participants noted that external audiences may not understand that performance measurement is an evolutionary process. They suggested that external audiences are sometimes inclined to be unduly critical of departments of transportation if the agency does not “get it right” the first time. Participants discussed how external interest groups can be inconsistent in advocating for outcome versus output types of measures, regardless of their validity or usefulness. In addition, external interests may have a poor understanding of the data challenges associated with many types of measures.

Participants discussed the problems that can occur if external interests feel threatened by the real or perceived influence of performance measures on important decisions, such as funding allocations. These problems can create challenges for state departments of transportation using performance-based decision making.

Participants noted that development of their own measures by state departments of transportation could create unrealistic or unattainable performance expectations among external audiences and thus make it difficult for state departments of transportation to manage.

Participants noted that externally driven performance reporting needs often differ from internal reporting needs with respect to detail, timing (e.g., frequency and reporting cycles), terminology, and presentation, and that there are no clear guidelines for how to merge internal and external timing needs.

Research Needs

- Develop strategies and best practices for engaging external audiences and managing their expectations, specifically in creating and implementing performance measures and performance targets.
- Develop strategies and best practices for educating external audiences about the connection between policy challenges and performance measurement needs.
- Investigate how external influences have actually improved the use of performance measures at state departments of transportation.
- Complete case studies of how state departments of transportation have sought and obtained support for their measures from external groups, particularly in the areas of freight and environmental quality.

THE ACCOUNTABILITY CHALLENGE: EFFECTIVE PERFORMANCE COMMUNICATION

Gregory Selstead, Moderator
Keith Cotton, Recorder

Topics Discussed

Participants in this breakout session discussed a variety of topics related to communicating information on performance measures effectively. Participants first identified a list of ideas for discussion. Techniques for reporting performance measures, methods for determining what the public wants to know, internal communication techniques, and providing information on tax increases were discussed in more detail.

Participants identified the following possible topics for discussion:

- Turning data into external reporting and decision making—public relations or information perspective;
- Benchmarking and performance for comparison with other departments of transportation;
- Providing information to local elected officials;
- Engaging with the public;
- Converting data from advanced systems into useful information;
- Using information to communicate and drive decisions;
- Communicating more effectively and increasing understanding;
- Consulting with and obtaining information from clients on what those clients think about communication;
- Formalizing the process—it is not the measures, it is what you need to say; and
- Identifying which performance measures are easy to communicate.

Participants discussed how to report and communicate performance measurement. Examples of strategies and techniques were provided. Performance measures are internally oriented tools that allow you to tell your story externally. Agencies gain credibility and engagement from citizens, legislators, council members, and others when you connect their experiences to the story you are telling and the information you present. It is important to connect to the audience’s local interests, such as districts for legislators. Audience members should see themselves in the story you are presenting.

It can be challenging to translate measures into an understandable story and to get people to focus on what is important. It is important to collaborate and bring in people to work with the technical staff. We often ask the people who monitor and analyze the data “to try to speak English” rather than involving professional com-

municators and others who are experts in communication. Agencies should consider either providing support and training for the technical staff or having others provide the messages for external groups.

It is essential to build a conversation and communication process around the measures. Using this approach gives you both the story and the means to manage what is happening. The person collecting and analyzing the data does not typically know all that is happening on the system. Facilitating communication among all groups helps you learn from each other and improve processes.

One example of a way to build trust with the legislature is to bring legislative staff into quarterly project review meetings so they can see the problems firsthand. Also, explaining to the commission or other policy groups the background behind the specific numbers is important. You can then drill down to more detailed information. The first-level information needs to be a simple message.

Managing expectations is critical, especially with regard to funding. A circus analogy was described. At the circus, rather than telling the audience how good he is and doing the hard stuff right away, the trapeze artist builds the tension over time. The audience feels the tension building, and as the routine grows more difficult, the audience does not know whether the person can pull it off. Then the artist does a perfect, death-defying stunt and the crowd goes wild. The analogy: we must do the drum roll and let people know that project delivery is hard and that we might fall the first time, but that we will get up and keep trying. Once in a while when we meet expectations the crowd goes wild. We must communicate that this work we are doing is difficult.

Everyone in the process needs to be educated about the constraints of project delivery. Agencies will not meet project targets 100 percent of the time. The issue is balancing high expectations with realistic steps to manage problems and do the best job.

From the maintenance perspective, in Los Angeles the complaints from citizens often center on garbage and graffiti rather than congestion or pavement condition. Speculation is that citizens in the area expect congestion but want the road to look nice. The public complains to legislators about aesthetics, who then tell the department to clean up areas and focus resources on aesthetics, which is a low priority for the department. Yet for the agency, the emphasis needs to be on improving and maintaining the system.

The public does not necessarily associate transportation services with costs. Participants discussed the need to explain the costs clearly, what it takes to respond to complaints, and what is not being done when resources are diverted to aesthetics and other items. An article in the newspaper to give the department perspective on

what is most important was suggested as one technique. The Seattle, Washington, example of tracking customer comments on incident response services, which is very well received, provides a huge political benefit.

Participants discussed different audiences for performance measure information. It was suggested that the initial audience needs to be the legislators, since they control funding.

Participants discussed how to measure the costs of what agencies do on a daily basis, especially work in response to special interests. It is important to report how much things cost per unit, or how much it costs to perform certain functions. A clear, concise graphic showing the costs and benefits of certain items can help tell the story.

Participants discussed what the public wants to know and different techniques for gathering this information. Agencies have used customer surveys, including telephone surveys, and found that the public's priorities did not always match department priorities.

The most visited Federal Highway Administration website is National Traffic and Road Closure Information—the public wants traveler information.

Listen to talk radio. Urban myths abound, especially on talk radio. Listening may be painful, but understanding the points of view presented is important. Opportunities for intervention are there, especially since ratings depend on the conflict/controversy. A local agency used a town hall meeting with community leaders to hear issues and prioritize what they discussed. One state department of transportation has a radio show where people can call in and ask questions.

Talking to your neighbors was suggested as a good approach. Listen to what they say, understand, and care about. You need to be able to talk to them with stories; otherwise you are not really talking to anyone. With talk radio, you get the bias of a segment of people and can learn what they think. Monitoring letters to the editor and opinions is important—the communications group in an agency should be monitoring, and potentially responding to, opinions that can spread misinformation.

Participants discussed whether performance measurements have been embraced by rank-and-file staff within agencies and how far down the measures cascade into organizations. It is important to link different measurement processes and initiatives. Measure what you need to manage, but make the link follow through to the administration.

There is often employee resistance to using performance measures as a stick—for example, transferring resources from good to bad performers. This issue leads to lack of buy-in and resistance. Reward good performance and communicate the background to document the external factors and forces influencing performance.

As you drill down into statewide numbers, agency staff can make their own performance assessments and appraisals. Good information used fairly will liberate information you would not have obtained any other way at the top.

Performance measures may set false expectations. You may achieve on-time and on-budget targets, but are they the right projects? Look at trends and system outcomes rather than numbers and percentages. You can deliver projects in a bad plan. You need to work with others in the organization to develop good plans and projects.

Using measures to manage is essential. Providing information to the right people in the right format internally is also important, as is understanding the data that are being used. If information is not getting to the right people, you do not know how you are doing or what to change.

The importance of iterative and adaptive measurements was discussed. This approach can help ensure that you do not get locked into an unintended effect. One example is measuring project advertisement dates. A project may be rushed just to meet a date and not done well. Measures should not be easy to manipulate.

Participants discussed different approaches agencies have used to communicate with the public on tax increases. Providing accurate information on why the increased funding is needed and how it will be spent was stressed.

Research Needs

- Identify and document techniques to use performance measures as carrots and sticks to influence, encourage, and reward behavior. Explore approaches to provide flexibility to change the process and use measurement iterations to arrive at the proper outcomes.
- Explore approaches for communicating problems encountered with meeting performance measures. In the public sector, we cannot gamble with taxpayers' money. We have to be successful. Identify ways to provide a more realistic assessment of the difficulties associated with project delivery.
- Identify techniques to provide clear information on performance measures to various audiences. There is a delicate balance in using performance measures as a communication tool. You are either putting out propaganda—putting a spin on “objective” performance measures—or you are trying to communicate the difficulties and risks of delivery. At the same time, to manage effectively you need your measures to be accurate. Explore how much explanation of the risks is appropriate.
- Explore marketing and communication techniques for use by transportation agencies. Marketing is a central

piece. Listening, especially with the right mind-set, is crucial to marketing. If you just say “we are meeting our goals” and are inflexible, you are not connecting with the citizens. If the public does not believe that we are meeting their goals, we are not meeting the goals we should be meeting. Be flexible listeners with the right mind-set, and do not use performance measures as an excuse.

HOW TO SET PROGRAM TARGETS AND MAKE TRADE-OFF DECISIONS

Robert Romig, Moderator
Brian Watts, Recorder

Topics Discussed

Participants discussed the issues typically associated with setting performance measure targets and making trade-off decisions. A major focus of discussion was performance measures addressing preservation versus adding capacity. Other topics included regional versus statewide priorities, transportation and economic impacts, trucking and freight, and funding issues.

Participants discussed different approaches to establishing performance measures and setting targets for preservation versus capacity projects. It was noted that Florida has standards and targets established by legislation, while other states have struggled with setting policies in this area. In Washington, a system to prioritize and implement projects was developed with input from private and public interests.

The experience from the international scan indicates that setting targets for preservation and capacity is being addressed in other countries. The basic goals are set at the national and state levels, and everything flows from the high-level outcomes. This approach helps encourage understanding among local and statewide groups.

Participants discussed the following approaches to addressing regional versus statewide transportation priorities:

- Florida is trying to move state projects to 75 percent statewide system and local projects to 25 percent.
- California is focusing on comprehensive corridor planning and on working with partners to obtain funding and planning support. There is a need for a clear assignment of roles and responsibilities among state agencies and regional and local agencies in this process.
- Virginia is examining long-term planning in corridors. This approach may save funding in the long run.

Participants discussed the possible economic impacts of the transportation system, including approaches to defin-

ing return on investment and measuring the economic influence of different transportation improvements.

The importance of measuring how improvements to corridors influence economic conditions and the local economy was noted. Decision making should be based on facts, including consideration of the gross domestic product and other economic factors. The need to be informed and to examine the entire picture, rather than being limited to database decision making, was suggested.

California and Washington have investment boards to help examine these economic impacts and manage resources and direct projects. Leveraging private investments can affect public investment.

California focuses on the economic impact of transportation projects, including identifying costs and benefits of projects and the number of jobs created by projects. It is difficult to determine the contribution of a transportation improvement to job creation. There is a need for better tools to estimate these types of factors. The model of Regional Economic Models, Inc. (REMI), may be of use in this effort.

High-occupancy vehicle data have supported the use of these types of facilities. These data add to the argument for better management of capacity. When this type of information is available, it is helpful in selling initiatives to policy makers.

Multimodal issues generally seem to be regional concerns. For example, consideration of mass transit versus more highway capacity is typically a corridor issue. Regional governments and state agencies may have different approaches to the corridor solution.

Participants discussed possible trucking and freight performance measures; sources of data on freight movements; and coordination among public agencies, trucking companies, and businesses. Several participants noted that it is often difficult to obtain data from the trucking industry. There is no standard data reporting from trucking industry organizations. The lack of data makes analysis, measurement, and decision making associated with freight challenging.

An example was provided of high truck volumes on a specific freeway. The state department of transportation met with shipping companies, merchants associations, and other groups. One of the recommendations was to provide incentives to companies to ship in off-peak hours. This approach received positive feedback, and progress has been made in moving some truck traffic to off-peak periods.

The example of the raising of tolls on the Ohio Turnpike was described. The turnpike is separate from the department of transportation. When the turnpike raised tolls on larger trucks, many truckers changed routes to use state roadways. Truck volumes increased on the other highways, which caused safety and capacity concerns.

Participants noted that large volumes of commercial vehicles may cause other operational issues. Incident management and clearing of accidents may be more difficult. More information is needed on the causal factors associated with truck accidents. Usage charges and fee structures for trucks for capacity management were discussed. A little improvement at the right time of day can have a large impact overall. These examples focus on reliability, which is a key measure. Tolling can be an answer in managing capacity and maintaining the flow to improve reliability. This approach translates into the ability to add capacity on other roads.

Participants discussed the following topics related to funding issues:

- In California gasoline and sales tax revenues have not kept up with highway funding needs. It appears that existing legislation provides regional governments with the responsibility to address these funding problems.
- Tax revenues and the political nature of funding have a big impact on transit and public transportation. For example, tax initiatives have had a negative influence on transit in Washington State. Transit fares typically pay for 40 to 50 percent of transit operating costs at best. In New York State, tolls subsidize some transit operating costs. User charges may be more politically acceptable than general taxes.

Setting targets by corridors may make sense in some cases. This approach would allow improvements to be prioritized in local areas. Most corridors include more than just highways. Rail, transit, and other modes are frequently funded within major travel corridors.

Research Needs

- Develop best practices and case studies of performance measures addressing operations versus adding capacity. The case studies would examine the efficiency of existing facilities versus the expansion of facilities.
- Explore performance measures that address transportation and land use.
- Examine the trade-offs associated with mobility versus security and performance measures addressing the two. This study would evaluate the impact of new security procedures on mobility. Long-term issues would be explored along with approaches to balance mobility and security. The experience in New York could be used as one case study example. The study would also examine trade-offs in investments.
- Examine the potential to extend the REMI model or develop other economic models to include consideration of the economic impact of investments in other modes. Explore how these models can be used in set-

ting performance targets and evaluating project impacts.

- Examine the use of high-occupancy vehicle facilities for freight movement.
- Examine the influence of transportation on economic development in the state as a whole, as well as regionally. Identify performance measures to address economic development.
- Examine bringing a supply chain analysis to corridors.
- Examine how performance-based management can address trade-offs in investment in small communities needing transportation improvement to encourage economic development versus congested areas where demand exceeds capacity and the lack of transportation improvements is impeding economic expansion.
- Examine underserved communities from the standpoint of economic growth versus economic development. Document approaches for addressing these issues.
- Develop tools and techniques for land use and site decisions. These tools would focus on economic considerations in the plant and industry location decision-making process.

WORKING WITH LEGACY DATABASES AND MANAGEMENT SYSTEMS

Leonard Evans, Moderator
Mark C. Larson, Recorder

Topics Discussed

Participants in this breakout group discussed the issues and opportunities associated with legacy databases and their use with transportation performance measures. The limitations of legacy databases were examined, along with techniques to enhance the use of these systems. Areas for additional research were identified.

Participants noted that there are some problems associated with updating project management systems.

The use of old and new parallel systems at the same time can be a problem. Frequently the old system is not shut down. Washington State established a separate project management system database because the old system was inadequate. Both systems are being used because the legislature did not provide funding for the new system and required that the old system be used for reporting milestones.

It was noted that several states are exploring and using data warehouse technology to improve data quality and enhance coordination at reasonable cost.

Clear accountability and business rules for project management systems are needed. Ohio provides a link

to accounting data. The system is web based and is integrated with pavement data, which allows queries of pavement condition values. Legislation in Ohio includes an individual career manager performance accountability system. A manager's performance is linked to promotions and potential demotions. District performance values are included in manager performance plans. Action plans are required if there are deficiencies.

It was noted that quality tends to increase if data are used on a regular basis. In Virginia, demand for regular project status reports to the commission has driven an improvement in data. Data from a number of sources must often be integrated.

The age and inadequate capacity of legacy databases in some states cause problems and concerns. Legacy databases in many states are 30 to 50 years old. Problems may be encountered with temporal data. The viability of project management systems, which are often used in reporting project milestones to legislatures, managers, and other stakeholders, is important.

Participants discussed funding needs and noted that obtaining funding from state legislatures for database systems can be an issue. California has legislative restrictions on information technology projects exceeding \$500,000. The Washington State legislature terminated funding for the new project management system. There are also limits on the use of federal funds.

Participants noted that there is often a lack of cost information early in the project development process. The lack of good cost estimates may cause problems in later phases of a project.

Research Needs

- Participants noted that developing shared geographic information system (GIS) and management system standards for state departments of transportation may be beneficial. This approach would encourage vendors to offer standard applications that are lower in cost rather than customized systems for individual states. NCHRP Project 20-64, XML Schemas for Exchange of Transportation Data, could be used to provide guidance in this effort.

- Identify and document the formats for management reports used by various agencies and organizations. Identify formats and approaches that appear to best communicate key information to policy makers and other external groups.

- Identify and document techniques to develop partnerships to increase funding for system enhancements. The partnerships could focus on increasing funding at all levels of government, as well as exploring other available resources.

- Some participants noted that setting standards for GIS at all levels of government would be beneficial.

Identify and agree on common benchmarking and other standards to provide for comparisons among states.

- Identify and document approaches to address state regulations relating to the use of information technology and database systems that create barriers for state departments of transportation in sharing systems with local governments, contractors, and other key customers. Provide best practice examples.

NEW TECHNOLOGIES FOR DATA COLLECTION

Anthony Pietropola, Moderator
Kent Barnes, Recorder

Topics Discussed

Participants in this session discussed new technologies to assist with data collection needs associated with performance measures. Participants discussed the issues and opportunities associated with various technologies.

Participants discussed a number of new technologies that are being used to collect data about different aspects of the transportation system. These technologies include the Global Positioning System (GPS), weigh-in-motion, virtual weigh-in-motion, and electronic toll collection (ETC). These technologies can provide data on trucks, commercial vehicles, and buses. ETC and other onboard systems may also be available for collecting data on passenger vehicles. Issues associated with privacy and vehicle and infrastructure integration may need to be addressed. For example, it is difficult to estimate bus travel times by using GPS because of all the stops buses make to pick up and drop off passengers. One possible approach for addressing this concern is to use changes in the overall bus travel times.

Participants noted that new travel forecasting models may also be of use in assessing performance measures. The TRANSIMS model and other advanced models may eventually be used, but many of them are still in the development stage and thus are not as user-friendly as they ultimately will be.

Participants discussed possible technical barriers that may need to be addressed with new technologies. For example, some of the older data collection techniques cannot meet the quality standards needed with the new analysis. Equipment frequently needs upgrading for expanded use. For example, closed-circuit cameras can now be used for many more purposes, but the older equipment may not be adequate for the expanded applications. Additional maintenance or better equipment may be needed. There is a desire to avoid two layers of data collection, but they may be needed at least in the short term.

Participants also noted that institutional issues may need to be addressed with the introduction and use of new data collection and analysis technologies. There may be a need to inform and educate potential users about the benefits of new technologies and to justify additional costs to policy makers and funding sources. Asking the right questions is important to all groups, as is having the information needed to answer the questions.

In addition, participants noted that problems with data collector reliability remain a concern in most metropolitan areas.

Research Needs

- Research technologies for obtaining vehicle occupancy information, including infrared and other advanced technologies. Explore vehicle infrastructure integration needs and the expanded use of transponders for all types of vehicles.

- Identify best practices to present information to policy makers and the public on the use of new technologies. Examine approaches to address privacy issues, funding concerns, and other possible issues.

STANDARDS FOR DATA AND PERFORMANCE MEASURES

William Cloud, Moderator
Robert Winick, Recorder

Topics Discussed

Participants in this breakout session discussed issues and opportunities associated with standards for data and performance measures. They discussed the experiences and challenges with different approaches. They also identified areas for future research.

Participants noted that some state agencies have formal enterprisewide standards for data and performance measures. Islands of data and databases that are not integrated were noted as problems at some agencies.

Participants discussed the importance of data quality standards. Sharing information among states about establishing and maintaining data quality standards was suggested.

Participants discussed benchmarking. The International Roughness Index was discussed as one measure that many states use. Sharing information on what other states are doing with regard to data standards and data collection issues and procedures would be of benefit.

Participants discussed possible secondary uses of data. Issues with secondary uses were noted. For exam-

ple, secondary users must be considered. A change in culture within a department related to data ownership may be needed—a change in thinking from “my” data to “our” data.

Standards development and the use of different standards were discussed. The internal organizational structure for dealing with standards was discussed. Some agencies use committees, while some have one individual or group in charge. The importance of addressing data security and backup was noted.

Top management support is needed in the development and use of standards. People who use the standard on a day-to-day basis should be involved in standards development.

Participants discussed whether standards that deal with dynamic changes associated with some types of data are needed. For example, while road geometry data are mostly static, such data can change slowly over time as improvements are made. Other data can be dynamic, such as progress in snowplowing and removal or crash-related data. Work related to intelligent transportation system (ITS) data archiving is dealing with aspects of data for roadway operations and use that change frequently over time.

Participants discussed the need for data audits. Data audits need to check for omissions as well as having too much data.

Participants discussed the need to start with realistic expectations for data standards. This approach means starting small and building on successes. Identify a few critical standards as a starting point.

Participants discussed providing access to data and possible roles related to being a data broker that state departments of transportation can play. This approach might help minimize duplication of effort and reduce the costs of data collection. The fact that data and technology are not information was also discussed. Information is needed for performance measurement.

Research Needs

- Examine staff capability and resource needs associated with developing and maintaining performance measure database systems. Identify potential issues with staff training and staff retention. Identify and document approaches to address these issues.
- Examine the current use of benchmarking by state transportation agencies. Identify and document what information is being collected, how it is being collected, and how it is being reported. Identify possible benefits from benchmarking across all state transportation agencies. Examine methods to ensure that agencies are collecting and analyzing the same data in the same way so that benchmarking can occur and accurate comparisons can be made.

- Conduct surveys of database needs and links between databases and operating systems.

PERFORMANCE FORECASTING: FINANCIAL ISSUES, SCALE, AND IMPLEMENTATION TRACKING

Jeff May, Moderator

George Gerstle, Recorder

Topics Discussed

Participants discussed a variety of financial, scale, and implementation tracking issues associated with performance measures. Issues associated with the scale of performance measures and concerns related to financial forecasting were discussed.

Participants discussed financial forecasting and the influence of poor estimating on project cost and effectiveness. How much to spend on performance-related data collection was discussed. It was noted that the Motor Vehicle Safety Administration spends 5 to 10 percent on management systems data. Data collection approaches used by different agencies were discussed. The data collection of the San Diego Association of Governments (SANDAG) is oriented toward highways. Data collection for lower-classification roadways is much less extensive. The Sacramento Area Council of Governments collects data as grants come in for system performance monitoring. MPOs typically conduct less direct data collection than state departments of transportation.

Participants discussed the value of data and how it will influence decision making. Decision makers should be educated about the importance of data, the costs associated with data collection, and the uses of data.

Participants discussed risk assessment and how it relates to project costs. Some agencies conduct peer reviews of project costing before it is included in the transportation improvement plan. Participants also discussed techniques for communicating risks to the public. Use of design–build can shift risk to contractors. Financial forecasting is different from planning forecasts. Elements to consider in financial forecasting include noncompete clauses and effects on parallel roads.

Participants discussed different scales for performance measures, including statewide, metropolitan areas, and corridors. Possible integration of measures for these different scales was discussed, as was the need for comparisons among different levels. Coordination among agencies at the different levels is needed, as is consistency in the approaches used. California has started trying to coordinate with MPOs in the state.

Participants discussed approaches for evaluating the effectiveness of capacity projects given latent demand. Techniques for showing long-term benefits were discussed, including measuring economic benefits and reduction in vehicle- and person-hours traveled.

Research Needs

- Complete a synthesis of MPO data needs for performance monitoring and management.
- Complete a synthesis of data collection needs for performance measures associated with quality of life, environmental quality, and other related measures.
- Conduct and document case studies and a synthesis of performance measures and data collection needs related to economic development, return on investment, equity, and transportation and land use.
- Explore techniques for relating project purpose and need to performance objectives, especially the more intangible performance measures.
- Conduct a synthesis of techniques for incorporating risk assessment and uncertainty into project costing.
- Evaluate private-sector performance measures on toll facilities and how they relate to public measures.
- Conduct and document case studies of parallel performance data coordination.
- Conduct a study of the technology of evaluating effectiveness of capacity projects given latent demand and methods to document long-term benefits.
- Analyze factors that may influence cost increases after project advertisement and project scope creep.

LINEAR REFERENCING SYSTEMS—OR WHERE IN THE WORLD IS THAT BRIDGE?

Louis H. Adams, Moderator
Riju Lauanya, Recorder

Topics Discussed

Participants in this breakout group discussed a variety of topics associated with linear referencing systems. The following seven questions provided the basis for discussion. Participants also identified areas for further research.

- What technology changes are in your immediate future, and what benefits do you foresee as a result of the forthcoming implementation?
- What advances in linear referencing and dynamic segmentation state of the practice are needed to support or expand capabilities for measuring, reporting, and mapping of transportation system performance?

- What are your suggestions for technology transfer or research?
- What has worked or been implemented successfully, and what are some key factors that resulted in that success?
- What has not worked or has experienced major implementation problems, and what insights should other practitioners consider as a result of your experience?
- What can agency managers do to address any linear referencing and dynamic segmentation barriers that constrain expanded use of performance measures?
- What is the relationship of linear referencing to performance-based decision support?

Participants discussed national standards for linear referencing systems. Transportation is one of seven layers on the nationwide map, but it is not finalized yet.

Participants discussed some of the issues associated with using linear referencing systems, including those associated with bridges. For example, capacity is an issue on a bridge. Under a bridge, clearance is the issue. Clearance may vary along the distance of a bridge, so a bridge can be treated as a single segment (value) for capacity purposes, but that same bridge may need to be divided into several segments to define its height. Similar issues may be encountered with freeway ramps.

Participants discussed various hardware and software issues. It was suggested that the ITS community is on a track different from the infrastructure management system. The need for border states to coordinate with Canada was noted as creating more problems. Joint naming was noted as a problem. GPS cannot see the lower road in cases where one road runs over the other. Two points having the same x - and y -coordinates but being different physical entities may also be a problem. Adding multimodal facilities becomes more complex.

Participants discussed cost issues and the need to conduct financial analyses.

Participants noted that e-government is on the president's agenda. Movement in this area may help transportation agencies.

Participants discussed the possibility of remote sensing for updates of GIS instead of physically driving on the road.

Participants discussed links to inventory systems.

Research Needs

- Conduct a synthesis of the current status of linear referencing systems.
- Explore the use of remote sensing and other related approaches for updating linear referencing systems.

CONGESTION AND RELIABILITY

Timothy Lomax, Moderator

Steven M. Pickrell, Recorder

Topics Discussed

Participants in this group discussed a wide range of issues associated with developing and using performance measures related to congestion and reliability. Topics included current performance measures, possible barriers, expansion of the use of congestion and reliability measures, and other possible measures. Participants also identified areas for further research.

Participants discussed positive experiences with congestion measures. The following elements were identified:

- Provide the public better access to better trip data (e.g., travel speeds), such as the San Francisco Metropolitan Transportation Commission website.
- Travel information systems (511 systems) are working, though getting the word out to the general public is a challenge.
- Make the connection between safety-related improvements and congestion improvements to help sell congestion improvements. Comparing safety analysis with congestion analysis might provide agreement between the two problems. Investing in a solution for one might help the other. “Turf wars” between safety and congestion factions in agencies and among external stakeholders may be reduced if the two needs are not viewed as competing. Removing a bottleneck that causes accidents as well as delay was provided as one example.
- Provide side-by-side comparisons of travel times for automobiles versus transit on the roadside. The example came from Australia, where transit and automobile travel times in a particular corridor are shown on a message sign.
- Communicate the overall improvement (e.g., total capacity in person trips, average delay, average travel time) to system capacity when a new facility is opened, rather than just communicating the improvement for the new facility. This was suggested as a method to counteract the problem of latent demand quickly absorbing all new capacity in an improved corridor, which could make it appear as though the investment was for naught.
- The use of real-time data has helped one agency understand and explain recurring and nonrecurring congestion; it has also allowed the agency to better distinguish between the two when such data are used for diagnostic purposes.
- The California Department of Transportation’s (Caltrans’s) Los Angeles district is compiling a log of

traffic data specifically linked to special events and incidents to improve its understanding of the impact of such events on traffic conditions.

- Implementing variable speed limits and aggressive, automated speed enforcement (Australia) has allowed an agency to improve management of the effective capacity of a congested corridor. By gradually reducing drivers’ speeds as congestion mounts and using video enforcement, the agency is able to delay or avoid the onset of a breakdown in flow rates. This approach reduces collisions at the back of the queue and allows freeway lanes to flow more smoothly and accommodate relatively high speeds for longer periods.

Participants discussed possible barriers, concerns, and questions with regard to congestion and reliability. How do agencies identify their role in congestion problems and solutions? What can agencies actually do about the problem? What can we demonstrate we are doing to make things better? Several responses were provided by the group:

- Examine data from operations centers to develop congestion patterns and data and identify potential solutions.
- Ensure proper traffic signal maintenance and operating status.
- Municipal agencies should be a part of regional multiagency groups that examine problems and solutions. The traveling public and freight movers do not always know which agency operates what components of the facility or system—it’s just “transportation” to them, and they expect seamless, coordinated service delivery.
- Speed and travel time data are important, especially at decision points between alternate routes. The 511 system is beginning to help where it is deployed. Agencies can help by making better data available to the 511 system and to the general media, which distribute a lot of information via television, radio, and so forth.
- The congestion problem begins with a lack of coordination between land use and transportation plans. It is difficult to address transportation in a comprehensive manner without an effective land use plan. Agencies can strive for a better land use–transportation linkage in all of their planning and development-related activities.
 - The poor link between land use and transportation undercuts congestion and reliability efforts. As a result, latent demand soaks up new capacity. Agencies have a limited ability to affect land use decisions; there should be a better link between land use goals and actions and the causes and measures of congestion.
 - What is the ideal mode split for a given corridor or region? The opinion was expressed that different

regions all have an optimal mode split, that disproportionately spending too much money to push mode split far beyond the optimal range is inefficient, and that benefits do not justify costs. There is a need for research or peer exchange on different optimal mode splits for different areas, system types, and related factors.

- Different customer market segments have different definitions of reliability as well as different expectations in terms of reliability. There is a need to clarify the terms and to understand the different expectations.

- Selling the benefits of operational improvements is still difficult. An example was presented by a highway district of a great package of operational improvements that it would like to fund, but the district has had no success in selling the package. It cannot make a compelling argument for operational improvements. In response, participants indicated that measures and data need to be refined to communicate the importance and value of improved system management and operation.

- “Telling the story” is the challenge. Do not focus so much on the data or the measures, but rather on how you use them to make the point.

- Why has the rapid spread of telecommunications to home and office not led to more telecommuting, shift of trips to different times of day, and other related changes? Peak periods still experience major congestion despite the increased ability to use computers, the Internet, and other technologies to conduct work and perform jobs.

Participants discussed methods to expand the use of congestion and reliability measures in transportation decision making.

- More funds are needed for traffic operations centers to post more trip information, including more accurate, up-to-date information.

- Define and clearly communicate the additional system (highway and transit) operational demands and burdens created by new development. Demonstrate more fully the system impact from development and the impact that is not offset by any mitigation fee.

- Models should be improved to incorporate different values of time—for example, time spent in congested versus uncongested travel conditions (similar to in-vehicle and out-of-vehicle time values used in transit modeling).

- Monetize the benefits of agency actions (such as incident management) that improve operations by preserving capacity. This will better demonstrate the value of such programs and of allocating agency resources to activities such as freeway patrol. (Refer to *NCHRP Research Results Digest 289* for more information.)

- Similarly, monetize and demonstrate the cost of incidents to help sell increased funding for improved system management practices. Communicate the problem and the magnitude of the costs and benefits to other agencies that play a role in system management, such as police and fire. For example, communicate the high value of incident management in reducing secondary accidents. This is something that police and other emergency response agencies can value.

- Identify data on smaller improvements that have been implemented with good results. These have been successful in some areas in reducing congestion and showing the public a good return on spending (high benefit-to-cost ratios).

- State departments of transportation need to think and operate more multimodally, from a system perspective.

Participants discussed reliability and the relationship to congestion.

- SANDAG is using the concept of increased reliability to promote its managed lanes program as well as light rail service. Users enjoy greater reliability than mixed-flow lane travelers.

- Hedonic modeling can demonstrate the value placed on reliability, as expressed in terms of real estate valuation. Would increased reliability have an effect on land values and location choices?

- Reliability seems to be a key metric or concept for the future. Congestion reduction or average travel time may not be the primary measures of success because of the great difficulty in actually reducing congestion without more draconian measures such as dynamic congestion pricing. For example, airlines compete on reliability of on-time departure and arrival rather than on trip duration. Yet the question was raised, does the promise of a more reliable system with slower travel times “work” in a regional improvement plan? Do leaders and the public agree that this should be the goal?

- Participants discussed measures related to congestion and reliability that need further examination.

- Ensure that whenever possible, performance measures are comparable across regions, states, and time frames. Comparisons are made between data items that appear similar. If the data are not comparable, that should be clearly noted in footnotes and explained in text.

- Develop lost system capacity (throughput) graphs, like those presented in the opening session.

- Does relating future congestion levels to “what would have been” or “what was projected” provide perspective on the effect of growth? Congestion may be worse, but was it predicted? Were projections and decisions based on accurate data?

- Compare user costs of congestion problems with the benefits of living in large metropolitan areas. Com-

communicate the message that you gain something in return for enduring higher levels of congestion by choosing to live in an urban area or congested location.

- Communicate measures that demonstrate the impact of congestion and unreliability on business—in particular, those that provide or rely on local collection and distribution of goods and packages. Comments in an earlier session indicated that up to 80 percent of truck trips (not miles) in an urban area relate to relatively local collection/distribution. Congestion and unreliability have a big impact on the productivity of these services and thus the businesses that rely on them.

- Express the value of time and cost of congestion in terms that are relative to other regions (benchmarking) rather than solely in absolute terms.

- One state department of transportation has changed to measuring whether actual congestion is less than 85 percent of the projected value. It is not using reliability measures at present.

Research Needs

- Examine available information on latent or induced demand that fills transportation facilities. Robert Cervero's article in the *Journal of the American Planning Association* in 2003 provides a good summary of the subject, but more research on the topic is needed.

- Identify and document methods and techniques to improve the way we tell our story to the media and the public. This study would focus on developing a narrative that describes the data and findings, not on “spinning” the data.

- Examine and document the effects of different types of land use and land use patterns on congestion problems.

- Examine and document factors that influence the mode split and mode share. Among the elements to be considered are land use and city and region size. The study should also consider whether there is an optimal mode split.

- Identify and apply techniques for estimating safety and travel time benefits.

- Identify and document guidelines or plans concerning how to operate systems on a regional basis. Freeway managers can operate the main lanes at relatively high speeds or high throughputs, but the influence of this approach on local streets should be examined. In addition, how a corridor analysis identifies the benefits of transit and good operations options should be considered.

- Identify and document approaches to use technology more aggressively in data collection devices. Possible technologies include in-vehicle navigation systems, cell phones, and GPS-equipped personal data assistants.

The potential to use the same infrastructure to increase distribution and utility of traveler information would be examined.

- Examine and document the data needs for a broad range of facilities and conditions—urban and rural, weekday and weekend, persons and freight. These data needs go beyond the traditional peak-period work trip focus.

- Examine and document the effect of congestion and reliability on the activity patterns of American households and businesses. It appears that there have been gradual but significant changes in household and business activity patterns due to congestion, but more research in this area is needed.

- Examine techniques to forecast speeds and travel times for future years or alternative strategies. Models are not generally calibrated to speed. This capability should be improved, and models that address this need should be developed.

- Examine available hardware, tools, and data needed to estimate recurring and nonrecurring delay percentages. Develop techniques, tools, and methodologies to improve estimates of delay percentages.

- Examine techniques for microsimulation of operations improvements. Identify available tools, data needs, and benefit estimation programs. Develop better techniques to assess changes in traffic flow and traffic volumes from operations improvements.

- Examine and document the influence of changes in fuel costs on congestion levels. Examine how economic slowdowns affect congestion.

ENVIRONMENTAL

Michael Meyer, Moderator

Topics Discussed

Participants in this breakout session discussed a variety of environmental issues and possible performance measures for addressing these concerns. Topics included human health, ecosystem health, environmental quality, and land use.

Participants discussed potential human health issues associated with the transportation system, which are becoming more important concerns in many areas. This interest may miss other causal factors besides transportation, however. There is a need to examine a range of options and outcomes linked to specific issues. One example is health effects related to automobile emissions related to compliance with permits.

The direct link with transportation may decline over scale. If there is a link, the question becomes what can

we do about it and is it a transportation issue? For example, could roads be moved away from sensitive locations? There may be areas that should be monitored where some populations might be at risk. A better system for forecasting air quality concerns may be needed. A better mechanism is needed to link transportation and strategy effectiveness. There are strong possibilities for collaboration in high-risk areas, including the use of Congestion Mitigation and Air Quality Improvement program funds for projects.

Participants discussed transportation and ecosystem health issues. It was noted that in California special studies have been conducted for habitat and species preservation. Development interests have been involved in some of these efforts. However, a number of smaller areas do not have these types of resources. The California examples appear to be the exception rather than the norm.

Participants discussed possible links and coordination between state departments of transportation and state resource agencies. Transportation agencies have funding and have a formal planning process. A framework may be lacking for resource agencies. A framework may be missing for transportation agencies to evaluate transportation's role in ecosystem health issues.

Participants discussed possible performance measures and how to measure and monitor ecosystem health. For example, is it possible to develop a measure of corridor permeability or acreage developed for culverts and fish habitats?

The issue of state-level responsibilities versus local land use decisions was discussed. Transportation agencies typically have a large-scale perspective. Transportation agencies have a responsibility to ensure that the right things are accomplished. The degree to which transportation played a role in achieving ecosystem health would be important to highlight.

Participants discussed possible roles for state departments of transportation in all of these issues. Should transportation agencies be the facilitator for all these types of issues? Is it transportation's responsibility to pay for all of these things? There is a need to facilitate a meeting of the minds early on rather than waiting until the end. In this way, large mitigation costs might be avoided. It might be useful to identify tools or methods to measure the benefits of mitigation strategies. Being able to tell the story about the value of transportation strategies in environmental projects would be of benefit. Care should be taken to incorporate dollar values of environmental costs into estimates of return on investment. Better estimates of external costs are needed. However, these are really value issues and cannot be quantified.

Participants discussed the need to quantify benefits and costs of environmental strategies. This information

could help determine whether a project is no longer the right project. A Washington State Department of Transportation study of environmental mitigation strategies and costs shows that costs varied widely. It is difficult to quantify roadway relocation projects and environmental mitigation. What do you call amenities mitigation and what is needed to produce a good design?

Participants discussed transportation and land use issues. Land use is a larger issue that involves numerous public- and private-sector players. Addressing urban sprawl is a complex undertaking. More information is needed on the secondary and the cumulative impacts of sprawl. Transportation documents should consider the issue of sprawl.

Research Needs

- Conduct a study to analyze the influence of changes in fuel types on health, especially for individuals living near major roadways. Examine the potential benefits to improved health from changes in fuel types.
- Conduct research to develop a better understanding of the relationship between air quality strategies and performance outcomes.
- Examine the experience in states where natural resource agencies have strategic planning frameworks, and explore the role transportation plays in these frameworks. Examine the approaches to addressing issues with habitat connectivity.
- Examine the impacts of transportation and communities on ecology.
- Identify and define the costs associated with environmental mitigation. Help define environmental stewardship and document the benefits of transportation and the improvements it makes as part of environmental mitigation measures.
- Conduct a study identifying elements of good design versus mitigation versus amenities. Identify common approaches among states and the experience of implementing agencies.
- Conduct follow-up work for NCHRP Project 20-20, including examining the costs associated with additional environmental strategies. Convening a panel of designers might be one approach to address some of these topics.
- Conduct studies focusing on the impact smart growth has had on various measures. Examine the experiences in Maryland, Florida, and other states with major smart growth initiatives.
- Conduct research on the factors that cause urban sprawl, including local governments' incentives for developers. Denver, Colorado, which is promoting infilling and transit-oriented development, might be one case study.

- Conduct scenario planning on the costs of infrastructure and environmental preservation.

CUSTOMER SATISFACTION

Randy Halvorson, Moderator

Mark C. Larson, Recorder

Topics Discussed

Participants in this breakout session discussed techniques for obtaining information on customer satisfaction with the products and services provided by transportation agencies. The use of customer satisfaction information with performance measures was also discussed.

Participants discussed use of the Internet for customer surveys. It was noted that the methodology used and the response rate are important for the results of Internet surveys to be meaningful. This approach is effective for some population groups but not for the general population. Internet surveys can also be used effectively to survey agency staff and other agencies. The Internet has worked well for specialized trade-off surveys at some transportation agencies.

Participants discussed internal employee communications tools. The Minnesota Department of Transportation used 25 employee meetings to communicate the new performance-based state plan. Surveys conducted with managers in Oregon focus mainly on their satisfaction with internal management services, such as human resources and finance. Approximately half of managers are surveyed each year. Automated Outlook survey software is used. This software provides for anonymous responses. The entire state government is now doing this in some fashion. The surveys also provide the opportunity for narrative feedback.

The Washington State Department of Vehicle Services conducts 2-day forums to convey key messages to managers. The director and assistant director travel throughout the state and have one-on-one meetings with staff in a structured program focusing on relationship building. Another approach is to have employees rate how well they believe they are delivering services and how well they believe they are able to do it given constraints or other issues. This approach can be Internet based and is used extensively in the private sector.

The use of comprehensive service and accomplishments reports for organizations and a customer report card for all city services was discussed. Seattle, Washington, and New York City were identified as using this approach. More information is available from the Federal Highway Administration performance and accountability reports.

Questionnaire design was discussed. It was noted that questionnaire design is crucial in conducting customer surveys. Be sure to test the survey first. Draw on existing knowledge, with a special focus on what cities and counties have done. They are fairly advanced, and many have done benchmarking.

The use of market research to validate measures and set targets was discussed. The Caltrans maintenance department has a web-based customer complaint process. Some 800 responses were received last year in Los Angeles County. Caltrans monitors the patterns and the high-frequency issues. Complaints are answered within 2 weeks. Letters and phone calls are also received by the department. The Caltrans maintenance department meets with travel information staff monthly to improve public information and obtain feedback.

It was noted that surveys of legislators have been conducted by some state transportation agencies.

Concerns about nonprofessionally designed surveys were discussed. The sequencing and frequency of surveys were also discussed. It was suggested that annual surveys of the same user groups may be too frequent. The purpose of customer satisfaction surveys is to determine whether new investments make a difference. Survey methodologies should also provide for comparisons between different regions of a state.

Research Needs

- Consider conducting a national symposium or peer exchange focusing on customer research practices and experiences. This symposium would focus on sharing experience and advancing the state of the practice with transportation customer surveys.
 - Compile and make available the basic types of questions that should be included in transportation customer satisfaction surveys. The book by Gallup, *Now Break All the Rules*, may be of use in this effort.
 - Identify and document the analytical methods available for use by transportation agencies interested in conducting customer satisfaction surveys.
 - Identify and document how market research is linked to the decision-making process, including investment decisions. Provide best practice case studies.
 - Conduct research examining the factors that influence customer decisions related to what modes they will use.
 - A scan of all customer surveys in use by state departments of transportation is being conducted. States can buy into extra samples in the National Travel Survey this fall. Examine the opportunities for benchmarking versus national average or peer states. Explore waiving match requirements if states use state planning funds.

FREIGHT

Barbara Ivanov, Moderator

Mark Hallenbeck, Recorder

Topics Discussed

Participants in this breakout session discussed a variety of issues related to freight performance measures. Topics included identification of bottlenecks and problem areas for freight transportation, identification of appropriate roles for state transportation agencies and other public agencies, safety and security issues, techniques for obtaining information on freight movements and needs, and the involvement of freight stakeholders in the planning and performance measures development processes.

Participants discussed the need for better freight data. Many state transportation agencies do not have extensive information on freight. Information concerning the volume and direction of freight movements, problem areas or bottlenecks, and the needs and concerns of the various freight stakeholders is often lacking. Other information that would be of benefit relates to the influence of just-in-time delivery needs on the weight of loads per truck and the number of trucks on the roadways. Most public transportation agencies do not have extensive expertise in freight or logistics. Better information is needed at the technical level within transportation agencies and for presentation to decision makers.

Participants discussed institutional issues related to freight performance measures. There may be institutional issues that influence freight movement, including those associated with international borders or cultural differences. For example, natural resources and manufacturing capabilities in Quebec, Canada, may miss opportunities for customers in the eastern United States because of border crossing issues or bottlenecks between the countries.

Participants discussed techniques to involve freight stakeholders in the transportation planning process. Many areas would benefit from examples and suggestions concerning techniques to enhance involvement of freight stakeholders in all aspects of transportation planning, policy development, operations, and evaluation.

Possible performance measures were identified and discussed by participants. Potential freight performance measures include freight mobility indicators, bottlenecks affecting freight movements, and freight travel and delay times.

Participants discussed potential relationships between freight and economic growth. A few areas are exploring this relationship. For example, the New York State Department of Transportation has a project to simulate the freight network and intermodal connections.

Participants discussed safety and security issues associated with freight movement. There are trade-offs between security and efficiency issues. Many transportation agencies are examining what these trade-offs are; what role transportation agencies can and should play in helping facilitate discussion of these trade-offs; and what technologies, techniques, and policies can be used to enhance both safety and efficiency. ITS and other advanced technologies provide opportunities to address safety, security, and efficiency concerns.

Research Needs

Participants noted that there were research or information-sharing opportunities associated with each of the topics discussed. The following research needs were suggested to help advance the state of the practice with freight performance measures.

- Conduct a study of the tools and technologies for obtaining, collecting, and analyzing freight data. Case study examples would focus on identification of data needs; collection and analysis of freight data; and methods to present information to stakeholders, policy makers, and other groups.
- Examine institutional issues that may influence the movement of freight, including international border crossings.
- Identify and synthesize best practice case studies of methods to involve freight stakeholders in the transportation planning, policy making, and project development process.
- Conduct a study to examine current freight performance measures used by transportation agencies and to identify other possible measures. Best practice studies would be included. Direction on more extensive freight performance measures would be provided.
- Examine the relationship between freight and economic growth in a synthesis or a more detailed study.
- Conduct a study examining freight safety and security issues as they relate to the development of performance measures, including trade-offs with efficiency.

RESOURCE PAPERS

Performance Measurement in Transportation

State of the Practice

Theodore H. Poister, *Andrew Young School of Policy Studies, Georgia State University*

Transportation agencies in the United States and elsewhere have dramatically transformed the way they do business over the past 10 to 15 years, and performance measurement is an essential ingredient in their quest for managing effectively to produce results. The general movement toward managing for results has been driven by (a) increased demands for accountability and improved performance from the public, elected officials, and the media; (b) strong leadership and the desire to strive for excellence within agencies; and (c) recognition that sea changes in the environment in which transportation agencies function require strategic thinking to plot new courses of action and then measure success in implementing them.

The commitment to increased accountability and performance has led to a plethora of approaches to improved management and decision making, typically initiated first by a few leading-edge agencies and then adopted by the mainstream. The approaches have radically transformed, or have the potential to transform, the way these agencies operate on a day-to-day basis. Tools include strategic planning and management, performance-based transportation systems planning, stakeholder engagement processes, asset management, performance management, performance budgeting, process reengineering, and quality/productivity improvement processes. Transportation agencies have also adopted performance measurement systems widely. These systems are results-oriented management tools in their own right but are also critically important in linking and aligning other planning and management processes.

Transportation professionals need to remember that pressure for more effective and responsive government in this country is by no means limited to the field of transportation (Newcomer et al. 2002). Requirements for systematic goal setting and performance measurement are embodied in the Government Performance and Results Act of 1993 at the federal level and in legislative or executive mandates in virtually all of the states (Melkers and Willoughby 1998; Aristigueta 1999). Local governments have also jumped on the performance measurement bandwagon, as exhorted by Osborne and Gaebler (1992), who pointed out that “if you don’t measure results, you can’t tell success from failure.”

The extent to which this results-oriented management approach has permeated government in the United States was examined by the Government Performance Project (GPP), conducted jointly by university researchers and the editors of *Governing* magazine. Applying a set of systematic criteria through detailed surveys and site visits, the GPP evaluated all 50 state governments, 35 major cities, and a sample of federal agencies in terms of their practices in the areas of financial management, human resources, information technology, capital management, and managing for results. The resulting grades ranged from A to F and indicated, not surprisingly, that while some jurisdictions indeed have strong management capabilities, there is still considerable room for improvement (Ingraham et al. 2003). Parenthetically, in its second round of evaluations at the state level, the GPP plans to grade the performance of the departments of transportation (DOTs) and environmental protection programs as well as central state governments.

Transportation agencies are arguably often on the leading edge of results-oriented management and performance measurement practices at all levels of government. This is illustrated by the fact that transportation agencies have often been asked to pilot goal-setting and performance measurement processes in the federal government and various state and local jurisdictions and that DOT personnel have often been called on to help other agencies undertake these initiatives.

Local public transit agencies have been monitoring comprehensive sets of performance measures with regard to operational efficiency, ridership, and revenue versus expense for more than two decades in an effort to manage strategically in a competitive industry (Fielding 1987). State DOTs have been experimenting with, refining, expanding, and enhancing their performance measurement systems over that period. While the DOTs have always been “data rich” agencies in some respects, early measurement systems were oriented internally and focused principally on production and cost-efficiency.

However, the field continued to evolve, and a Transportation Research Board synthesis report published in 1997 found that the “new” performance measures tracked by DOTs were significantly more outcome oriented, were tied to strategic goals and objectives, and focused more on service quality and customer service (Poister 1997). Other articles published around the same time illustrated such developments in a number of states, including New York (Albertin et al. 1995), Wisconsin (Etmanczyk 1995), Washington (Ziegler 1996), Delaware (Abbott et al. 1998), Virginia (Sorrell and Lewis 1998), and Texas (Doyle 1998).

Most of the managerially oriented work cited above focuses more on measuring organizational performance than transportation systems performance. However, other transportation professionals have been working to incorporate performance measurement more centrally in transportation planning processes (Halvorson et al. 2000; Newman and Markow 2004). A few years ago a guidebook on performance-based planning was published to help agencies improve the development, implementation, and management of their transportation plans and programs. The guidebook added performance measurement to existing planning processes to allow evaluation of alternative programs, projects, and services against overall transportation plan goals and objectives (Cambridge Systematics 2000).

Growing out of a CEO workshop on managing change, a recent report addresses the need for transportation agencies to tie performance measures to strategic planning processes (TransTech Management 2003). The report makes a distinction between externally and internally driven performance measures and summarizes the kinds of measures used by DOTs in such areas as mobility and congestion, safety, community

quality of life, environment, economic development, system preservation and maintenance, project delivery, and human resources.

In fall 2000 a national conference focused on the use of performance measures to improve the performance of both transportation systems and transportation agencies (Transportation Research Board 2001). The general sense of the conference was that performance measurement was becoming a permanent way of doing business in transportation agencies and that, although several issues remained, a number of lessons had been learned concerning the development of measurement systems, data collection, effective utilization of performance data, and maintenance of measurement programs over the long run.

The purpose of this paper, then, is to track recent trends in the development and use of performance measures in transportation, assess the current state of the practice, and point out further issues that must be addressed to use measurement systems most advantageously. Focusing primarily on state DOTs, it addresses the questions of what is measured, how performance is measured, how performance data are reported, and how performance measures are used. The paper concludes with a summary of recent trends in the field and outlines continuing challenges that need to be addressed.

WHAT IS BEING MEASURED?

Transportation agencies have become more holistic in the coverage of their measurement systems. They focus on the full range of performance as illustrated in the program logic model shown in Figure 1. The major focus areas are agency performance, system performance, and broader impacts. While agency performance concerns service delivery, projects completed, improvements made, and so forth, system performance focuses on the capacity and condition of transportation systems and their performance in terms of travel time, cost, convenience, and safety. Increasingly, transportation agencies are also concerned with the broader impacts of transportation initiatives with regard to community quality of life, economic development, and the environment.

The kinds of performance measures monitored by transportation agencies span the entire model. Some focus on resources, primarily human and financial, while others measure outputs and agencies’ operating efficiency in producing them. Effectiveness measures are tied to outcomes-oriented objectives for improving transportation system performance and generating positive impacts. Quality measures relate both to service outputs and to outcomes, and customer satisfaction measures similarly reflect satisfaction with outputs but even more so with transportation outcomes. Finally,

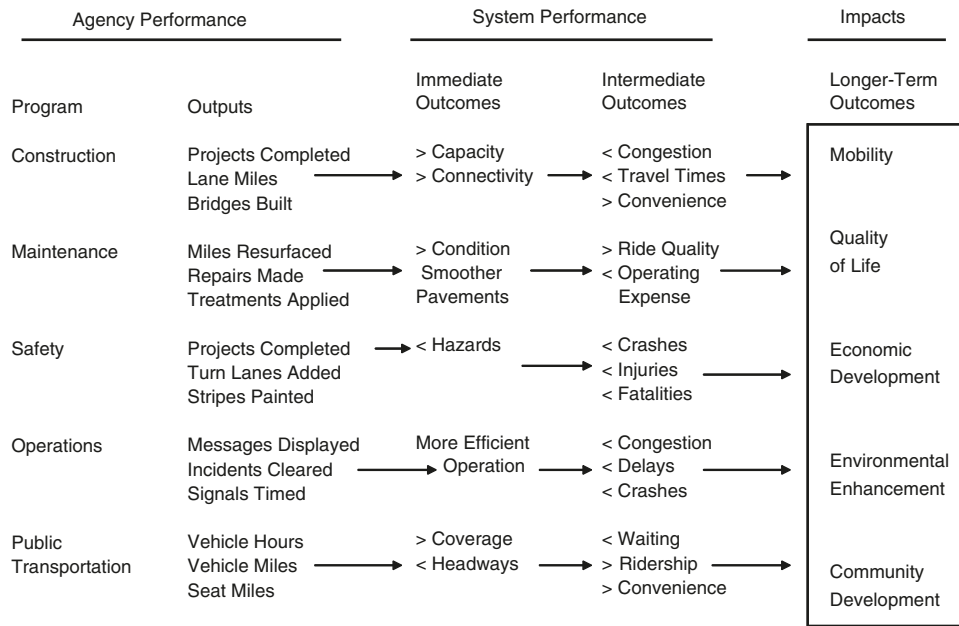


FIGURE 1 Transportation program logic model.

cost-effectiveness measures and benefit–cost measures relate transportation outcomes and broader impacts to resources consumed and other costs.

Balanced Scorecard Models

Many transportation agencies have used the balanced scorecard model (Kaplan and Norton 1996) to ensure both an internal and an external perspective and a process as well as results orientation in defining goals and performance measures. The Charlotte, North Carolina, Department of Transportation pioneered the use of this approach in the field of transportation. It developed measures for each of the four original quadrants of performance, including the customer, financial, internal business practices, and learning and growth perspectives. Other DOTs have customized the model. The Illinois Department of Transportation, for example, has identified customer satisfaction and partnerships, business practices, delivery of programs and services, and learning and growth as the focal points of its strategic objectives and performance measures. The Georgia Department of Transportation organizes its strategic goals and performance measures in the six domains related in its strategy map (see Figure 2).

Program Delivery

Many states now are especially concerned with getting more effective control over program delivery and imple-

menting their annual State Transportation Improvement Programs (STIPs). This concerns the entire process, from planning, preliminary engineering, design, and letting through actual construction. This is an important core business of all state DOTs and consumes a substantial proportion of their financial resources and professional workforce on an ongoing basis. In this age of accountability, governors, legislatures, and transportation commissions have mounted substantial pressure on DOTs to deliver on the projects to which funds have been committed.

Thus, the top priority of many state DOTs around the country now focuses on delivering the projects that have been promised to their customers. For example, in the wake of serious financial mismanagement issues in a previous administration, the Virginia Department of Transportation “jump-started” its renewed strategic planning process in 2002 with the central objective of getting its program delivery process back on track. Thus, measures associated with moving capital projects through the pipeline to completion predominate in all of the department’s internally and externally focused performance reporting systems.

In addition, at least a few states, such as Washington, Oregon, and New Mexico, have received large increases in funding through additional revenue sources or expanded revenues from traditional sources and will now be responsible for delivering significantly larger programs. In Ohio, Governor Taft’s Jobs and Progress Plan calls for significant increases in both federal and state funds to put more Ohioans back to work on expanded highway construction programs over the next

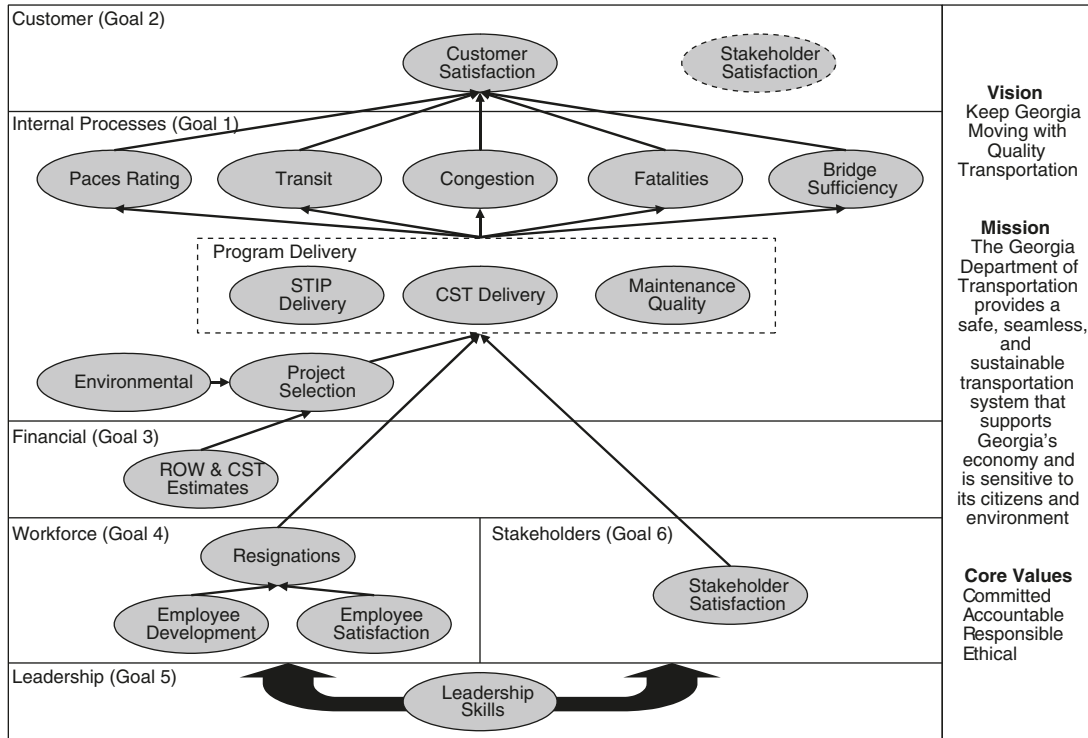


FIGURE 2 Georgia Department of Transportation strategy map, fiscal year 2005.

10 years. In Georgia, Governor Perdue’s Fast Forward Program provides for some \$15 billion over the next 6 years, mostly for roads and bridges but also some for transit and rail. This infusion of new money from bond issues will double the size of the overall program, which has been running at about \$1.2 billion per year.

Given the pressure to make good on their commitments to the public and in some cases the added challenge of moving significantly more projects through the process, most DOTs are increasingly concerned with tracking measures of program delivery. The focus is usually on bringing in projects on time and within budget. In examining these measures more closely, some DOTs have been surprised to find that their performance in bringing projects to contract letting in the year programmed for letting is significantly lower than previously assumed. This has led to substantial efforts to streamline their processes, but it has also led to recognition that in some cases STIPs have been dramatically overprogrammed and that programs need to be “right-sized” to afford more reasonable expectations of what they can accomplish.

DOTs recognize the need to maximize the number of projects completed given the resources available for a given year; at the same time, they are concerned that projects can be stalled or slowed down by numerous factors beyond their control. Therefore, some DOTs see

a need for providing a reservoir of projects in the annual STIP so that if some projects encounter difficulties along the way, others will have approval and be ready to go. At least a couple of states, for instance, program a 25 percent overrun in the number or dollar value of projects to be brought to letting in a given year. This translates into a target of letting 80 percent of all projects programmed for the year, which these DOTs see as ambitious but feasible.

To improve program delivery through a highly structured process improvement effort, the Pennsylvania Department of Transportation has 10 working groups focusing on issues such as planning and preliminary engineering, funding and programming, environmental clearance, right-of-way acquisition, utilities, permitting, design and development, consulting agreements, contract management and construction, and bridge design and construction. The performance measures the department is developing to track the efficiency of its program delivery focus on cycle times for completing overall projects as well as the individual elements of the process. However, at this point it is encountering difficulties in operationalizing some of these indicators because it needs better reporting mechanisms to provide the data input.

The Pennsylvania Department of Transportation task force is also trying to develop good measures of the cost

of and level of effort required in completing various elements of the overall program delivery process. It is considering development of an information system for design and project delivery analogous to its highway maintenance management system. Such a system would track person-hours of effort and other direct costs expended on each stage of each project in order to monitor productivity and cycle times. In addition, the department would like to build measures of quality into such a system and is beginning to think about what kinds of measures to use in this regard.

Incident Management

Over the past several years, operating the highway system has been increasingly recognized as a central component of a DOT's highway program responsibilities. In addition to utilities and work zone management, this includes coordination of signals and other traffic controls, pavement markings, use of high-occupancy vehicle lanes, signage, and the use of intelligent transportation systems technology to provide motorists with current traffic information via on-site variable message signs, websites, and the media.

A major thrust in this emphasis on system operations concerns incident management—in particular, coordination of effective responses to traffic disruptions on highways due to crashes, debris in the road or spills of hazardous materials, vehicle repairs, repair work zones and construction lane closures, and so forth. Effective management of such incidents can have major impacts on both subsequent traffic congestion and secondary crashes, and DOTs have developed proactive programs to respond to them, particularly in large urbanized areas.

Thus, DOTs are now monitoring the occurrence of such incidents and tracking their performance in coping with them. For example, the Maryland State Highway Administration tracks such indicators as incident duration, initial response time, and overall recovery time in terms of service quality and initial outcomes. In annual evaluations of its Coordinated Highway Accident Response Team, the administration also computes measures of the reduction in vehicle operating hours, total traffic delay time, fuel consumption, total emissions, and secondary accidents avoided because of its incident management efforts, as well as an overall benefit–cost ratio (Chang et al. 2003).

Customer Satisfaction

In addition to focusing on service delivery and operations, transportation agencies increasingly have been

monitoring quality and effectiveness from the customer perspective (Stein and Sloane 2003). Public transit agencies have a long history of using customer surveys, not only to obtain information on trip origins and destinations but also to solicit feedback on customers' perceptions of the reliability, safety, convenience, and overall quality of the services they provide.

State DOTs that conduct regular surveys of the public at large, motorists, or other stakeholder groups include those in Minnesota, New Mexico, Illinois, Kentucky, Pennsylvania, Ohio, and Georgia. The Pennsylvania Department of Transportation, for example, has conducted periodic surveys to monitor residents' overall ratings of a variety of services ranging from highway construction and maintenance to roadside beautification, snow and ice removal, welcome centers, transportation planning, financial support for public transportation, vehicle inspection programs, and vehicle registration and titling services.

Closer to the operating level, the department conducts an annual Highway Administration Customer Survey mailed out to 1,000 randomly selected licensed drivers in each of the state's 67 counties. The survey tracks changes in customer satisfaction with a number of performance attributes related to ride quality, traffic flow, and safety separately for Interstate highways, numbered traffic routes, and secondary roads on the state system. It provides statistically reliable measures at the statewide, district, and county maintenance unit levels.

The Florida Department of Transportation uses a mix of telephone surveys, mail surveys, and response cards to monitor feedback from six customer segments including resident travelers, visitor travelers, commercial travelers, special needs travelers, property owners, and elected officials. The data indicate the percentages of these groups who are satisfied versus dissatisfied with Florida highways, transit services, and other modes as well as with the department's communications and interaction with external stakeholders. They are reported as individual performance measures but are also aggregated into an overall index of customer satisfaction.

HOW IS PERFORMANCE MEASURED?

Transportation agencies are increasingly careful about how they specify particular measures of performance, and this can be critically important in driving decisions and actions. In the area of highway safety, for example, trying to reduce fatalities as measured by the number of traffic fatalities per 1,000,000 vehicle miles focuses attention on safety improvement projects, improved operations, and more effective enforcement activities—

a strategy of making the roads safer. Tracking the number of traffic fatalities per 100,000 resident population might prompt the same kinds of policies but also emphasize the use of alternative modes and telecommuting and in the long run the changing of land use patterns to reduce highway usage—basically a strategy of getting people off the roads. The National Highway Traffic Safety Administration and some state DOTs track data on both these measures.

In an example relating to highway system preservation, focusing attention on increasing the percentage of lane miles in good condition would tend to prompt a worst-first strategy for targeting resurfacing projects, perhaps even giving priority to lower-volume roads where repair work is less disruptive and easier to perform precisely because traffic management problems are not at all severe. In contrast, monitoring the percentage of vehicle miles traveled (VMT) carried on lane miles in good condition would encourage targeting higher-volume roads in substandard condition for resurfacing and would produce more beneficial consequences.

Highway System Safety and Condition

All state DOTs track measures of highway safety and highway and bridge condition on a regular basis. The standard safety measures concern the number of crashes, injuries, and fatalities per million vehicle miles traveled on an aggregate basis, but some states also compare numbers of crashes occurring at high-accident locations after safety improvement projects have been completed with the numbers before the projects were undertaken. Other outcome-oriented safety measures include the number of crashes at at-grade railroad crossings, the number of pedestrian and bicycle injuries or fatalities on state highways, and the number of crashes at highway repair work zones.

State DOTs monitor the condition of their highway systems in terms of ride quality, measured chiefly by the international roughness index (IRI), and pavement condition, as monitored in Georgia for instance with the Pavement Condition Evaluation System. The Ohio Department of Transportation measures system condition every year with pavement condition ratings based on visual inspections of 100 percent of its pavements. Similarly, the Pennsylvania Department of Transportation conducts annual windshield surveys of its roads to track pavement deficiencies, shoulder conditions, drainage problems, guiderails, signs, and other appurtenances. The department also emphasizes ride quality data. It runs 100 percent of its Interstate highways and 50 percent of its other National Highway System highways for IRI data every year. States also monitor the number of deficient or weight-limited bridges.

Traffic Flow and Congestion

General

Tracking good measures relating to traffic flow and congestion on state highways has been more challenging. Traditional volume–capacity ratios have been the mainstay in this area, but they may be problematic in terms of knowing what the traffic-handling capacity of particular segments of highway really is. The Ohio Department of Transportation runs computer models applied to highway capacity measures to compute volume–capacity ratios on the entire network over 24 hours. From the results the department develops annual estimates of the percentage of lane miles congested, the percentage of VMT in areas exceeding congestion limits, and the percentage of peak-hour VMT exceeding congestion limits.

The *Annual Urban Mobility Report* produced by the Texas Transportation Institute tracks traffic congestion in the 75 largest urban areas in the United States (Schrank and Lomax 2003). This method uses Highway Performance Monitoring System data collected by the Federal Highway Administration, with supporting data from state and local agencies. The resulting measures are computer-modeled estimates based on roadway characteristics and traffic volume counts because high-quality actual speed data are not available for many cities. The measures include

- Travel time index—ratio of peak-period travel time to free-flow travel time,
- Delay per person—hours of extra travel time divided by number of residents,
- Cost of congestion—value of extra time and fuel consumed because of congestion,
- Percentage of VMT congested—traffic occurring on congested roads during peak periods,
- Percentage of congested lane miles—lane miles congested during peak periods, and
- Percentage of congested time—percentage of time travelers expected to encounter congestion.

Methodologies exist or are being developed to estimate the impact of a range of solutions on reducing congestion, including additional highway construction, demand reduction, freeway entrance ramp metering, freeway incident management, traffic signal coordination, use of high-occupancy lanes, and public transportation improvements.

Urban Congestion Measures

Mitretek reports travel time trends on a monthly basis for 10 metropolitan areas where public- or private-sector organizations provide suitable point-to-point travel time

data (Wunderlich et al. 2004). This approach involves the automated acquisition of roadway travel times posted to traveler information websites, such as www.georgia-navigator.com in Atlanta or www.smartraveler.com in Miami, Florida, for 5-minute intervals for times of the day and days of the week when information is monitored. The measures reported include

- Travel time index—ratio of congested travel duration to free-flow duration for all congested trips (those over 130 percent of free-flow travel time);
- Buffer index—average time a traveler would have to reserve during the day for a trip to be on time 95 percent of the time;
- Average duration of congested travel per day—hours that a network is designated as congested, when 20 percent or more of all trips are congested (over 130 percent of free-flow travel time); and
- Percentage of congested travel—hours of congested travel as percentage of time.

The urban congestion measures reported by Mitretek sometimes differ substantially from the urban mobility measures reported by the Texas Transportation Institute because they are derived from travel time data rather than traffic volume counts.

In the Atlanta area, one of the cities included in the urban congestion report, the Georgia Department of Transportation has instrumented some major corridors. It uses its Automated Traffic Monitoring System to measure speeds and then converts the data to trip times for particular point-to-point segments. In other areas, the department uses pilot vehicles to drive specified segments and measure trip times. It sticks to the same season and same operating conditions to assess changes over time. The department has the potential to get trip time data through traffic signal systems by using detector loops but has not implemented this yet.

Washington State

The Washington State Department of Transportation uses archived loop detector data to track travel times between specific pairs of origins and destinations on 12 of the most heavily traveled corridors in the Puget Sound region. These real-time data are used to report current travel times in each of these corridors for each 5-minute interval throughout the day and are posted on a website (www.wsdot.wa.gov/pugetsoundtraffic/travel-times) along with the average travel times for the same trips. The department believes that it is important to distinguish between recurrent and nonrecurrent congestion that might be due to incidents, construction lane closures, debris in the road, inclement weather, unusual

driving conditions, or abnormally high traffic volumes. At this point the department simply labels as nonrecurrent trips that take twice as long as in normal free-flow conditions, but it is hoping to develop actual incident data sets that can be correlated with the archived travel time data to identify incident-related delays.

The department recognizes the limitations of loop technology for monitoring travel times and is beginning to experiment with other emerging technologies that may provide more accurate data and be more cost-effective than loop detectors. In one county the department has begun to use roadside speed cameras to estimate travel speeds, and the data are processed and reported the same way as the loop detector data. In addition, the department is considering the possibility of using automatic vehicle locators for this purpose in the future. Many public transit systems use this geographic information systems satellite-based technology at present, which is feasible because they are operating relatively few vehicles.

Travel time reliability is another important indicator of the quality of transportation. The Washington State Department of Transportation also uses its travel time data to compute estimated 95 percent reliable travel times, within which trips in particular corridors can be completed 95 percent of the time. Interestingly, the Minnesota Department of Transportation has measured perceived travel time reliability for numerous pairs of origins and destinations around the state from motorist survey data.

Florida Mobility Measures

The Florida Department of Transportation has been developing a set of mobility measures for some time now, and it is still a work in progress. The department has identified four dimensions of mobility—quantity of travel, quality of travel, accessibility, and utilization—and has defined multiple indicators of each for both highways and public transit. The department is working to overcome some data problems in operationalizing these measures, for instance by using automobile occupancy data to track person miles traveled as well as VMT. The department reports data on some of the mobility measures in the Short-Range Component of its statewide transportation plan and expects to be able to set targets for these measures in the plan and its short-range objectives. It is also hoping to expand the mobility measures to incorporate rail, aviation, and water transportation in addition to highways and transit.

Use of Alternative Modes

Most DOTs track the volumes of passenger trips on their urban and rural public transit systems, and at

least one, the Georgia Department of Transportation, measures the annual growth in transit ridership as compared with the growth in VMT on highways. Occasional surveys can provide measures of the percentage of work trips, or total trips, made by transit, bicycles, or walking, but this requires heavy sampling fractions. A desirable measure of comparable service quality might focus on average transit travel times in an urban area in ratio to average driving times for the same trips, but that is difficult to operationalize. Other indicators of the efficient utilization of urban area transportation systems focus on numbers of vehicles or individuals using transit park-and-ride lots and the percentage of vehicular traffic on highways that does not consist of single-occupant vehicles.

Environmental and Economic Impact

The kinds of performance measures typically used on an aggregate basis to track the environmental impacts of transportation projects focus on outputs in environmental compliance such as the number of wetlands affected and preserved or the number of sites mitigated. The Maryland Department of Transportation, for example, tracks the number of acres of wetlands created and reforestation planted as a percentage of acres required and the number of storm water management enhancements completed compared with the number targeted. The Washington State Department of Transportation uses the following measures of environmental compliance:

- Number of noncompliance events concerning fish habitats, wetlands, water quality, or other issues;
- Total acreage of replacement wetlands through creation, enhancement, buffers, or restoration; and
- Number of replacement wetland projects meeting all standards, some standards, or no standards.

With respect to the economic development impact of transportation improvements, one of the most important performance measures may be the number of jobs that are created or retained in a state through initiatives in which transportation commitments or projects are a contributing factor.

Generally speaking, ongoing research, program and project evaluations, and case studies continue to illuminate our understanding of the real impacts of transportation facilities and services. Quantitatively and qualitatively, however, few practical measures exist at present for environmental quality and economic development that can be incorporated into performance-monitoring systems on a regular basis (Meyer 2001).

Benefit–Cost Ratios

While benefit–cost ratios have long been used by transportation agencies to evaluate the worth of proposed projects, agencies are now starting to use them to monitor the overall economic efficiency of their programs on an annual basis. For example, in the state of Victoria, Australia, VicRoads tracks the aggregate benefit–cost ratios for all projects completed in a given year. In addition, VicRoads monitors the “achievement index” of all projects, which compares postproject benefit–cost ratios computed 2 years after project completion in ratio to benefit–cost ratios projected before project implementation.

Use of Indices

As the number of measures incorporated in some monitoring systems proliferates to a point where minutiae tend to overwhelm a central overall focus, some agencies have developed indices that combine multiple measures in order to summarize performance with fewer numbers. The Florida Department of Transportation, for example, focuses on 11 key performance measures to monitor progress in accomplishing its strategic objectives and executive board initiatives. While a few of these measures, such as construction project time changes and cost changes, are captured by single indicators, others are indices in which a number of indicators are combined to provide an overall assessment of performance.

As discussed earlier, for instance, the department’s key indicator of customer satisfaction is an index combining measures of feedback from six customer segments with a variety of transportation modes and departmental services. Another of the department’s key performance measures focuses on system condition, which is an index of maintenance ratings and bridge condition and replacement measures. In turn, the maintenance rating program includes 84 separate indicators of various aspects of highway condition. All of these items are used to compute an overall weighted index of system condition, which is one of the few key measures monitored by top management. Where the data indicate slippage, executives can drill down to find which components of system condition are the source of the problem. At the program management and operating levels, the individual measures are more meaningful because they are more directly actionable in terms of resource allocation, treatments, and managerial initiatives.

The Ohio Department of Transportation uses its Organizational Performance Index (OPI), created in 1997, to evaluate performance in various areas and combine dozens of performance measures into a single index of overall departmental performance. The depart-

ment has decentralized decision making and operational responsibilities, and the OPI focuses on the performance of the department’s 12 districts, and by extension the 88 county-level maintenance units, in the following eight functional or “topical” areas:

- Construction management,
- Contract administration,
- Equipment and facilities,
- Finance,
- Information technology,
- Plan delivery,
- Quality and human resources, and
- System condition.

While the measures for finance and contract administration consist of single indicators, in the other six areas performance is monitored on multiple indicators, which are tracked individually but also combined into indices. In each case the index is evaluated on the basis of the sum of points scored as a percentage of the total points available. The eight indices are further combined

into a single index of overall departmental performance in the same percentage format.

All the individual measures and the eight indices are monitored in monthly reports for each district. As illustrated in Figure 3, they are also combined into total index values for each district and the department as a whole. While the system has the capability of setting differential weights for the measures and subindices, at present all or most of them are weighted evenly. The measures in each of the eight topic reports are “owned” by a deputy director or other senior manager in the department’s four central office functional divisions, who reviews the monthly OPI reports and works with district engineers to take corrective actions in areas where performance might be slipping.

Setting Standards and Targets

Increasingly, transportation agencies are identifying performance measures and then setting numerical standards or targets to be attained on those measures by

District	Total Index Value	Construction Management	Contract Administration	Equipment and Facilities	Finance	Information Technology	Plan Delivery	Quality and Human Resources	System Conditions
1	95.8333	83.3333	100.0	72.0238	100.0	88.8889	100.0	75.0	100.0
2	91.6667	79.1667	100.0	82.7381	100.0	100.0	50.0	87.5	95.0
3	97.9167	91.6667	100.0	85.119	100.0	100.0	80.0	93.75	91.6667
4	97.9167	91.6667	100.0	83.9286	100.0	100.0	95.0	68.75	100.0
5	100.0	91.6667	100.0	91.6667	100.0	100.0	95.0	93.75	100.0
6	100.0	83.3333	100.0	86.3095	100.0	88.8889	83.3333	93.75	93.3333
7	95.8333	91.6667	100.0	88.6905	100.0	100.0	65.0	87.5	100.0
8	100.0	91.6667	100.0	87.5	100.0	100.0	95.0	87.5	98.3333
9	89.5833	87.5	100.0	66.6667	100.0	100.0	50.0	75.0	100.0
10	95.8333	100.0	100.0	90.4762	100.0	100.0	90.0	56.25	93.3333
11	93.75	79.1667	100.0	95.8333	100.0	100.0	65.0	87.5	100.0
12	91.6667	79.1667	100.0	82.7381	100.0	100.0	70.0	81.25	93.3333
ODOT INDEX	93.2192	91.6667	100.0	90.4762	100.0	94.4444	83.3333	87.5	98.3333

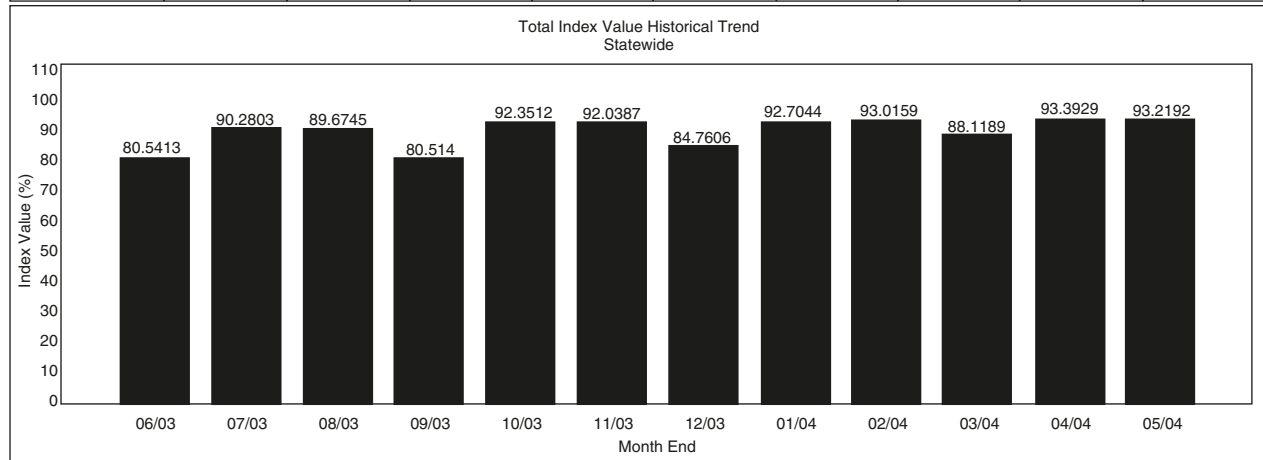


FIGURE 3 OPI executive summary, Ohio Department of Transportation.

specified years rather than simply calling for improvement over time. For example, a state DOT might set targets for reducing the travel time index during congested hours in its major urban areas from the current value of 1.8 down to an average of 1.75 in 2005, 1.70 in 2006, and 1.65 in 2007. With respect to ride quality, for instance, a DOT might define a standard for “good” ride quality on non-Interstate numbered traffic routes as IRI values of 120 or lower and set targets for achieving that standard on 80 percent of those roads in 2005, 85 percent in 2006, and 90 percent in 2007.

Measuring performance against preset targets, however, raises the question of how to establish “stretch” objectives that challenge the organization to make meaningful improvements while still being realistic. Considerations that usually go into decisions regarding targets include past and current performance, service delivery characteristics, available resources and technologies, customer preferences, public sentiment, media attention, and political feasibility. Obviously, these factors do not always point in the same direction, and transportation managers are forced to make difficult decisions about priorities.

HOW ARE PERFORMANCE DATA REPORTED?

Since usefulness to managers, decision makers, and policy makers is the bottom line for assessing the worth of any performance measurement system, transportation agencies have learned that reporting performance data in terms of informative comparisons is of critical importance. Typically, the most relevant analysis tracks change in performance over time and compares actual performance against targeted performance. Other useful reporting formats compare performance across organizational units (e.g., offices, districts, maintenance units), across user groups, or against counterpart agencies or programs.

Scorecards and Dashboards

“Scorecard” in many agencies refers to a format for presenting performance data, often tied to strategic plans, in which key indicators are presented as measures of success in achieving goals and objectives, often in terms of targeted versus actual values over recent years (quarters or months) as well as targets projected into future time periods. “Dashboard” typically refers to a display of performance data in a format designed to convey critical information at a glance. It often uses green, red, and yellow light designations to provide a quick look at the status of programs or initiatives.

The Pennsylvania Department of Transportation was one of the first transportation agencies to use both

scorecards and dashboards. The department’s scorecard consists of a set of strategic goals and objectives, performance measures, and targets against which current progress is monitored by a strategic management committee on a quarterly basis. As department executives became concerned, however, that the scorecard measures keyed to change-oriented strategic initiatives did not help to track the status of certain other core business functions, they developed a dashboard for management-by-exception monitoring of the status of their ongoing core functions on a monthly basis. At this point, most of the department’s districts and central office bureaus use their own scorecards and dashboards.

Many other DOTs use dashboards to track selected sets of key performance measures at the executive level. Figure 4, for example, shows the Minnesota Department of Transportation’s dashboard, which provides a monthly snapshot of the performance of infrastructure investment and planning programs as well as maintenance and operations.

Similarly, the Missouri Department of Transportation uses a dashboard format to monitor progress in implementing its departmentwide business plan through a high-level set of performance measures. The dashboard, which is geared toward outcomes envisioned in the department’s business plan, is produced every 6 months and is targeted to the Transportation Commission, legislators, and other key external stakeholders.

In addition, every headquarters business unit at the Missouri Department of Transportation maintains a scorecard of measures tied to its work plan. These scorecards track the implementation of strategies in the department’s business plan as well as service delivery and work processes in key core functions. The scorecards are reviewed by top management on a quarterly basis and are used more as a management tool to ensure the accountability of these units in advancing the department’s strategic plan.

Aggregation and Disaggregation Options

Many transportation agencies now have performance measurement systems that afford the ability to support denser and more finely granulated performance data at the same time. As the software systems supporting the data have become more powerful, flexible, integrative, and interactive, performance data collected and monitored at operating levels are routinely rolled up to higher levels in the organization. At the same time, managers can monitor summary data for the department as a whole or for major divisions and then drill down to lower levels in the organization to examine the variation among operating units or projects and sometimes identify sources of problems.

Measure	Status Year Before	Status Current	State Data Trend	Districts Current	Future	Years of Data
Infrastructure Investment and Planning						
Pavement – Ride Quality PSR - Principal Arterials	●	△ 2003	Dropped below targets - 3-year decline	2 or 8 on target % Good PSR 3 of 8 on target % Poor PSR	Forecast future decline	10
Pavement – Ride Quality PSR - Minor Arterials	●	△ 2003	Dropped below target - 3-year decline	1 of 8 on target % Good 6 of 8 on target % Poor	Forecast future decline	10
Pavement, Public Satisfaction – Ride Quality	△	△ 2003	Slight gain. Below target every year	N/A		6
Pavement – Remaining Service Life (RSL) Principal Arterials	△	△ 2003	Dropped below targets - 3-year decline	No districts on targets	Forecast future decline	10
Pavement – Remaining Service Life (RSL) Minor Arterials	●	△ 2003	Dropped below targets - 3-year decline	3 of 8 on target % High 4 of 8 on target % Low	Forecast future decline	10
Pavement Preventive Maintenance \$ Investment	△	● 2003	Far short of target	No district on target	Target under review - HSOP	2
Bridge Condition – Principal Arterials	△	△ 2003	Declining % Good Improved % Poor	4 of 8 on target % Good 5 of 8 on target % Poor		7
Bridge Condition – Minor Arterials	●	● 2003	Improved	7 of 8 on target % Good 6 of 8 on target % Poor		7
Bridge Condition – Collectors	△	● 2003	Improved to exceed targets	7 of 8 on target % Good 4 of 8 on target % Poor		7
IRC Travel Speed – % miles meeting speed targets	No target	● 2002	Small gain 1999–02; expect drop 2003–04	N/A	Forecast gains 2005–14	4
Congestion – % miles of Metro Urban Freeways	△	△ 2002	Deteriorating toward red	N/A	Targets under review - TSP	9
Transit Advantages – Bus Shoulder Miles - Metro	●	△ 2003	Achieved target 3 or last 4 years	N/A	Forecast on target 2004–06	12
Balanced Letting	△	△ FY 2003	Small declines 2003 & 2004 thru May	1 on target	Schedule 05–06 shows gains	6
Letting Timelines – 1st Year STOP - All projects	△	△ FY 2003	Small improvement	4 on target		6
Letting Timelines – 3rd Year STIP - MC, RC, BR	●	● FY 2003	Declined	1 on target		3
STIP Cost Estimates – 3rd Year - MC, RC, BR	●	△ FY 2003	Large improvement	3 Yellow 5 Red		2
Lettings on Schedule – Next 3 years - Milestones	7-2003	△ 4-2003	Improved	4 on target Year 1 4 on target Year 2 6 on target Year 3		1
Construction Limits on Schedule – Next 3 years - Milestones	△ 7-2003	△ 4-2003	Improved	8 on target Year 1 6 on target Year 2 4 on target Year 3		1
EIS Duration – Major Projects		New measure	Improved steadily since 1990	N/A		15
ROW Processing Time		New measure	Short of target	N/A	Forecast smaller workload	3
Plan Quality for Bid – Mn/DOT Plans	●	△ FY 2003	Dropped slightly below target last year	6 on target % Exceptional 4 on target % Poor		9
Plan Quality for Bid – Consultant Plans	●	● FY 2003	Far below targets every year	N/A		9
Construction Cost Deviation from letting to completion – MC, RC, & BR	△	● 2003	Deteriorated over last 5 years	4 on target		6
Construction Timelines – % of MC, RC & BR Projects meeting completion dates	△	△ 2003	Small decline	N/A		6
Operations and Maintenance						
Public satisfaction with Maintenance	△	△ 2003	Dropped below target last 3 years	Metro area and GrMN both yellow		6
Snow and Ice Removal – Hours to Bare Lane - Annual Average	●	● 03–04	On target overall last 6 years. All Road Classes on target.	All districts on target		6
Incident Clearance Time Metro Freeways	△	△ 2003	Deteriorating last 3 years	N/A		9
Striping – Maintenance Indicator	Old Measure ●	△ 2003	N/A – New Measure	6 districts yellow		3
Signing – % of signs replaced to meet 12-year cycle	Old Measure ●	● 2003	N/A – New Measure	3 on target		3
Fatalities – Trunk Highways (new target)	No target	No target 2003	Long-term deterioration	58% of TH Fatalities are in Metro, D3 and D8 (2002)		9
Crash Rate – TH Crashes per Million VMT (new target)	No target	No target 2002	Long-term improvement (No 2003 data)	Highest crash rates in Metro & D6 (2002)		6
High Crash Cost Locations – Improvements Scheduled	●	● 2003	On target last 2 years	N/A		2
Fleet – Units Within Life Cycle	● 4-2003	△ 4-2004	Improved	5 meet 2003 target 0 meet 2005 target		3
Fleet – Equipment Achieving Minimum Utilization	● 4-2003	● 4-2004	Declined	0 meet 2003 or 2005 targets		3
Fleet – Preventive vs. Reactive	● 4-2003	△ 4-2004	Flat	2 meet 2003 target 0 meet 2004 target		3
Summary of Measures						
Green ●	10	5				
Yellow △	13	20				
Red ●	7	6				

• 9 measures dropped to yellow or red (4 in pavement)
• 5 measures improved to yellow or green

FIGURE 4 Minnesota Department of Transportation dashboard: performance versus targets, June 2004.

HOW ARE PERFORMANCE MEASURES USED?

State DOTs use performance measures for a number of purposes, and systems are being designed to support particular uses. The uses include reporting performance to governor's offices, legislatures, oversight bodies, and funding agencies; communicating with the public at large; and planning, budgeting, and performance management.

Communicating with the Public and Other External Stakeholders

The Virginia Department of Transportation publishes a quarterly report card for public consumption on its website and makes hard copies available to groups of external stakeholders. Consistent with the department's top priority, the report card focuses solely on project delivery: the number of construction contracts actually completed versus scheduled for completion, the number of maintenance contracts completed versus scheduled, the percentage of construction projects completed within budget, and the percentage of maintenance contracts completed within budget. The report card also compares projects completed in the current period in terms of aggregated cost overruns and time extensions against previous years. An innovation is the department's project dashboard, also published on the web. The project dashboard indicates the status of all projects and allows the user to select projects by district, local government jurisdiction, road system, route, or contract ID.

The Washington State Department of Transportation produces a quarterly report, *Measures, Markers and Mileposts*, for the Washington State Transportation Commission and makes it available to the public on its website at www.wsdot.wa.gov. Often referred to as the *Gray Notebook*, this report uses "performance journalism" to provide brief narrative explanations and illustrations along with a mix of tables, charts, and graphs conveying a wide range of performance data. The *Gray Notebook* contains a major section on project delivery. In addition, it serves to monitor performance in such areas as worker safety; employment levels and training; highway safety; asset management; highway maintenance; environmental programs; incident response; and the use of vanpools, park-and-ride lots, Washington State ferries, and state-supported Amtrak service. This report simultaneously provides accountability and makes a departmental case statement to a variety of external stakeholders.

Transportation Planning and Programming

Performance measures increasingly are being used to establish the criteria for transportation systems plans as well as for subsequent decisions about preserving exist-

ing assets and programming projects to advance those plans. The Ohio Department of Transportation recently completed work on its statewide multimodal transportation plan, Access Ohio. This project-specific plan is keyed to a number of performance-based objectives for the next 10 years, including the following:

- Reduce the frequency of crashes from current levels by 10 percent.
- Reduce the crash fatality rate from the current 1.31 fatalities per 100 million VMT so that it does not exceed 1 fatality per 100 million VMT.
- Maintain an average level of service of D on the urban state freeway system and an average level of service of B on the rural freeway system.
- Reduce the growth in vehicle hours of delay on the state's multilane divided system to 8 percent per year from the current 12 percent per year.
- Sustain Ohio's pavements so that at least 93 percent of all state-maintained lane miles meet pavement condition rating standards.

Planners at the department ran separate sufficiency ratings for safety, condition, and congestion over the entire network to identify locations that fell below standards that had been established in each area for each functional class of highway. The projects contained in the plan were selected to remedy these deficiencies and meet other objectives established by Access Ohio. The department will monitor progress in moving toward these performance targets and will alter programming or adjust funding between programs and districts as necessary to achieve these objectives.

The Minnesota Department of Transportation updated its statewide transportation systems plan in August 2003 in an effort that completed its conversion to a performance-based planning process. This statewide plan is guided by the department's three strategic objectives and 10 strategic policies, which then led to identifying outcomes, performance measures, and 20-year targets. One or more performance measurement sets have been identified for each of the 10 strategic policies, with specific performance measures defined within each category, separately for each modal group as appropriate. While Minnesota's statewide transportation plan specifies transportation outcomes, measures, and targets, it does not quantify needs on a statewide basis. However, the eight districts are now developing district plans that will represent the first attempt to quantify needs in order to fulfill the performance-based 20-year plan.

Strategic Planning and Management

Many state DOTs have well-established strategic planning processes at this point, and performance measure-

ment systems are a critical element as these agencies focus more attention on implementing their strategic agendas and accomplishing strategic goals and objectives (Poister 2004). The Virginia Department of Transportation's strategic planning process illustrates the central role of performance measures in this regard. Strategic goals are defined to address critical issues, and then performance measures are identified for tracking the intended results. Strategies are developed for achieving the goals, and the measures are monitored to evaluate success in implementing them.

In past years, the New Mexico Department of Transportation's Compass has been the prototypical example of a performance measurement system used proactively as a management tool. Initiated under a previous administration to help the organization stay focused on its "true north" values, the Compass incorporated 16 customer-focused key results monitored through a total of 80 performance measures. Because it grew out of a quality improvement tradition, departmental executives looked for continuous improvement on these measures rather than setting annual targets for them. Through detailed quarterly reviews involving 50 to 70 managers, the Compass became the driving force behind all departmental management and decision making. For several years the Compass served as a de facto strategic agenda for the department, even though it had never conducted a formal strategic planning effort.

Recently, however, the new administration at the department has developed a strategic plan on the basis of an assessment that, although it was useful as a performance management tool, the Compass lacked a big-picture strategic orientation, included too many measures, and was limited by its total reliance on available data. Thus, the New Mexico Department of Transportation's strategic plan for 2004–2005 includes strategic objectives and approximately 40 high-level performance measures with ambitious targets, some of which will have to be operationalized with new data collection procedures. Plans are for the top management team to review these strategic performance measures on a monthly basis. While some of the Compass measures have been incorporated in the new strategic plan, the Compass itself is being aligned with the strategic agenda and redirected to the operating level, where it will continue to be used as a principal performance management tool.

The Pennsylvania Department of Transportation has been involved with strategic planning for more than 20 years, with performance measures as a central part of the process (Mallory 2002). Under the previous administration, the process was redesigned into a comprehensive strategic management process that was fiscally realistic and more oriented toward implementation. Performance measures and targets were established for each strategic objective, and a department-level score-

card was developed for tracking progress on these initiatives on a monthly basis. Districts and central office divisions developed their own strategic goals and scorecards to support the enterprise-level plan, and these guided the development of annually updated business plans, which also emphasized performance measures and targets for all programmed activities.

The current administration has retained the strategic management focus but is moving to streamline the process. The department's current strategic plan contains five strategic focus areas and eight strategic goals, with performance measures and targets identified for each, and it drives the business-planning process in the districts and central office divisions. Scorecards are used at both levels, and the Pennsylvania Department of Transportation is currently deciding how frequently these performance data will be reported and reviewed.

Performance Management

In many DOTs performance measures play a central role in managing the work of managers and employees and focusing their attention on strategic objectives and other organizational goals. Most DOTs assign individuals as owners, sponsors, champions, or results drivers of specific strategic objectives or other initiatives and hold them responsible for achieving the expected results. In some states, such as Pennsylvania, South Carolina, and California, these expectations are incorporated in individual-level performance contracts and performance plans, while other states, such as Illinois and Kentucky, use less formal approaches. In either case, however, periodic reviews of the performance measures associated with these initiatives provide powerful incentives for individuals to keep their assigned initiatives on track.

The Ohio Department of Transportation's business plan identifies objectives to be achieved by executives and members of the department's Career Professional Service—the top 200 to 300 managers in the department and professional employees not in the collective bargaining unit—over a 2-year period. For senior managers in the department's central office support functions (e.g., planning, finance, and information technology), the individual-level objectives and their accompanying action plans are developed to ensure that they provide effective support to the districts, where services are delivered. Many of these performance expectations for both district and central office managers are tied to measures included in the OPI, discussed earlier, supplemented by other individualized objectives.

All members of the Career Professional Service are evaluated in annual performance reviews, which are based in part on predetermined performance measures, including in some cases OPI measures, as well as 360-

degree appraisals. The results, in the case of strong performance, influence decisions with regard to promotions and pay raises (although pay rates are frozen at present). Poor performance triggers plans for corrective actions and in some cases has led to demotions into positions with fewer responsibilities and lower salaries.

Performance Budgeting

As transportation agencies are more committed to results-based allocation of funds to programs and organizational units, performance data are used to project differential levels of outputs and outcomes associated with alternative funding levels. The performance measures provide the linkage between plans and budgets, sometimes between strategic plans and budgets, or between strategic plans and business plans and then between business plans and budgets.

The Minnesota Department of Transportation's budget is organized along product and service lines on the basis of an activity-based budgeting structure. The department has established four product and service lines including multimodal systems, state roads, local roads, and general support and services. Within each product and service line, the department's budget is formatted to a hierarchy consisting of budget activities, products and services, core activities, and specific work activities. Parenthetically, with respect to the lowest level in this budget structure, the department has established sets of approved activity codes, and each individual employee's time sheet records the time spent on each activity, which allows actual costs to be assigned to programmatic activities.

The department's biennial budget allocates resources to these products and services, and each product and service is tracked in the budget with performance measures that are linked to the department's strategic plan, the 20-year statewide transportation plan, supporting district and metropolitan area plans, modal plans, and the business plans prepared by the districts and functional divisions. The business plans are developed to advance the department's strategic agenda and 20-year transportation plan. Because funds are being allocated to products and services, core activities, and specific activities, the Minnesota Department of Transportation is building the capability to track the dollar investment in each of its strategic policies and evaluate the results by cumulating the corresponding sets of performance measures.

The New Mexico Department of Transportation began transitioning to a performance budgeting process in 2001, as required by New Mexico's Government Accountability Act. This entails budgeting funds to programs rather than organizational divisions and relating budgets to outputs and outcomes with performance

measures. Thus, the department has developed a program structure that overlays the organizational structure. The major program areas consist of construction, maintenance, program support, aviation, traffic safety, and public transportation, and each of these is divided into various programs.

For example, the overall maintenance program comprises three separate but related programs: preservation, scheduled maintenance, and routine maintenance. Responsibility for these programs crosses organizational lines. For instance, the Engineering Design Division, the Transportation Planning Division, the Highway Operations Division, and the Road Betterments Division all share responsibility for the construction program, and the overall budget for the construction program therefore is allocated among these units, as shown in Figure 5. The performance measures related to this budget include project profilograph numbers for construction projects, the percentage of final cost increase over bid amounts, the number of calendar days between the date of physical completion of a project and the date of final payment notification, and the number of combined systemwide miles in deficient condition.

Comparative Performance Measures

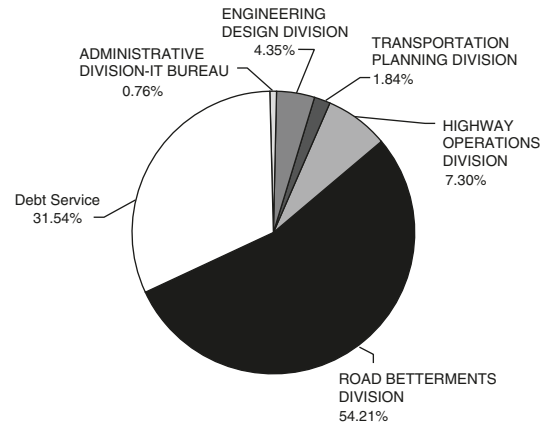
There are many examples of comparative performance measurement across transportation agencies in the United States, including the U.S. Department of Transportation's *Conditions and Needs Report*, the National Bridge Inventory, and the National Transit Database, in addition to the urban mobility and urban congestion reports discussed earlier. In addition, many state DOTs in the United States benchmark performance data against DOTs in neighboring states or those with similar-size systems or programs to see where they stand in the field and where they might get ideas for improving their own programs and operations.

One university-based research report annually compares the 50 states on a wide range of performance measures relating to their highway programs in terms of condition, congestion, safety, and expenditures (Hartgen 2004). The ongoing controversy concerning the rankings produced by this report illustrates the complex issues involved in trying to secure uniform measures from different agencies as well as in specifying and standardizing measures that afford fair and useful comparisons.

A project being conducted for the Transportation Research Board, NCHRP Project 20-24(37), is exploring possibilities for systematic comparative performance measurement within peer groupings of state DOTs, with voluntary participation, which might be configured differently for different focus areas. The use of "adjusted" performance measures, the percentage of miles of good

FY05 CONSTRUCTION PROGRAM

	FY04 OPBUD	FY05 OPBUD	FY04 VS. FY05
ENGINEERING DESIGN DIVISION			
200 Salaries and Benefits	15,108.1	17,078.5	1,970.4
300 Contractual Services	950.0	948.0	(2.0)
400 Other Costs	2,187.4	2,604.5	417.1
Total	18,245.5	20,631.0	2,385.5
TRANSPORTATION PLANNING DIVISION			
200 Salaries and Benefits	4,067.8	4,673.6	605.8
300 Contractual Services	2,553.1	2,553.1	0.0
400 Other Costs	1,462.6	1,508.5	45.9
Total	8,083.5	8,735.2	651.7
HIGHWAY OPERATIONS DIVISION			
200 Salaries and Benefits	24,993.3	28,038.3	3,045.0
300 Contractual Services	280.2	280.2	0.0
400 Other Costs	5,267.1	6,288.4	1,021.3
Total	30,540.6	34,606.9	4,066.3
ROAD BETTERMENTS DIVISION			
300 Contractual Services	226,088.8	239,336.7	13,247.9
400 Other Costs	17,418.4	17,717.0	298.6
Sub total	243,507.2	257,053.7	13,546.5
700 Debt Service	109,205.1	149,569.8	40,364.7
Total	352,712.3	406,623.5	53,911.2
ADMINISTRATIVE DIVISION-IT BUREAU			
200 Salaries and Benefits	1,811.3	2,021.2	209.9
300 Contractual Services	234.3	184.3	(50.0)
400 Other Costs	1,337.5	1,410.9	73.4
Total	3,383.1	3,616.4	233.3
TOTAL CONSTRUCTION PROGRAM	412,965.0	474,213.0	61,248.0



Construction Program Issues:

- Salaries and Benefits contains a 1.8% vacancy factor. The category also contains a 2% salary increase, which is effective the first full pay period after July 1, 2004.
- The FY05 OPBUD is reconciled to January 2004 Revenue Projections.
- Overall Local Government OPBUD reflects a projected growth of 2.7% over FY04.
- Administrative Division now administers IT budget through CIO.

Purpose: To provide improvements and additions to the State's highway infrastructure to serve the interests of the general public. These improvements include those activities directly related to highway planning, design and construction that are necessary for a complete system of highways in the state.				
PERFORMANCE MEASURES		TYPE	FY 04	FY 05
a	Number of combined system wide miles in deficient condition	Outcome	3,800.0	2,500.0
b	Time in calendar days between the date of physical completion of a project and the date of final payment notification	Efficiency	200.0	182.0
c	Project profilograph for construction projects (road quality and smoothness)	Quality	≤4.2	≤4.7
d	Percent of final cost increase over bid amount	Quality	4.1%	4.0%

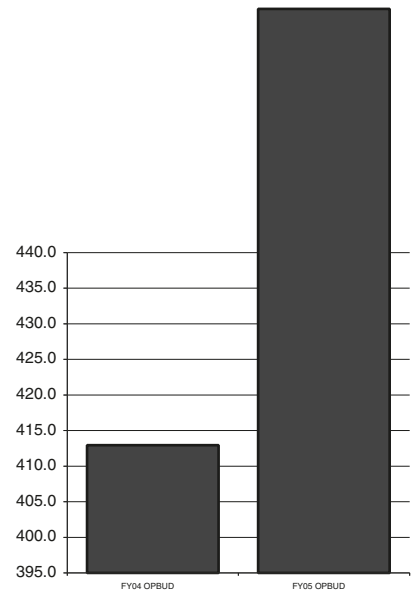


FIGURE 5 New Mexico Department of Transportation budget example.

pavement statistically adjusted for average number of freeze-thaw cycles or maintenance expenditures per lane mile, for example, might also help make comparative performance data more palatable and more meaningful to transportation agencies.

Integration of Measurement Processes

As transportation agencies utilize a number of measurement systems of varying scope and purpose, it is important to articulate the relationships among them and ensure that collectively they meet the organization's need for performance information. The current performance measurement framework at the Minnesota Department of Transportation is referred to as the performance measures pyramid. As illustrated in Figure 6,

it starts at the top with transportation system-level measures that are based on the department's statewide system plan and strategic policies. Below that are measures associated with district plans and modal plans, and then the pyramid flows down to business plan measures and then to operating measures linked to work plans for individual organizational units.

The policy-based, system-level measures at the top of the pyramid reflect outcome targets over a 20-year period, identified in the state's long-range transportation plan, which in turn is consistent with the department's strategic directions and 10 strategic policies. The business plan measures, on the other hand, are tied to both output and outcome targets over a 2-year period, while the operations-oriented or project-related measures at the bottom of the pyramid are tied to output targets to be achieved within 1 year.

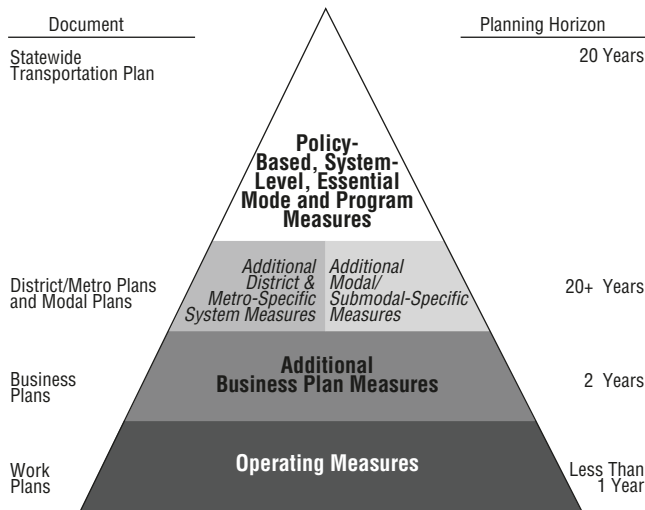


FIGURE 6 Minnesota Department of Transportation performance measures pyramid.

At the systems level, the Minnesota Department of Transportation has been developing measure sets—groups of performance measures that collectively track performance that is related to a particular policy or measurement category, for each of the 10 policies in its strategic plan. Wherever appropriate, these measure sets include subsets or specific measures linked to a given policy for each of four modal groups, including highways and bridges, passenger service/bicycle/pedestrian, motor carrier/railroad/waterways, and aeronautics. The top management team at the department uses its monthly dashboard to monitor the status of some 30 selected performance measures that are tied to the strategic plan. Where performance is slipping, managers can drill down into district reports, business plan measures, or operating measures to locate the source of problems and request explanations and remedial actions.

The Florida Department of Transportation ties its organizational and program planning to transportation systems planning through a strategic planning process that includes four components: the Florida Transportation Plan, the Short-Range Component, annual strategic objectives, and executive board initiatives. The Florida Transportation Plan, updated every 5 years and about to be updated to a 2025 plan, is a 20-year project-specific transportation plan for the state developed in conjunction with a wide range of transportation agencies and stakeholders. The Short-Range Component is basically a 5-year work program that the department will undertake to advance the Florida Transportation Plan. It is updated annually, and the Florida Department of Transportation guarantees complete delivery of the first year of the Short-

Range Component to the governor and the legislature. While performance measures tied to the Florida Transportation Plan are reviewed annually, the department monitors delivery of the Short-Range Component on a monthly basis.

The department has identified nine strategic objectives, also updated annually, that are largely focused on strengthening its workforce, business processes, leadership, and customer orientation to ensure the organizational capacity needed to deliver the Short-Range Component effectively. In addition, a number of executive board initiatives concern various other issues or processes that are also important elements of overall organizational effectiveness. The department monitors dashboards for the strategic objectives and executive board initiatives on a quarterly basis.

The Florida Department of Transportation is developing a business planning process in three tiers to provide a focal point for implementing the various elements embodied in the various components of its strategic plan. Tier 1 is the department's statewide business plan, which is monitored on a quarterly basis and updated annually. Tier 2 will consist of business plans developed for 24 core processes and major functional areas that sometimes cross organizational lines, while Tier 3 will consist of business plans developed by each of the department's districts and functional units. Performance measures tied to the initiatives, work programs, and other activities included in these business plans will allow departmental managers to monitor progress in implementing the overall strategies for achieving the goals identified in the long-range transportation plan, the Short-Range Component, strategic objectives, and executive board initiatives.

CONCLUSIONS

This review of performance measurement in transportation indicates that the state of the practice continues to advance. Obviously, there is wide variation among agencies with respect to the evolution of performance measures, the kinds of measurement systems they have, and how and the extent to which they use performance data in planning, management, and decision making. A few agencies have mature systems at this point, characterized by (a) a range of sophisticated measurement systems in place; (b) alignment of measures with performance-oriented goals, objectives, standards, and targets; (c) useful performance-reporting processes tailored for various audiences and management needs; and (d) systematic procedures for reviewing performance data and using the information to strengthen planning and decision making.

Summary of Recent Trends

Some of the more notable developments over the past few years include the following:

- More states committed to using performance measures. Some are just starting out, but leading-edge agencies are implementing second- and third-generation systems that are more sophisticated.
- Continuing trend emphasizing more strategic performance measures, more outcomes, and more customer-oriented measures.
- Emphasis on measures to track performance in program and project delivery, but also advances in implementing better measures of transportation system performance.
- Increased use of customer satisfaction measures.
- More holistic approaches in terms of coverage that relate different performance measurement systems and track data at different levels (roll up, drill down).
- More disciplined efforts to align measures with goals and objectives and to use them as tools for integrating systems.
- More sophisticated software applications, system support, and data displays.
- Proliferation of performance measures, but also recognition of the need to focus more selectively on the “vital few” strategic objectives.
- More disciplined efforts.
- More intentional use of measurement systems to support other management, planning, and decision-making processes.
- Increased reporting of performance data directly to the public, especially in online report cards, to promote transparency in government.

Continuing Challenges

Transportation agencies are investing increased resources in performance measurement and finding innovative ways of measuring the performance of transportation systems and programs. The real objective here has to be the development and implementation of measurement systems that are cost-effective tools whose contribution to improved planning and decision making is worth the effort. Some of the issues that still need to be addressed include the following:

- Agreeing on a common terminology (e.g., dashboards, benchmarking).
- Improving measures concerning travel times, congestion, and delay, especially on noninstrumented roads.

- Developing measures that allow cross-modal comparisons with regard to service levels, quality, travel times, and costs.
- Developing improved measures for freight transportation.
- Obtaining systematic feedback from other external stakeholders beyond motorists and the public at large (e.g., other user groups, local governments, legislators, the media).
- Interpreting the implications of customer satisfaction measures in relationship to engineering and professional planning performance criteria.
- Setting appropriate targets that are aggressive yet realistic (e.g., Federal Highway Administration ride quality standards).
- Using objectives and performance measures relating to system performance to articulate the relationship between strategic plans and transportation system plans more clearly.
- Implementing workable comparative performance measurement systems that provide information that is useful for benchmarking and process improvement.
- Strengthening linkages between measures and employee performance management systems to ensure that individual managers and employees are motivated and held accountable for accomplishing agency goals and objectives and hitting targets.
- Institutionalizing strategic planning and performance measurement more effectively in agencies so that they can provide useful support rather than be derailed by changes in elected officials, politics, funding, or top administration priorities.

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Organizing for Performance Management

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The public-sector transportation community now has 15 to 20 years of experience in learning to plan and manage with performance measures. The paths of development vary widely from one organization to the next, yet they converge toward some common elements of effective practice.

Great progress on this journey has been logged. Today, transportation investments are being selected on the basis of performance deficiencies and forecast benefits. Project status is reported regularly to managers, legislators, and the public. Politicians debate the performance level of snow and ice removal. And a state transportation commission has posted experience in performance management as a critical qualification for a new secretary of transportation.

This paper focuses on how that progress has been achieved—the factors that have contributed to success. Through interviews with veterans of practice and evidence from the Minnesota Department of Transportation's experience, the paper examines key drivers of development and elements of successful practice. The paper shares what experienced organizations see as the next steps in development. It looks at what tools can be added to the repertoire to make performance management more effective. Finally, the paper explores emerging challenges and issues.

Interviews were conducted with eight states and two metropolitan planning organizations (MPOs). Additional information was collected from the American Association of State Highway and Transportation Officials' Standing Committee on Planning meeting and peer exchange in Charleston, South Carolina, in May 2004; the October 2003 U.S. Department of Transportation roundtable in

Washington, D.C.; the 2004 Transportation Research Board international scan; and other sources.

This paper aims to crystallize the experience of a number of organizations and provoke thought and discussion. Other organizations may be blazing different paths to effective performance management. Transit organizations and regional organizations, for example, have experiences that are different from those of states.

DRIVERS OF DEVELOPMENT

Performance-based management was well established in the private sector before being brought to the public sector. Its growth reflects the need for public organizations in a democratic nation to be customer driven and open and transparent to citizens. It reflects the requirement that public organizations adopt modern, data-driven, scientific tools of management or risk becoming non-competitive and marginalized. Our transportation counterparts—freight haulers, railroads, airlines, and transit operators—are driven by industrywide measures of on-time performance, capacity utilization, and operations efficiency that are monitored regularly by stakeholders. Some of their measures are set by regulation or statute. We may be moving in that direction.

External Drivers

It is instructive to look at the origins and triggers of performance measurement in public transportation organi-

zations across the country. Among states interviewed, the most common drivers have been external—legislatures, governors, and transportation commissions.

- Oregon, Maryland, and New Mexico: The legislature required regular performance reporting by state agencies. In Maryland, the governor mandated all agencies to tie measures to budget submissions.

- South Carolina: The legislature mandated reporting. The state department of transportation (DOT) does annual and quarterly reports.

- Arizona: The legislature mandated performance-based planning and programming and prescribed categories of measures.

- Montana: The legislature requested information on what could be accomplished with additional funding and what had been accomplished with the last increase. This sensitized DOT leaders to the need to communicate performance and built support for developing the Performance Programming Process (P³).

- Washington State: The Washington State Department of Transportation has used measures for years, but performance management was held back because the agency had trouble agreeing on “good enough” measures. In early 2001 the Washington State Transportation Commission put out a call for a new secretary with a background in performance management. Douglas B. MacDonald was hired from the outside and quickly broke the deadlock. He directed the organization to move ahead with applying measures in public communications and decisions. He stressed that performance measurement is an iterative process; measures would be refined, adjusted, or replaced as the agency gained skills and data. In 2002 the legislature directed the establishment of benchmarks in nine priority areas. They were added to the department’s already extensive Gray Notebook quarterly performance reporting process.

- California: Despite some 10 years of experience with a comprehensive policy and performance framework, California also has been hampered by an inability to arrive at consensus on specific measures. In 2004 under Governor Arnold Schwarzenegger, the new Cabinet Secretary of Business, Transportation, and Housing asked for development of common measures for the state’s transportation system by the California Department of Transportation (Caltrans), regional organizations, and stakeholders by summer 2004. Reporting is to begin in the fall. The secretary has exerted ongoing leadership to support this goal.

Legislatures, governors, and transportation commissions have issued a wake-up call. In response to crises in public credibility or for other reasons, some legislatures have stepped into what they saw as a vacuum of accountability. They not only have prescribed performance

accountability but also have participated in selecting goals, measures, targets, and even projects. This may be understandable, since the industry has not agreed on standard measures of performance to the extent of many other industries. Design standards and other traditional guidelines are no longer enough to satisfy stakeholders. If we do not set performance outcome standards, others eventually will—sometimes to a significant level of detail.

Nevertheless, whether we are accustomed to it or not, there is no question that the role of governing bodies is to set broad policy priorities and monitor results.

Internal Drivers

A somewhat different internal path to development came in several Midwest industrial states and elsewhere. Large-scale total quality management or Malcolm Baldrige programs initiated in the 1990s were vital building blocks of performance management in Pennsylvania, Ohio, and New Mexico. Quality programs helped build cultures of accountability. Paralleling the manufacturing sector, industrial engineers have helped develop performance management tools in several states. Some of these initiatives were initiated by governors but then took strong root in transportation departments. The following are examples:

- Pennsylvania: From 1994 to 2002 Secretary Malory embraced the Malcolm Baldrige business model and “management by fact” (i.e., implementation of performance measures).

- Ohio: The Ohio Department of Transportation began a corporate change process at a leadership conference in 1991 that led to development of a culture and system of accountability. By 1994 this new direction was embodied in the department’s Vision 2000 Strategic Plan. Dramatic changes followed, including the redefinition of core business functions, decentralization of responsibility to 12 districts, and the beginning of a quality culture of continuous improvement. An initiative to incorporate performance measurement led to creation of process measures and the Organizational Performance Index (OPI).

The department’s quality movement was part of a statewide quality improvement program enacted by the governor, called Quality Services Through Partnership. It brought union leadership and management together in a quality management program that resulted in mass training of state employees.

- New Mexico: The New Mexico Department of Transportation has had a Quality Bureau since the 1990s. It created widespread awareness of measures and accountability in the agency and was instrumental in the

growth of performance management practice. Recently the new secretary of transportation transformed it into a small Quality and Business Performance Division that reports directly to her and will have representatives in all six districts.

- **Montana and Minnesota:** In these two states, the use of measures took hold internally as a result of the state transportation planning process in the mid-1990s. Montana developed the P³ investment analysis approach from the pavement, congestion, and bridge management systems and began using it to optimize funding distributions to maximize system performance. In the Minnesota Department of Transportation, additional roots of measurement practice in the 1990s were in a maintenance business planning team, which was influenced by quality management principles.

- **California:** The new cabinet secretary has started a process to choose internal organizational performance measures, in addition to system measures, to be completed by late summer 2004.

FUNDING FOR ACCOUNTABILITY: THE NEW QUID PRO QUO?

In Ohio the statewide quality program laid the groundwork, but the legislature became the catalyst for further development. There, as in several other states, the legislature agreed to provide more resources in return for greater accountability. In some parts of the nation, carte blanche increases in gasoline taxes or other funding are no longer on the menu. Instead, resources are offered only when the transportation commission, legislature, or governor has a strong role in buying into or setting performance priorities, or even selecting projects. Here are several cases:

- **Florida:** The legislature is seen as the key driver behind what is today one of the most highly developed performance management systems among state DOTs. Since a gasoline tax increase in the early 1980s, the legislature, the governor, and the Florida Department of Transportation have coupled new funding initiatives to accountability measures. A major stimulus was a “crash and burn” failure in which \$800 million in contracts had to be canceled. After that, extensive project delivery measures were created. Targets for preservation of pavement and bridges were written into statute. The Florida Transportation Commission was set up in the late 1980s to oversee accountability. Today the department believes it has great credibility with the legislature and stakeholders.

- **South Carolina:** The state DOT provides regular reports to the legislature on the on-time, on-budget status of the largest construction project in state history, the Cooper River project.

- **Ohio:** In 2003 the Ohio Department of Transportation obtained a 6-cent gasoline tax increase amounting to \$5 billion over 10 years while other agencies were being cut. This Jobs and Progress Plan funds system improvement and expansion projects. Now the department is focusing on delivering on its promises. It has established a detailed tracking system. Monthly meetings are held to monitor projects.

- **Mississippi:** The legislature was concerned that projects were not selected on the basis of “professional criteria” and was concerned about cost escalation. It passed a capacity improvement program—Vision 21—to be based on “technical criteria” and “needs-based priorities.” Now the department has a regular business plan and reporting process.

- **Arizona:** Planning, programming, and project measures are reported every 6 months and are tied to a ½-cent sales tax expansion program. It expires in 2007, and renewal for another 20 years is seen as dependent on achieving a target of 90 percent on-time program delivery. Performance as of May 2004 was 95 percent.

- **Washington State:** In 2003 the legislature enacted a new 5-cent gasoline tax in response to enhanced trust built through regular performance reporting and in exchange for accountability for project delivery. Projects were rated and ranked with performance-based criteria, then selected by the legislature. Now progress on more than 100 projects funded by the tax is tracked regularly via the “beige pages” within the quarterly Gray Notebook performance report and on an enhanced public website. Revenues will be from \$600 million to \$1.1 billion for each of the next five biennia.

From the standpoint of performance-based management, the quid pro quo can take either a positive or a negative turn. If the criteria for project selection are not significantly performance based but purely political, we will move backwards. If the governing entities are brought into the fold of understanding, trusting, and supporting performance-based criteria, they may become forces for a bigger and better-performing pie. If, as in Florida and Washington, greater transparency brings greater public support for transportation, a win-win partnership can result.

CURRENT AGENDAS FOR DEVELOPMENT

Let's turn now to examining the current stage of development in performance management practice (see Box 1), as reported by organizations recently interviewed. They were asked what their focus of development is at this time. The answers vary widely, but there are some common emphases:

BOX 1

General Stages of Development in State DOTs**Stage 1. Measures creation and monitoring—past oriented.**

Passive, learning, undifferentiated. Either systems or process measures developed, or both, but not connected. Typified by annual legislative reports. Focus may be internal, process/quality improvement, or external/system. Customer awareness develops. The pursuit of “perfect” measures may paralyze progress. Inadequate measures or poor data often cited as reasons for not reporting.

Stage 2. Beginning to manage and plan with measures—real-time and future oriented.

Active, aligned to organizational priorities. Still deterministic. Set targets, but experience difficulty prioritizing among them. Start to move to quarterly, monthly, and real-time reporting. Begin to analyze performance trends and factors. Begin to integrate with strategic and long-range plans. Begin to apply measures in programming and project selection.

Stage 3. Modeling performance and resource decisions.

Future orientation aggressively developed. Multifactorial. Integration of cost and benefit information. Scenario oriented. Optimization driven rather than deterministic targets—the best blend of cost and results. Aim to minimize life-cycle costs. More systematically align capital programs with best scenarios.

Stage 3 may include more progress on complex measures that are beyond direct transportation organization control: safety, quality of life, access, economic development, and environmental and land use measures that require multiagency analysis and planning and more modeling.

- Project delivery measures reporting;
- Reducing the number of top-level measures and aligning measures with strategic and long-range transportation plans;
- Improving performance-based decision support tools;
- Developing modal and intermodal measures, typically as part of expanding long-range plans to be multimodal; and
- Moving beyond well-established measures for preservation and maintenance to develop better measures for quality-of-life related goals, mobility, and safety.

Project Delivery Measures and Real-Time Tracking and Reporting Systems

Confidence in project delivery is often essential to restore or maintain accountability with legislatures, especially when new funding is sought. At the October 2003 U.S. Department of Transportation roundtable in Washington, D.C., it was agreed that credibility in obtaining greater long-term system investments is closely tied to credibility in delivering short-term outputs. The delivery of priority construction projects on time and on budget is paramount. Highly visible maintenance services, such as snow and ice removal, are also important.

The Ohio Department of Transportation has a strong performance management system and now has development of a project delivery reporting system as its top priority. After gaining a 6-cent hike in gasoline tax revenue in 2003, the department’s challenge became to deliver on time and on budget. It has developed a tracking program to monitor progress milestones specifically for Jobs and Progress projects.

Examples of organizations with project delivery tracking systems in place are the San Francisco Bay Area Metropolitan Transportation Commission (MTC) and the DOTs of Virginia, California, Washington State, Florida, Minnesota, and Arizona.

Typically, project delivery reporting systems encompass the department’s highest-priority projects, especially those funded under special legislative or gubernatorial packages. Failure to make delivery of those projects transparent, on time, and on budget exposes organizations to great risk. Conversely, project reporting for high-priority initiatives is a compelling way to build a performance management culture. The Minnesota Department of Transportation’s greatest advance in acceptance of real-time dashboard reporting came with monthly statewide monitoring sessions initiated in 2001 for 50 projects in the Moving Minnesota package funded by the legislature out of one-time general fund dollars. This practice continues with the new bond-accelerated projects program, which consists of more than \$800 million in projects.

Aligning Large Measurement Systems with Strategic or Long-Range Plans and Goals

Numerous states developed measures in response to legislative mandates or quality initiatives but ended up with dozens of unrelated measures without clear priorities. They laid a cultural foundation for measurement practice but did not give clear direction. In an era of tight resources, it becomes obvious that achieving system performance targets across the board is not affordable. If priorities are not set, the process of performance management can be undermined.

- New Mexico is revamping its long-standing Compass report to support five strategic priorities in the new governor’s strategic plan. This will mean fewer department measures than in the past. In some cases measures are being modified and new ones sought.
- Pennsylvania, one of the older practitioner states, is moving from more than 70 department measures to identification of a smaller select set to track at the executive level. Other measures will be delegated.
- Washington State is working to align its new transportation plan and measures with nine key issue areas. This will lead to a constrained investment proposal to the 2007 legislature.
- Minnesota completed refocusing its measures on 10 policies in a comprehensive 20-year statewide transportation plan in 2003. The Minnesota Department of Transportation is now applying the policy framework and measures down the organization, into district long-range plans, a new freight plan, and a first-time Highway System Operations Plan. Also in 2003, a regular monthly reporting schedule was initiated for commissioner’s staff for measures tied to the nine highest-priority objectives in the transportation plan and strategic plan. The department is also reevaluating its funding for-

mula for districts and MPOs and adding performance factors.

Improving Performance-Based Decision-Support Models

Montana is working to develop its P³ business process (see Figure 1) further. P³ develops a performance-based budget by system level, district, and type of work for about 70 percent of the capital program. It predicts future performance on the basis of funding alternatives within the three primary management systems the state uses—those for pavement, bridges, and congestion. The process requires iterations. Efforts are under way to simplify the process and to incorporate explicit performance consideration of economic development in the analysis and funding distribution. Work is proceeding on a software tool for selecting projects on the basis of linkage to performance status and outcomes. The Montana Department of Transportation is attempting to improve bridge condition forecasting capabilities and add performance information for selection of safety projects. It wants to do more evaluation of program results. In addition, Montana is training planners in the Highway Economic Analysis Tool for use in performance-based systems development and project development.

Minnesota has hired a consultant to help adapt PONTIS to model and forecast bridge condition. This capability is essential for doing investment scenarios. One objective is to adjust bridge condition targets to reflect lowest life-cycle costs. Also, benefit–cost factors are being developed for five priority bridge preventive maintenance strategies. Performance measures and targets for bridge preventive maintenance will be proposed in fall 2004 as part of the department’s new Highway System Operations Plan.

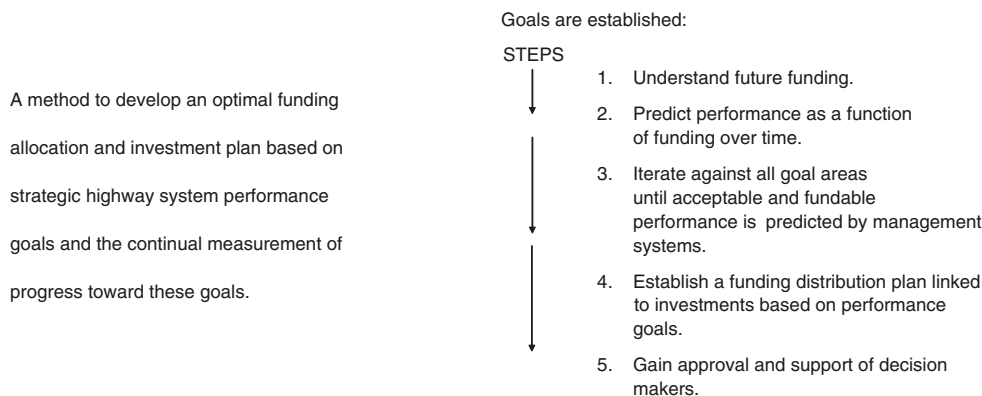


FIGURE 1 Montana’s P³ and mechanics of P³ funding plan.

California cites a more basic challenge—finding the resources and developing better data collection and monitoring systems across districts and in concert with regional organizations—to support uniform performance measurement.

Modal Measures Development

Several states with performance measurement systems are expanding to encompass modal or intermodal objectives. The Mississippi Department of Transportation is developing level-of-service measures for its ports and modal operations. Wisconsin is expanding its statewide transportation plan and New Mexico its strategic plan to include modal measures. Florida faces a major challenge in partnering with outside agencies to develop measures related to the performance of the recently designated Strategic Intermodal System. Currently various modal administrations in Florida do not use the same data or measures.

Development of freight measures is a priority for California. Minnesota and others are working on freight measures also.

System and operational measures have been in place for 3 years in Minnesota for freight and commercial vehicle operations, aeronautics (see Figure 2), and transit. They are rooted in the statewide transportation plan and business plan and are reported three times a year and in budget documents.

Quality-of-Life Measures Development: Beyond Preservation and Maintenance

Florida, like a number of other states, believes its preservation and maintenance measures are well established. It is now engaged in developing better measures for mobility and quality of life—safety, bicycle and pedestrian, and economic development measures. California has had difficulty agreeing on measures in some of these areas going back to the 1990s but now appears to be breaking through. Colorado has established preservation measures and targets and is beginning to look at development of mobility measures but is concerned about the cost of data development.

These are some of the focal efforts of organizations today. Later we will reflect on some of the challenges and issues for the future of performance management.

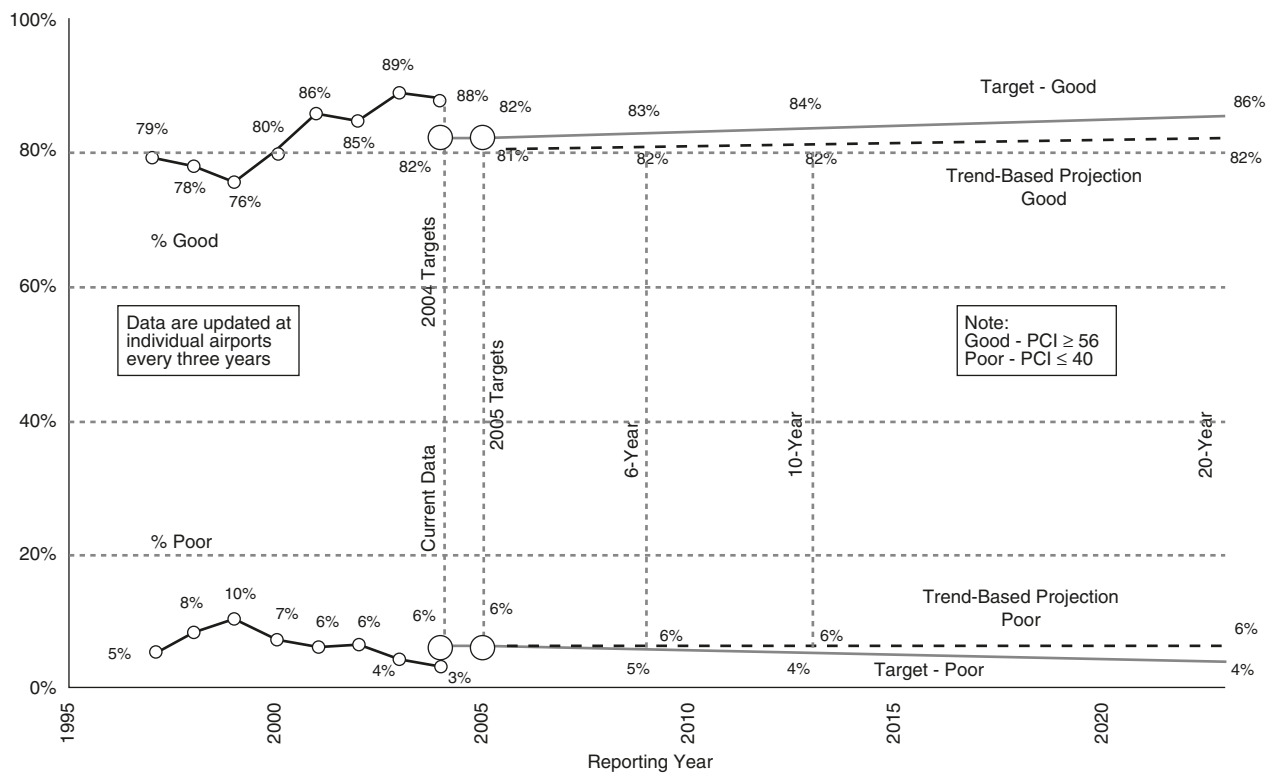


FIGURE 2 Minnesota Department of Transportation statewide plan preservation policy, aeronautics: percentage of regional trade center airport pavements meeting good and poor pavement condition index (PCI).

ELEMENTS OF SUCCESSFUL PRACTICE

The common objective among transportation organizations is to build performance management systems that provide compelling information for decision making. We have observed that paths to this goal vary widely. Nevertheless, we can identify some practices that are important to success.

The 2002 *Transportation Asset Management Guide* (1), prepared under NCHRP Project 20-24(11), provides some of the most forward-looking direction available. It provides tables of “benchmark state-of-the-art” best practices. The guide recommends that at the policy level, “The agency proactively influences policy formation with realistic estimates of agency resources that are needed to achieve specific goals. It works with its governing bodies to instill this realistic vision in resulting policy statements and objectives, as well as in measurable performance targets” (1, p. 2-6).

Another valuable source is *NCHRP Synthesis of Highway Practice 326* (2). It offers a practical list of “success factors” for strategic management, many of which relate to performance measurement (2, pp. 2–3).

SELF-IDENTIFIED SUCCESS FACTORS

Organizations interviewed for this paper were asked the key success factors in performance management. The following are some highlights:

- Leadership and regular executive performance monitoring from within top management. An attitude from leadership to “do it.” Improve measures as you go—don’t get paralyzed waiting for the perfect measure.
- Accountability links from policy to programming to performance monitoring. Individual program areas should not make policy independently (Florida, Wisconsin).
- Turn data into information and apply it in decision making—plans, programs, and budgets. If districts are making budget and program decisions, provide them with performance information feedback on the results that their proposals will achieve.
- Ownership by staff and program offices (bridge, maintenance, etc.). Instill expectations that measures adopted will be reported regularly at top management meetings (Florida, Minnesota, Ohio).
- Build legislative buy-in. The Washington State Department of Transportation provided a prioritized list of projects based on performance evaluation criteria to the legislature and gave it a role in selection.
- Build a vision of the payoff. Create a wide understanding of where the tools of measurement can take us.

Understand the funding implications of different performance goals (Montana).

- Have practical measures tied to compelling needs of the public or the organization.

In the case of Maryland, the Port of Baltimore was rapidly losing market share. Establishment of operational measures agreed on by the port, state, and union led to greatly improved operations and resulted in a revival of business. In Minnesota, monthly statewide video reviews of milestones for priority projects specially funded by the legislature accelerated understanding and acceptance of performance management.

BASICS OF SUCCESSFUL PRACTICE

Institutionalizing sound practices into mainstream processes should increase prospects of performance management’s being sustained and reduce the possibility of its being marginalized as an add-on activity. Some elements deserving further discussion are leadership, ownership, staffing, customer information, regular reporting schedules, performance targets, and integration into planning and decision making.

Leadership

The importance of sustained leadership from within top management was cited by many states as a key success factor. One organization stressed the importance of top managers demonstrating to others that they are using performance data for decisions. The literature agrees. While leadership from appointed officials can be powerful, it is important to develop support from the career managers and supervisors who will endure changes in administration.

Ownership

The list of success factors includes the importance of building ownership of an organization’s strategic objectives (2, p. 3):

- Identify “owners” of strategic objectives, initiatives, measures, and action plans who will be responsible for achieving results.
- Communicate strategic objectives to internal (and external) stakeholders at every opportunity.

Representatives of several states cited assigning ownership of goals and measures as an important success factor, as well as involving key staff in developing goals and

measures. The Pennsylvania Department of Transportation has assigned owners to its goals and measures for many years. The Ohio Department of Transportation's quality culture empowered many employees to participate, starting at the line level. The Minnesota Department of Transportation has strengthened its practice in the last year by charging the division director with the lead responsibility for results and the director with lead responsibility for reporting for each measurement area.

Representatives of several states conveyed the value of seeing performance reporting sessions as opportunities for problem solving to make the organization and its staff successful, not as sessions for judgment.

The Montana Department of Transportation undertook an arduous 3-year process involving multiple divisions to develop performance measures and its P³. It credits broad participation with spurring internal acceptance of its performance-based funding allocation process.

Staffing: Dedicated Versus Integrated

In earlier stages of development, during the 1990s when state revenues were healthier, at least a few organizations had substantial units to lead performance measurement. Intensive staff efforts are required in the development phase. Today, the maturing of performance management appears to have led to mainstreaming measurement responsibilities across organizations, with a surprisingly small central function. This sends the message to line managers and supervisors that measurement is part of their jobs.

The central function typically stimulates and guides development of measures and targets by program areas and assembles department-level reports for management and stakeholders. As long as the central function has enough staff, resources, and clout to carry out its mission, keeping its role limited appears to support wider institutionalization of performance management practice.

Central staff dedicated primarily to performance measurement amount to one in Florida and Montana, one and one-half at the Bay Area MTC, three in Washington and Minnesota, and two in New Mexico, with six liaisons in districts to be added. Caltrans has two central staff and is examining how to increase the measurement presence in districts and throughout the organization. In addition to central staff, others are often assigned to measurement in such areas as maintenance or regional traffic management. They put substantial hours into developing measures and collecting, processing, analyzing, and reporting performance data.

Often the central measurement function is in the planning division. Examples are Florida, Montana, Wis-

consin, Ohio, and Minnesota. Pennsylvania indicates that responsibility is distributed, though the lead staff person reports to the secretary's office.

Customer Information

The *Transportation Asset Management Guide* best practices recommend, "Policy formulation seeks input from customers and stakeholders, and reflects customer priorities and concerns in resulting policy statements and objectives, and performance targets" (1, p. 2-6). A further recommendation is that information on customer perceptions be "updated regularly through surveys, focus groups, complaint tracking, or other means" (1, p. 2-11).

A growing number of organizations are using customer information. The San Francisco Bay Area MTC hires third-party consultants to evaluate customer satisfaction with its 511 travel information program, which is operated by a contractor.

The Minnesota Department of Transportation uses professional market research staff and consultants to measure customer priorities in tandem with customer satisfaction levels. Satisfaction levels with maintenance services have been tracked for 10 years. The process has contributed to prioritizing resources for services rated most important, such as smooth pavement, and to reducing investment in services rated less important by the public, such as roadside mowing. Interestingly, recent declines in satisfaction with road smoothness and litter removal have correlated with reduced spending resulting from tight budgets.

Market research can be a powerful tool to assist in calibrating service level targets. Minnesota's market research staff has utilized specialized simulation studies with customers to establish target service levels for pavement smoothness, snow and ice removal, and other services.

Regular Reporting

Regular reporting of performance data, trends, and forecasts within the organization is essential to performance management for many reasons. It is one of the four legs of the Plan → Do → Check → Act performance management cycle.

The *Transportation Asset Management Guide* states that good performance-based management "implies that the right information is available to the right levels at the right time" (1, p. 2-4). Performance reporting should take place for a manageable number of objectives or measures on a regular cycle that is integrated as much as possible into existing planning and decision venues.

The Pennsylvania Department of Transportation cites the importance of a regular reporting system in keeping the performance measurement process alive and instilling a culture of evaluation and continuous improvement. Maryland is now exploring moving from annual to quarterly reporting to keep performance management on the agenda and stimulate program adjustments during the year.

Ohio encountered problems when it was unclear what was to be reported when. Now its OPI, covering some 70 transportation services, is reported monthly agencywide. The OPI has a common six-point scale and uniform reporting format. In addition, units in all divisions provide a focus report monthly to the division director on more detailed operational measures. This kind of intensity provides constant reinforcement of what is important. It facilitates real-time corrective action.

The Minnesota Department of Transportation first established a regular monthly rotating reporting cycle for its Operations Division in 2001 and has now extended it to commissioner’s staff. Top staff review measures for highest-priority strategic objectives and delegate reporting for lower-priority objectives to lower levels. Managers determined the frequency of reporting for each area on the basis of the sensitivity of the measure to change and its urgency. For example, milestones for high-priority projects are reported monthly to districts and quarterly to commissioner’s staff. Fleet management measures are reported quarterly to districts. Bridge and pavement condition measures are reported annually. Reports are done at regular management meetings to make performance discussions a normal part of business management. The impact has been gradual but strong, especially for managers now in the fourth year of this process. At the same time, use of measurement information is growing in budget meetings and other dedicated venues.

Setting Targets

The *Transportation Asset Management Guide* and several states have identified setting quantitative goals, or targets, as a key success factor. In Minnesota, the take-off of performance management was in the 2000–2002 period, when business plan and transportation plan targets were first established. Setting targets sent the message that measurement is about managing to get results, not just monitoring. In states such as Washington and Pennsylvania, targets for maintenance service levels and other areas are essential to the budget process.

In Minnesota most state transportation plan measures have 20-year targets. They are being applied in district long-range plan development. The performance-

based targets define performance gaps and fiscal gaps and form the basis for calculating long-term resource needs to close the gaps. Figures 3 and 4 show examples of 20-year targets.

Poister states that “numerical targets to be accomplished within specified time frames tied to strategic objectives and performance measures” are vital to guiding strategic initiatives (2, p. 3).

The Minnesota Department of Transportation has defined performance targets as “the level of service (quantity, quality or cost) to be delivered to customers (external or internal) for a specific period.”

Several elements are important in providing direction in setting performance targets:

- Baseline data trends;
- Projected or forecast performance trend based on programmed projects or other factors;
- Budget information and forecast;
- Analysis, such as benefit–cost, life-cycle optimization, and so forth;
- Customer expectations information—importance, satisfaction, and desired service level;
- Industry benchmarks and engineering standards; and
- Strategic vision and priorities of the commissioner, governor, and legislature.

The draft *International Scan on Performance Measures* cites the importance of analysis, such as benefit–cost, in underpinning the setting of targets and in determining the effectiveness of actions to reach the targets (3).

The ideal condition for setting targets is to have historical and forecast performance in hand along with customer information and budget data on unit costs. Sometimes, however, organizations need to set strategic targets with limited data to drive organizational behavior

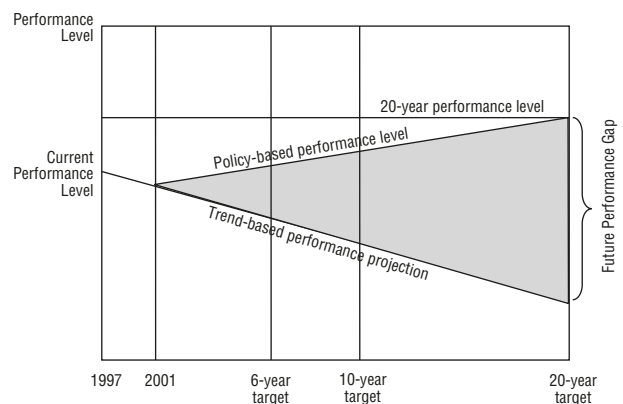


FIGURE 3 Setting 20-year targets for Minnesota’s Transportation Plan—Case 3: performance is worsening.

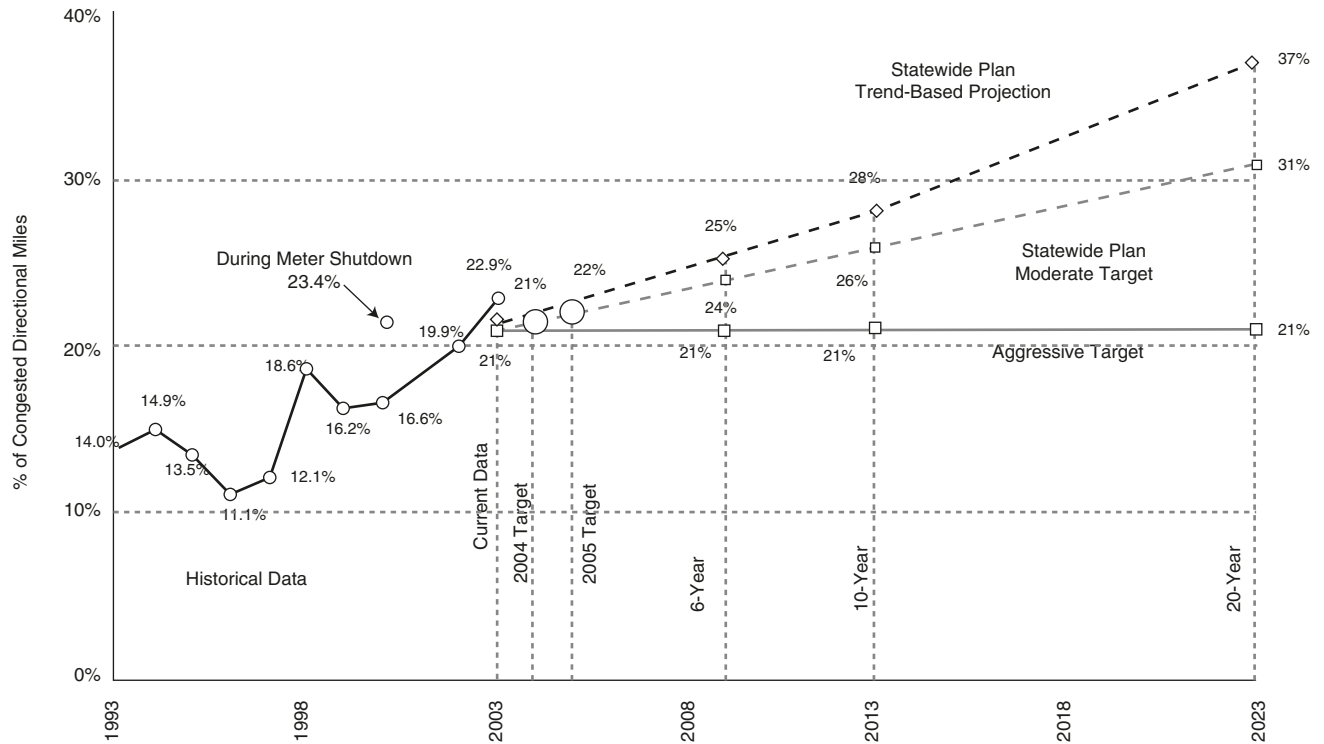


FIGURE 4 Percentage of congested miles of Twin Cities urban freeway system.

and focus public attention. This is especially true when high-priority innovative strategic initiatives are undertaken. On the one hand, failure to set a target may slow progress. On the other hand, casual targets without any credibility can undermine the performance management process.

An important issue is who sets the target levels. Participation by management teams and functional areas is important in achieving the buy-in necessary to mobilize and achieve the target. A balance of expert analysis and management vision is desirable.

In Minnesota, the “expert office,” such as Bridge, Materials, or Traffic, typically recommends a target level on the basis of baseline data, programmed projects, and planned initiatives. The division or department management team may adjust the target. Recently, aggressive 20-year plan targets for bridge structural condition were moderated when the assistant chief engineer, state bridge engineer, and planning office all agreed that there was no foreseeable scenario whereby resources would be available to meet the target.

Montana believes that setting targets becomes less academic once tools are available to predict performance over time as a function of budget. Hence, it has focused its efforts on reorienting management systems to do forecasting.

When transportation organizations themselves have not set credible goals and targets, the likelihood increases that governance bodies will. In Colorado, the

Transportation Commission has set ambitious targets. With a state constitution that bars tax increases, the Colorado Department of Transportation is concerned about the availability of resources to achieve targets for bridges and mobility.

Managing with performance measures and targets is a fact of life for transit systems. All transit systems receiving federal support must report uniform measures annually to the National Transit Database. Measures of ridership, capacity utilization, and subsidy levels are widely accepted and compared across systems. In Minnesota, the Metropolitan Council bus system uses two measures to help decide what routes are candidates for reduction or removal of service when budget cuts force action: subsidy per passenger and operating cost per revenue hour. All 35 providers in the region are required by state law to report on the same measures.

INTEGRATION INTO PLANNING, BUDGETING, AND DECISION MAKING

Transportation decisions take place in many processes. Not bringing performance information into the processes marginalizes its value. There must be a link to the budget process “or you have nothing,” said one state planning division director. Details of integration are touched on throughout the paper, and selected examples are provided in Boxes 2, 3, and 4.

BOX 2

**Integration of Performance Management Practices with Decision Processes and Budget:
Selected Examples**

Governance—legislative

- Florida Sixty annual budget activity measures reported to legislature. Targets for pavement, routine maintenance, and bridge condition set in law.
- Washington Specific legislative mandate in nine measurement areas. Budget-based performance measurement requirements and performance agreements with governor. Additional voluntary tracking of system, organizational, and project delivery measures quarterly.
- South Carolina Legislature mandates annual reports.

Budget process

- California New administration moving toward performance-based budgeting (2004).
- Florida Input-output targets and unit costs required by legislature and governor for all activities, tracked by new activity-based budgeting system.
- Minnesota Performance information incorporated in biennial budget documents. Activity-based budgeting expenditure data being developed to provide unit costs for products and services.
- Washington Maintenance accountability. Performance information used by department and legislature in negotiating targets for service levels and budget allocations for maintenance (see Figure 5).
- Ohio Performance data for up to 70 measures used in allocating funds to districts. For example, a “steady-state” goal is pursued, defined as the rate of rehabilitation projects matching the rate of deterioration. “Normalization” process used to equalize conditions across the state by adjusting district goals and funding.
- Wisconsin State budget office requires at least two measures for every program in budget.

Executive strategic initiatives

- California Governor and cabinet secretary asked Caltrans and regional organizations to adopt common core performance measures for the transportation system in 2004.
- Alaska Missions and Measures citizen accountability program. In 2003 the governor asked all agencies to set missions and goals and report on measures annually as part of their annual budget requests.

Activity	1.0	1.9	2.0	2.9	3.0	3.9	4.0	4.9	5.0	5.9	
	+	A	-+	B	-+	C	-+	D	-+	F	-
Group 1 Roadway Maintenance and Operations											
1A1 Pavement Patching and Repair			✓		⊙						
1A2 Crack Sealing						✓	⊙				
1A3 Shoulder Maintenance				✓	⊙						
1A4 Sweeping and Cleaning		✓		⊙							
1B1 Safety Patrol					✓	⊙					
Group 2 Drainage Maintenance and Slope Repair											
2A1 Maintain Ditches				✓		⊙					
2A2 Maintain Culverts						✓	⊙				
2A3 Maintain Catch Basins and Inlets				✓	⊙						
2A4 Maintain Detention/Retention Basins						✓	⊙				
2A5 Slope Repair			✓		⊙						
Group 4 Bridge and Urban Tunnel Maintenance and Operations											
4A1 Bridge Deck Repair			✓				⊙				
4A2 Structural Bridge Repair						✓	⊙				
4A3 Bridge Cleaning						✓	⊙				
4B1 Movable and Floating Bridge Operations	✓			⊙							
4B2 Keller Ferry Operations				✓	⊙						
4B3 Urban Tunnel Systems				✓	⊙						

FIGURE 5 Maintenance Accountability Process, Washington State Department of Transportation: activity service level targets and service levels delivered.

BOX 3

Integration of Performance Management Practices with Plans and Programs: Selected Examples

Strategic plan

- Minnesota Rotating monthly reporting schedule initiated in 2003 for measures tied to objectives in strategic plan and statewide transportation plan.
- New Mexico Measures recently realigned and reduced at executive level to support five strategic plan priorities of new governor. Targets set for 2004, 2005, and 2006.
- Pennsylvania Measures and targets set for eight strategic and focus areas in strategic plan, with scorecards for executive management and chief engineer.
- Montana The strategic business plan explicitly requires that 95 percent of projects programmed be consistent with P³.

Long-range transportation plan

- Minnesota Performance-based plan for 2003 sets 33 measures for three strategic directions and 10 policies. Eight district plans under development in 2004 will operationalize the plan and define the 20-year performance-based funding needs to meet performance targets. Constrained plans will identify projects to address performance gaps. New freight plan and Highway System Operations Plan will also support state plan policies and targets.
- Florida Twenty-year Florida Transportation Plan defines goals and objectives for all state and local transportation organizations. Annual Short-Range Component Plan documents strategic goals and objectives for Florida Transportation Plan for periods up to 10 years. Supported by Florida Department of Transportation 10-year Program and Resource Plan, which sets targets and guides program and funding decisions. Sixty legislative outcomes and activity measures used.
- Montana First statewide plan led to development of P³. The most recent plan emphasizes system preservation and consideration of economic development in process. Performance-based programming is consistently supported.
- Capital District
Regional
Transportation
Plan (Albany,
New York) Performance objectives and measures used to identify magnitude of gaps and support evaluation of alternative strategies in New Visions 2021 Regional Transportation Plan.
- Maricopa
Regional
Transportation
Plan (Phoenix,
Arizona) Performance measures used to evaluate the strengths and weaknesses of various future transportation approaches and scenarios in the Maricopa Association of Governments Regional Transportation Plan.

Program and project selection

- Florida Decision support tool includes information on bridge, pavement, safety, mobility, vehicle miles traveled, economic development (under development), and other performance factors. It identifies deficiencies and prioritizes projects. Can do preservation–capacity trade-off analyses.
- Southern
California
Council of
Governments Multimodal trade-off analysis tool applied to project analysis and selection process.
- Wisconsin Metamanagement system prioritizes projects on the basis of performance needs. Performance targets used to evaluate adequacy of program; analysis is fed back to districts.
- Montana Seventy percent of the capital program is distributed on the basis of P³, and 95 percent of projects entering the program are consistent with its performance-based budgets for districts, systems, and types of work. Preservation is the first priority and is funded first.

(continued)

BOX 3

**Integration of Performance Management Practices with Plans and Programs:
Selected Examples (continued)**

Washington	Performance-based programming and prioritization process. Asset condition and system performance (levels of delay, crash type, and frequency) are used in determining level of investment in program areas.
Corridor plans	
Colorado	“Corridor Visions” based on performance categories (mobility, safety, preservation) developed by citizens and rolled up into statewide transportation plan.
Minnesota	Travel speed targets used as basis for community-based corridor planning process. Deficient corridors targeted for projects.

BOX 4

**Integration of Performance Management Practices with
Operations and Management Processes: Selected Examples****Project delivery management**

Virginia	Public online project delivery dashboards established in response to legislative demands after a crisis in program delivery. Reported quarterly to governor.
Washington State	In-depth project delivery reporting in the <i>Gray Notebook</i> 's beige pages. Comprehensive web-based project status information posted.
San Francisco Bay Area MTC	Annual project performance report for operational projects provided to the public and the commission.
South Carolina	On-schedule, on-budget measures reports required by legislature for huge Cooper River bridge project.
Minnesota	Commissioner's bond-accelerated projects milestones, right-of-way, and costs monitored monthly at district video meetings and quarterly at executive meetings.
Florida	Florida Department of Transportation Executive Board and Transportation Commission monitor production management report, which shows percentage of project deliveries in compliance.
California	Project delivery milestones and budget status reported quarterly to the California Transportation Commission. Posted on the web.
Montana	Project delivery targets set annually. Quarterly reports posted on the web. Delivery targets for total lettings and program mix are seen as the most crucial for achieving system performance objectives.

Maintenance and operations

Ohio	OPI—exception reporting monthly to executive leadership and district engineers. Index of some 70 measures including maintenance reviewed quarterly.
Pennsylvania	Maintenance First. Well-developed system of regular reporting on performance versus targets as well as customer satisfaction.
Washington	Maintenance Accountability Process. Advanced system of maintenance measures reporting calibrated on a common numeric scale. Legislature helps set targets and funds to the target levels
Minnesota	Highway System Operations Plan. New 4-year plan under development to set target levels of service and identify funding gaps for pavement and bridge maintenance, traffic operations, safety operations, and facilities and fleet.
San Francisco Bay Area MTC	Targets and results reported annually for operations such as incident management, transit electronic fare system, and 511 traveler information.

The Florida Department of Transportation and other participants in the May 2004 peer exchange in Charleston, South Carolina, emphasized the importance of performance measures being driven by policy and not being an end in themselves. The general business management literature reinforces this point. “Strategic performance measures should be closely focused around a line of sight, driven from the strategy,” according to a DePaul University expert in strategy design and balanced scorecard initiatives (4).

Programming and Project Selection

The *Transportation Asset Management Guide* indicates that performance information should directly inform the process that builds the recommended program and budget (1, p. 2-6).

Project Delivery Management

The *Transportation Asset Management Guide* indicates that “well-understood project delivery measures and procedures are used to track adherence to scope, schedule, and budget” (1, p. 2-6). The guide disdains the use of “ad hoc processes” to control projects on an exception basis and states, “A process exists and is enforced to approve changes in project scope, schedule and cost.” While Minnesota and others have developed systems that use project milestones to monitor project schedule status, it appears that fewer organizations have developed effective measures and controls for project scope and costs.

The *Transportation Asset Management Guide* recommends that information on costs and project outputs be “maintained in a form that can be used to track program delivery” (1, p. 2-12).

Conclusion: Moving Toward Institutionalization

The examples presented in the boxes are a small sample of the progress being made toward integration. Integration—along with leadership support, regular reporting systems, customer monitoring, targets, effective mainstreaming of staff responsibilities, and building a culture that owns performance measurement—is essential in achieving institutionalization of performance management.

EMERGING STEPS IN DEVELOPMENT

Planning for Performance—Tools to Model and Manage Future Results

While the early years of performance measurement tended to rely on relatively passive retrospective moni-

toring of results, the future will rely more and more on planning for positive performance outcomes with the use of predictive tools. Among the tools for forecasting and evaluating results of investment options are modeling, scenario planning, benefit–cost analysis, life-cycle costing, and trade-off analysis. These tools are already being developed, used, and blended together. Among the most sophisticated integrated systems are those being used by Florida, Wisconsin, Montana, and the Southern California Association of Governments (SCAG).

Minnesota has forecasting tools for pavement and interregional corridor mobility (see Figure 6) and shares these analyses with district planners. In Minnesota’s decentralized system some statewide priorities are set, but districts do the integration by balancing competing targets and making trade-off decisions.

Modeling and Scenario Planning

The *Transportation Asset Management Guide* best practices recommend that performance reports provide scenario testing of trends in performance versus cost and optimal timing of preventive and corrective maintenance and provide information on benefit impacts of proposed investments (1, p. 2-7). For state-of-the-art practice it recommends “decision-support tools that facilitate exploration of capital versus maintenance trade-offs for different asset classes” (1, p. 2-12).

Montana’s work in this area was discussed earlier and offers a valuable case study.

Scenario planning tools are an emerging approach to modeling future performance on the basis of alternative sets of investments. The Capacity Building Program of the Federal Highway Administration (FHWA) is providing technical assistance and financial support for the use of several software tools that bring together transportation and land use planning. CORE PLAN is being used

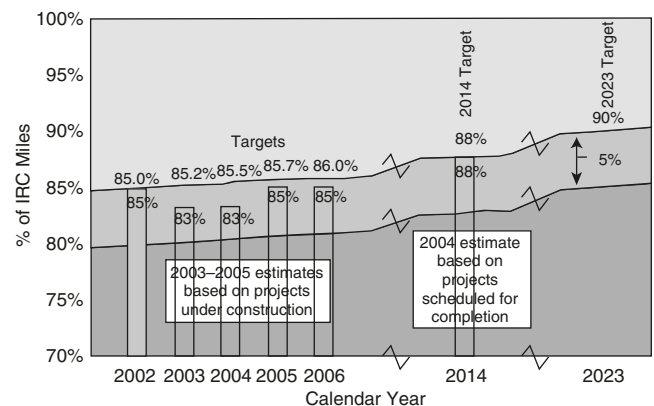


FIGURE 6 Percentage of interregional corridor miles meeting speed targets, Minnesota.

by Charlottesville, Virginia, among others, and PLACE 3S by the Sacramento Area Council of Governments. The tools allow inputting of demographics and land use and investment information, and they produce outputs for performance on level of service, access, and other measures. FHWA is looking for more interested parties and believes that small organizations with limited resources find these tools much easier to use than the old four-step model.

The Chicago, Illinois, region and the state of Utah are engaged in intensive visioning and scenario-planning efforts involving the public. For the Envision Utah project, investments are inputs, and performance results for measures such as transportation access are outputs. FHWA has held roundtable sessions with other interested organizations (www.chicagometropolis2020.org/ and www.envisionutah.org/).

In the Minnesota Department of Transportation’s decentralized planning system, districts use performance information for all major policy goals in the statewide plan to forecast gaps in infrastructure performance through 2030. As shown in Figure 7, the districts develop two scenarios: a performance-based scenario and a fiscally constrained scenario. Key areas include pavement condition forecast, bridge structural condition, forecast interregional corridor travel speeds, regional trade center mobility, transit fleets, freight connectors, and safety. Pavement and interregional corridor travel speed have predictive models.

Aggregating the fiscal gaps in performance and the costs to close the gaps will provide a statewide estimate of unmet future infrastructure needs—something that some legislators and stakeholders have been asking for. Districts have been asked to make preservation their highest priority. Pavement targets should be achieved by 2014 and demonstrable progress made toward bridge targets by 2023 (see Figure 8). The difference between the two scenarios will define the fiscal gap to meet long-range policy and customer-based performance targets. In addition to this process, in the short term some projects are nominated by districts and selected centrally on the basis of performance criteria.

- **Plan Horizon 2008–2030**
 - 2008–2014
 - 2015–2023
 - 2024–2030
- **Two Scenarios**
 - Performance-Based Plan
 - Investments needed to meet targets by 2023
 - Fiscally Constrained
 - Priorities for forecast revenues

FIGURE 7 Scope of Minnesota Department of Transportation district plans.

- System preservation is top priority
- Allocate sufficient resources in fiscally constrained plan to meet and maintain pavement target by 2014 and make demonstrable progress toward bridge target by 2023

FIGURE 8 Guidance, Minnesota Department of Transportation district plans: priority among performance targets.

Life-Cycle Costing, Benefit–Cost, and Other Optimization Tools

The *Transportation Asset Management Guide* to best practices recommends, “Projects are evaluated in terms of realistic estimates of life-cycle costs, benefits, and performance impacts” (1, p. 2-6). It suggests that simply ranking the condition of assets and programming the “worst first” is not the answer.

Life-cycle costing tools have progressed in certain areas and have some way to go in others. Minnesota has expanded from doing benefit–cost analysis on large projects to setting targets on the basis of minimizing life-cycle cost for pavement, truck fleets, and transit fleets by using measures of years of life of the asset. Efforts to calibrate bridge targets to least life-cycle cost are under way.

The Minnesota Department of Transportation’s Bridge Office has estimated a 4:1 benefit for application of a priority package of bridge preventive maintenance treatments in combination with capital investments versus the historic approach, which has been almost entirely capital investment. Measures and target service levels are being developed as part of a larger new Highway System Operations Plan, which supports the statewide transportation plan.

Trade-Off Analysis

Development of trade-off analysis is a goal of transportation performance management. Among the organizations that have created tools to do it at some level are SCAG and the DOTs of Montana, Wisconsin, and Florida. The Florida package includes pavement and bridge, congestion, vehicle miles traveled, and safety performance factors. Florida and Montana are both working to add economic development analysis elements to their systems. Figures 9 and 10 provide examples from Montana.

Conclusion

Further development and dissemination of these tools is a priority. Participants in the 2003 U.S. Department of

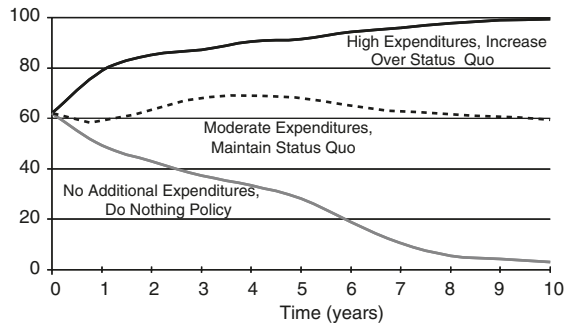


FIGURE 9 To predict performance as a function of budget, the Montana Department of Transportation uses scenario testing capabilities of bridge, congestion, and pavement management systems.

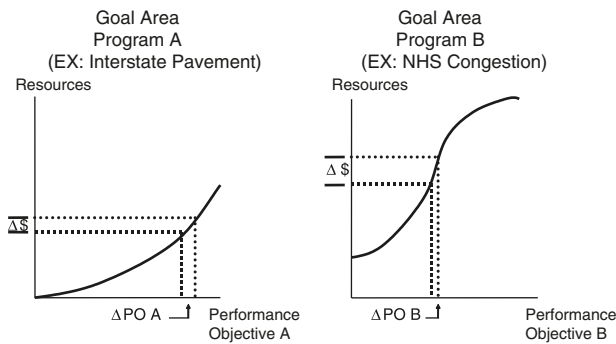


FIGURE 10 Trade-offs in performance goals (Montana). Some goal areas take more resources to change. NHS = National Highway System.

Transportation roundtable recommended upgrading management systems, such as PONTIS, to increase their capacity for forecasting. One cautionary note: while future-oriented tools are becoming essential to planners, participants in the roundtable cautioned that projected data are sometimes not as effective in making a case for investments to legislators and the public as historical data.

ADDITIONAL TOOLS

Geographic Information Systems— Mapping Performance

The *Transportation Asset Management Guide* state-of-the-art benchmarks recommend that performance information be based on a common geographic referencing system and a “common map-based interface for analysis, display and reporting” (1, p. 2-12).

Geographic information systems mapping is a promising tool for analyzing and communicating performance information. Numerous organizations show

real-time congestion maps on websites and television. Maps of high-crash locations have dramatized safety problems in certain corridors in performance reports to Minnesota Department of Transportation management. Next winter, the Maintenance Office plans to communicate electronic maps of snow and ice removal time results by route throughout its eight districts for use by supervisors, drivers, and managers. Figure 11 illustrates the speed performance forecast for 2014 for the interregional corridor system in Minnesota.

Dashboards and Performance Measurement Software: Real-Time Performance Monitoring

The private sector has learned that automated performance reporting systems are valuable in reducing staff burden and increasing management and staff access to performance status data. Many DOTs use Microsoft Excel and Access applications. Some are experimenting with commercial business intelligence software. The U.S. Department of Transportation roundtable in October 2003 recommended setting specifications for commercial software vendors for transportation performance measurement and planning applications.

Dashboard gauges are a visual tool promoted by commercial vendors and used by private- and public-sector enterprises. They are especially useful in monitoring large volumes of performance information. A common application is real-time monitoring of project management, such as in the Virginia Department of Transportation website (see Figure 12). Gauges may be less effective in displaying trend information, which is critical for sound analysis.

Typically green means “on target”; yellow means “at risk, requires monitoring”; and red means “seriously short of target, needs intervention.” The Minnesota Department of Transportation has used dashboards effectively to monitor construction project development monthly, snow and ice removal monthly, and fleet management quarterly, as well as information technology support and other administrative areas.

Past crises in program delivery in Virginia led to the creation of public online dashboards. They track progress on advertisements, construction contract deadlines, construction contract budgets, and contract work orders (dashboard.virginiadot.org). As in Minnesota, this information helps stimulate project teams to solve problems, shift resources, make decisions to get lagging projects on track, or adjust schedules if no other choice is available. The Virginia Department of Transportation uses the dashboards to hold project managers accountable and reviews them at monthly commissioner updates. Virginia also posts a quarterly report card showing performance on core business outcomes—construction and mainte-

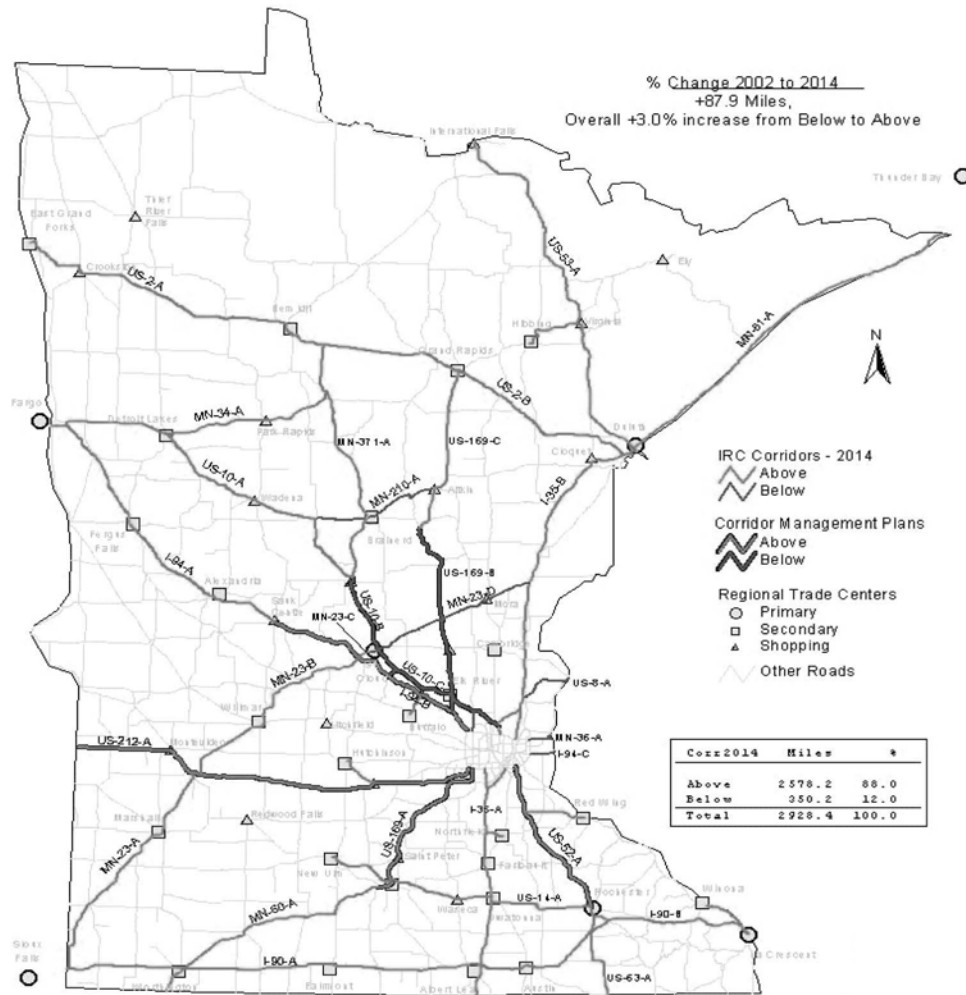


FIGURE 11 Interregional corridor system speed performance forecast, by corridor, 2014 (Minnesota).

nance contract schedules and budgets. The Minnesota Department of Transportation shares project status information with commissioner’s staff quarterly and posts summary information and dashboards on its public website (www.dot.state.mn.us/financing/#projects).

Minnesota is piloting application of commercial software (Hyperion Performance Scorecard) to map its hierarchy of measures. In winter 2004–2005 the Maintenance Office will test the software to manage and report large volumes of snow and ice removal data by district, route, and event.

The Florida Department of Transportation, which has a large number of measures, now has a performance measure for the percentage of key measures reports automated. It relied on Access database software but is in the second year of implementing commercial software (PB Views). It expects that the software will eventually enable all managers and employees to see to which measures in a hierarchy they

contribute. Implementation is tied to a Balridge quality initiative, the Sterling model.

Auditing Performance Data

As performance management matures and data become essential in decision making and funding, the obligation to guarantee accurate, auditable data arises. The Governmental Accounting Standards Board has recognized performance data as an essential component of sound management. Texas was one of the early states to require auditing of performance measures data for all state agencies.

The practice appears to be growing, sometimes with specific applications in transportation. In New Mexico the Legislative Finance Committee conducts audits every other year. The state DOT has initiated its own audits of performance data. In Florida the inspector general does a required yearly audit, including extensive

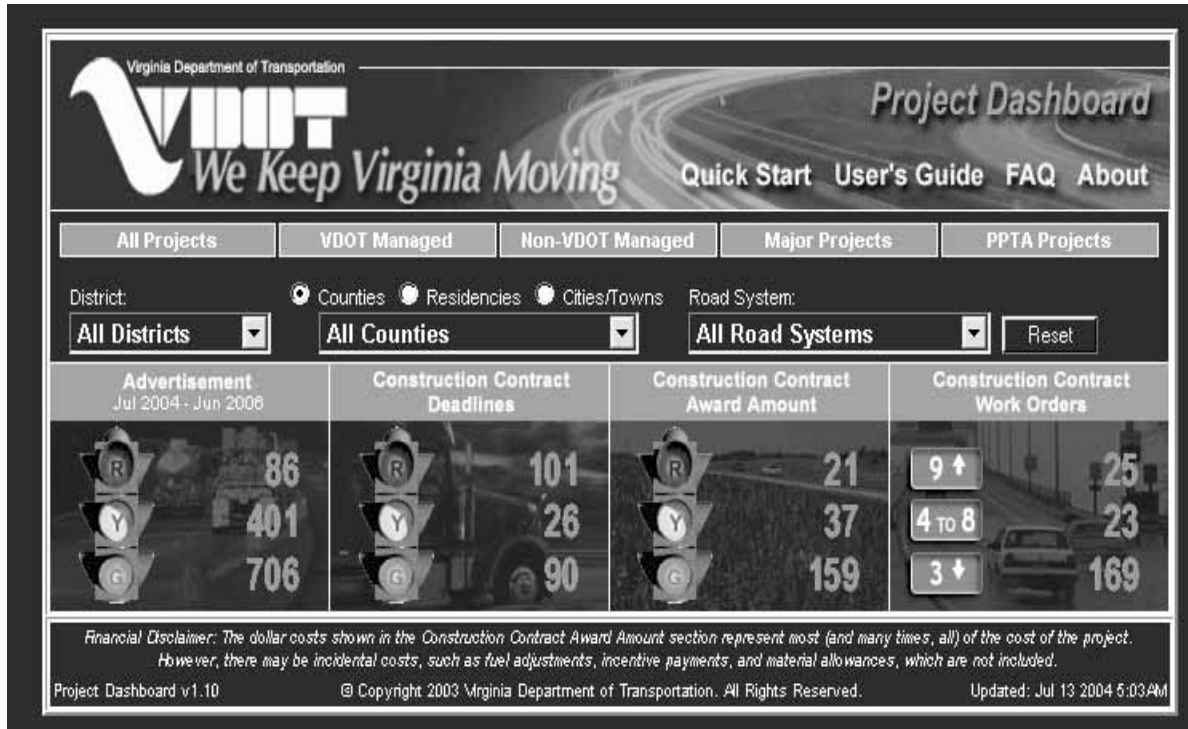


FIGURE 12 Project dashboard, Virginia.

reviews of data collection and processing methods. All 60 measures in the Florida Short-Range Component Plan must document replicable processes.

In 2003 the Washington State legislature created a Transportation Performance Audit Board consisting of legislative leaders and citizens. It is charged with reviewing performance measures used by several state transportation agencies and recommending performance audits (lrc.leg.wa.gov/tpab/default.htm). A request for proposals has been published, and a consultant will review and evaluate Washington State Department of Transportation measures.

Transportation organizations may wish to initiate their own processes. Use of third-party auditors may enhance credibility. Caltrans has requested its audit section to work with all program areas to ensure that proper paper trails exist for performance data. In Ohio, where funding and individual performance reviews depend on performance data, the state DOT has a nearly full-time person auditing district data. Deputy directors must sign off on monthly reports of the OPI.

Measuring and Managing Cost-Efficiency and Competitiveness

The *Transportation Asset Management Guide* recommends as a best practice that an agency know “its cost

for delivering its programs and services” by activity or class. Furthermore, it recommends periodic evaluation of options for delivery, such as internal, intergovernmental partnerships, outsourcing, or managed competition (1, p. 2-11).

The trend today is toward focusing performance management on a few vital strategic objectives. But financial managers and legislators in some jurisdictions want universal accountability for all products and services. This direction has also gained momentum from pronouncements of the Governmental Accounting Standards Board.

The DOTs of Florida and Minnesota are developing activity-based budgeting (ABB) systems aimed at answering the following questions: What is the unit cost of each transportation product and service? What is the performance result for each additional dollar invested? What is the cost and result for in-house delivery versus other options for delivery of the services? Florida’s legislature and governor have directed development of ABB unit cost information and input-output measures and targets for every activity in the budget. One early result is 200 additional pages of budget documents.

Minnesota is at an earlier stage, with the final scope and extent yet to be determined. A productivity and cost management task force is developing information for the “plan delivery” budget activity.

Monitoring Consultant Results— Performance-Based Contracting

Expansion of performance-based contracting beyond traditional construction project incentives is an issue for the near future. Maintenance, information technology, and project development all offer opportunities.

Benchmarking the Industry

Comparison of performance is done intensively in many if not all major industries. It is done for transit systems via required reporting to the National Transit Database. Benchmarking of highway system and transportation organization performance across states and metropolitan areas is not highly developed or accepted except in selected areas, such as congestion. Diverse definitions and data collection processes complicate the issue. Nevertheless, if the transportation community does not agree on common measures it is likely that others will define them. An American Association of State Highway and Transportation Officials initiative, NCHRP Project 20-24(37), Strategic Performance Measures for State Departments of Transportation: Benchmarking Performance, is exploring identification of shared measures. Figure 13 shows an example of benchmarking transit measures in Minneapolis–St. Paul, Minnesota.

LESSONS LEARNED

Looking back on the past decade or two of experience in learning performance management, transportation organizations surveyed offered these lessons:

- Keep it simple (Pennsylvania). Make measures understandable. Make the data reporting as simple and consistent

as possible (Ohio, Washington, Minnesota). Stick with key measures—don't try to measure everything (Florida).

- However, one size will not fit all. Be flexible in your approach—you cannot simplistically apply the same practices for measures, targets, and reporting to all areas of the organization (Washington).
- Start the process by taking small steps, then commit for the long haul. Use the best; don't wait for the perfect. Don't wait endlessly for the perfect measures and the perfect data. Do it and learn and adjust as you go. Even the most experienced states and MPOs are still refining their measures. First get your system established, then work continuously to make it more effective over time (Montana, New Mexico, Washington, Minnesota).
- Be dynamic and keep evolving. You are never done. When the environment changes because of a new administration or new public concerns, performance measurement must adapt (Washington).
- The practice of measurement must be aligned with and driven by a policy or management priorities—it does not exist as an end in itself (Washington, Florida, Minnesota, Montana).
 - The framework goes from goals to objectives to policy to measures to targets.
 - There must be a clear link from policy to programming to performance monitoring.
- Combine system outcome measures and organizational measures. The latter are more likely to be input or output measures (California).
- Getting local partners involved is vital, especially in states with many large and strong regional organizations (California).

Many of these points were reinforced by the international scan (3). The draft scan added another lesson: incorporate postevaluations. Compare the outcomes of transportation investments with the performance benefits projected before the investment was made.

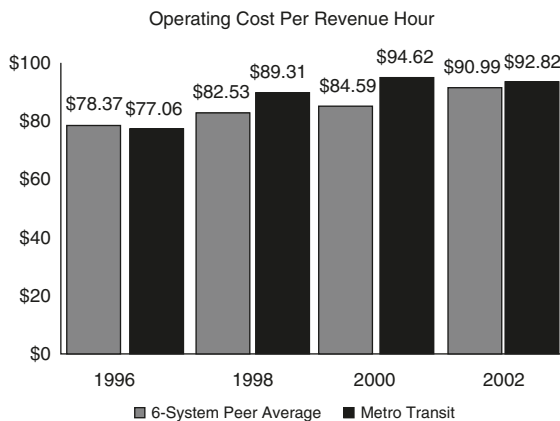


FIGURE 13 Benchmarking transit measures, Metropolitan Council, Minneapolis–St. Paul, Minnesota.

ISSUES AND CHALLENGES

Several challenging issues deserve further exploration if we are to continue progressing: how many measures to use, individual performance accountability, balancing strategic vision with use of measures, and cooperation between states and regional organizations.

How Many Measures? Steering with the Vital Few Versus Keeping All Areas Accountable

A prevailing view on the issue of how many measures to utilize is to limit the number of measures to those aligned with strategic and management priorities. The

report from the 2004 international scan recommends in its conclusions, “Don’t measure too many things. . . . In those situations where large numbers of performance measures were considered, a lack of focus resulted” (3, pp. 98–99).

A contrasting view is emerging. Some financial managers and legislatures wish to have measures for all products and services, regardless of their strategic priority. This means knowing the unit cost, productivity, and effectiveness of all activities. The benefit is to benchmark the competitiveness of the organization versus alternative modes of delivery or to identify opportunities for process improvement. As mentioned previously, without indicating the extent desirable, the *Transportation Asset Management Guide* recommends knowing the costs of programs and services and examining delivery options. The development of ABB and activity-based costing tools by the DOTs of Florida and Minnesota and others is making this more feasible.

The Minnesota Department of Transportation’s solution to managing large numbers of measures is, in concept, to delegate appropriate measures and submeasures to each level of an organization, within the strategic framework. Done properly, this can avoid measures overload while enabling all to understand their responsibilities. Executive staff have more high-level system and customer measures, while functional areas have more process and output measures to which they can actually manage day by day. Commercial software packages facilitate the mapping of measures hierarchies and the calculation of composite performance results.

Individual Performance Accountability as a Management Tool

Private-sector enterprises typically align individual performance goals and performance reviews with organization measures and goals. This approach has started to emerge in public-sector transportation organizations.

In Caltrans, all nine deputy directors have had annual written performance agreements with the Caltrans director. They include goals, objectives, and operational performance measures aligned to Caltrans’s strategic plan. Some of the same measures, such as those for project delivery, are also reported to the California Transportation Commission and the legislature. Division directors under the deputies also have performance agreements.

Ohio has an advanced level of accountability linking individual managers’ performance reviews to progress on department and district performance targets. Monthly state- and district-level exception reports of the comprehensive OPI are reviewed by the 12 district engineers and deputy director. Two-year business plan

targets are set for 2004, 2006, and 2008. All districts are expected to know their goal deficiencies and to set goals to close the gaps. As a result of civil service reforms originating in the total quality management initiative of the 1990s, career managers’ performance reviews are tied to progress on the measures. In addition, funding is tied to performance targets. Districts with system deficiencies may get additional funding to close their gaps, but failure to make adequate progress can put a manager into a probationary period.

The Washington State Department of Transportation, like that of Ohio, has gained major new gasoline tax revenues and is moving toward stronger accountability for individual managers in delivering priority projects on schedule and on budget.

The general management literature points to the need for some kind of feedback cycle: “If performance measurement systems are to operate as organizational catalysts rather than as mere historical records, there must be an interaction between the degree of performance observed by the system and the rewards and sanctions impacting on actors within the business. If this is not the case, then the degree of impact of the system will be lessened dramatically” (5).

How widely and deeply the practice of integrating managers and employee performance accountability with organizational performance objectives will be adopted remains to be seen. Experience shows that lack of accountability systems to manage project delivery can trigger imposition of accountability tools by elected officials.

Strategic Vision and Innovation: The Limits of Managing with Measures and Targets

There are many issues in the appropriate use of performance targets. First, when are measures and targets not the right planning tool? Second, when should targets be set? Third, how aggressively should they be pursued? Finally, under what conditions can they be adjusted to meet changing realities?

The role of planners and management is to be strategic. Organizations seeking major breakthroughs will not always find guidance in measures. Measures typically apply to what is being done today, not to new strategies and activities. For example, several years ago under Governor Jesse Ventura, the Minnesota Department of Transportation had as one of its strategic objectives to “increase multimodal transportation options,” with supporting performance measures. Governor Ventura led construction of the state’s first light rail line amid great controversy. As is typical of an entrepreneurial venture, its initial benefit–cost was not high. With the system now up and running, the owner-operator, the Metropolitan Council,

now has the responsibility to track its performance and optimize cost-effectiveness.

The Washington State Department of Transportation exercises caution in setting targets for areas that lack mature baseline data. The department rightly asserts that management targets need to be achieved. Once targets are set for strategic objectives, organizations must pursue them steadfastly to sustain the momentum and credibility of their goals. Leaving the door too wide open can erode the power of target setting.

At the same time, Washington and others acknowledge that sometimes “aspirational” or “stretch targets” are necessary to motivate action and innovation. In Minnesota, the 2003 state transportation plan set moderate and aggressive targets to reduce highway fatalities. Initially there was trepidation by safety engineers and district engineers about being accountable for reversing trends. But 2 years later, the targets have helped stimulate formation of a multiagency state–local task force to develop a comprehensive highway safety plan addressing the areas that state DOT engineers said were outside their influence: education, enforcement, and emergency response.

Performance targets should be serious and credible but not dictate decisions mechanistically. Such an approach negates executive managers’ responsibility to make decisions. Meyer states in the concluding lessons from the international scan, “Performance measures position you well to engage in debate, but may not necessarily be the determining factor in a decision, especially in the legislative arena. Measures sharpen and focus the debate” (3).

The Florida Department of Transportation has a balanced, flexible arrangement with its legislature. Annual targets are set for 60 required budget measures, and results are reported at the end of each fiscal year in June. At midyear, the legislature allows midcourse adjustment of targets, if justification is provided. This approach has contributed to realistic planning and a good relationship between the two bodies.

In general, shorter-term targets, such as for operations and budget planning, should be achievable and pegged to available resources. Where there is a major performance gap, short-term targets guide incremental gains toward long-term targets. More aggressive long-term targets can be maintained at the same time as a part of long-range plans. They should embody customer expectations, sound engineering, and optimum results with minimum life-cycle costs.

Cooperation Between States and Regional Organizations

The problem of differing measurement frameworks among states and regional organizations within states

was an important concern discussed at the U.S. Department of Transportation performance measures roundtable in 2003. It is an issue for all states but is especially challenging in large states with many MPOs.

In California planning is conducted in 43 regions, including MPOs and county commissions. They receive 75 percent of funding. Progress in establishing performance-based planning has been hampered by the lack of consensus on measures for policies long established in California’s state transportation plan. This year, with a new governor and cabinet secretary, the logjam is being broken. They have asked Caltrans to work with regional organizations and other stakeholders to agree on a common core set of system performance measures by summer 2004 and begin reporting them in the fall. If it is successful, this breakthrough may serve as a guiding light for other areas of the country.

SOURCES

Notes of the following were used in the preparation of this paper: the session of the American Association of State Highway and Transportation Officials Standing Committee on Planning, Charleston, South Carolina, May 2–5, 2004; the Transportation Research Board Peer Exchange on Performance Measurement, Charleston, South Carolina, May 6, 2004; the session on Using Business Systems for Accountability and Public Awareness of the Southern Transportation Finance Conference, May 17, 2004; and the U.S. Department of Transportation’s Roundtable on System Performance Measurement in Statewide and Metropolitan Transportation Planning, Washington, D.C., October 7–9, 2003.

The following organizations were interviewed or surveyed: the California Department of Transportation; the Federal Highway Administration; the Florida Department of Transportation; the Metropolitan Council, Twin Cities, Minnesota; the Metropolitan Transportation Commission, San Francisco Bay Area, California; the Minnesota Department of Transportation; the Montana Department of Transportation; the New Mexico Department of Transportation; the Ohio Department of Transportation; the Pennsylvania Department of Transportation, and the Washington State Department of Transportation.

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Linking Performance-Based Program Development and Delivery

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As citizens, system managers, and legislatures nationwide demand enhanced levels of accountability, many transportation agencies have turned to performance measurement to improve the planning, programming, and delivery of transportation projects and services. Performance information is also being used to monitor the transportation system by demonstrating not only that successive decisions lead to the identification, selection, and funding of the most effective projects and services but also that they are then delivered efficiently and produce the intended results. The combination of performance-based program development, project delivery, and system monitoring creates an effective, efficient, and accountable transportation management structure.

State departments of transportation (DOTs), metropolitan planning organizations (MPOs) and councils of governments, system operators such as transit agencies and toll authorities, local transportation agencies, and citizen oversight groups have all experimented with performance measures to varying degrees to predict, shape, and report on the results of system investments and operations. Performance-based long-range transportation plans (LRTPs) and capital or transportation improvement programs are increasingly common and illustrate the desire of agencies to demonstrate that their planning and programming processes are founded on fundamental goals and objectives that have the support of elected officials and the general public.

In addition to plan and program development, the delivery of transportation projects and services (simply, “the program”) has also come under greater scrutiny,

particularly from elected or appointed officials and watchdog organizations. The success of an agency’s revenue proposals increasingly depends on a proven track record of program delivery. In many states and regions, special-purpose revenue measures have been developed to fund a specific set of projects and services, and the implementing agencies must demonstrate delivery of the funded program given that there is a clear link between the funding measure (e.g., an incremental sales tax or bridge toll) and the voter-approved list of projects and services.

System condition and performance reports, which make available current information about the actual condition and performance of various components of an agency’s modal or multimodal systems, are also becoming more popular, particularly as the Internet has made wide distribution of such information easier and less costly. Agencies have also started releasing data on the timeliness and cost of delivered projects. This last component of performance-based management, system monitoring and reporting, brings full circle the use of measures to assess need, prioritize solutions, implement, and gauge results.

Although all three components—program development, delivery, and monitoring—are essential to performance-based management, the focus of this paper is on the linkage between program development and program delivery. Establishing a relationship between program development and program delivery will enable agencies to guide transportation decisions from conception to implementation. This paper begins with a discussion of performance measures application to the identification

and selection of projects and services and to subsequent delivery of the transportation program. Next, the importance of implementing these two components of performance-based management and the relationship between the processes are assessed. The paper concludes with an assessment of some of the challenges of further connecting program development and delivery and a few suggestions as to how these challenges can be addressed. With limited examples from transportation agencies that have fully connected these two procedures, the issues raised in the paper are designed to identify the need and opportunity to advance performance-based management of transportation systems.

USE OF PERFORMANCE MEASURES IN PLANNING AND PROGRAM DEVELOPMENT

A notable degree of progress in performance-based program development has been made since the passage of the Intermodal Surface Transportation Efficiency Act, which established the requirement that state DOTs develop multimodal transportation plans, similar to the requirement for MPO long-range plans. Initially, states' long-range planning processes produced numerous goals and objectives, often with extensive public outreach, but the resulting transportation program was often not well connected with those goals (1). The addition of specific performance measures and analytical procedures to predict the benefits and impacts of alternative investment scenarios has improved the connection between higher-level system goals and the resulting plan, whether it be a policy plan or a more specific long-range list of projects.

Beyond the development of the LRTP or modal plans, some agencies have used performance measures more aggressively to drive prioritization and selection of projects for inclusion in a capital improvement program. The process of "programming" projects in accordance with periodic agency budgets has historically been a common point of divergence between system goals and the actual projects. Many factors other than system condition or performance enter the programming decision process, such as regional formulas for distribution of funds, the need to keep construction or maintenance crews active, and political influence. While performance-based programming is unlikely to eliminate these other considerations and factors, it does allow agency managers to put more emphasis behind actual performance returns as a rationale for implementing certain projects rather than (or sooner than) others.

Performance measures, when introduced into the planning process, are useful in a number of ways (2):

- Establishment of a link between statewide goals and projects. Performance measures help clarify goals by

causing planners and decision makers to be specific about what they are trying to achieve through investment of public funds in transportation system improvements. For example, total hours of congestion and pavement condition by facility class are two measures that help define broader goals such as mobility or system preservation.

- **Prioritization and selection of programs and projects.** Performance measures can be used to identify programs and projects with the highest return per dollar invested or those that will improve system performance the most overall.

- **Accountability.** Clarifying the decision process behind program and project selection creates an atmosphere of trust between transportation agencies, elected officials, and the public. Performance measures also provide agencies with the means to demonstrate the benefits of public expenditures.

- **Allocation of funds and other program resources.** Agencies have used performance measures to guide budgetary decisions. For example, some transit agencies incorporate performance measures (e.g., operating cost per passenger mile) and single-dimension factors (e.g., ridership) into the allocation of resources to various services (3).

- **Trade-off analysis.** Performance measures can help sort out and address multimodal demands at transportation agencies that have responsibility for more than one modal system. Trade-off analysis becomes more rational when clearly defined objectives and measures of performance have been articulated. For example, mutually exclusive corridor or program investments can be compared on performance metrics to identify not only the benefits of choosing Project A over Project B but the costs (or impacts) of not choosing B.

- **External and internal communication.** Reports documenting performance measure data help clarify the implications of existing transportation programs, whether positive or negative, to elected officials and the public. Use of performance measures can also help create a unified message throughout an agency or department by making common goals and priorities a clearer part of the agency culture, much in the way that job site safety statistics have long been used in the construction industry to create an awareness and culture of accident prevention.

- **Benchmarking.** Performance measures have been used by some agencies to compare their performance with that of peer agencies or to help set achievement goals (e.g., the Oregon Benchmark Report).

The cumulative effect of performance measurement in planning and program development is both long-range guidance and near-term project selection that promises to deliver the system goals and objectives that

were adopted, usually with buy-in from the public, special user groups, and elected officials. Whether these are traditional highway system goals such as safety, mobility, and preservation or more multidimensional goals such as environmental protection, context-sensitive solutions, and economic development, an agency can point to a long-range plan and capital program of projects and services that have been selected because of their ability to deliver performance in these areas.

The application of performance measures in program development can be seen in a variety of examples around the United States. A performance-based LRTP, PennPlan, was adopted by the Pennsylvania Department of Transportation in January 2000. PennPlan outlines 10 statewide goals and lists action items and objectives that are linked to the broad goals (4). To monitor the attainment of the statewide goals, the department developed performance measures for each objective and target dates for implementation. Figure 1 shows an example of the relationship between the goals, objectives, measures, and targets. PennPlan also identified 29 corridors of statewide significance and established objectives for each corridor. The combination of statewide and corridor-specific objectives provides continuity between state and local goals. The performance measures in PennPlan help define policy direction and provide the means to report program results. Currently, under new leadership, the Pennsylvania Department of Transportation is updating PennPlan, which may change the role of performance measures. As part of this process, the department is evaluating how performance measures can be further used to select projects and help guide resource allocation decisions.

Several state DOTs have used performance measures to establish a more direct link between system plans and project selection. The Arizona Department of Transportation has recently substantially overhauled and updated its long-range transportation plan, MoveAZ, the core of which is now the identification, performance-based evaluation, and ranking of a 20-year program containing specific projects, consistent with recently enacted state law. An important component of the new draft plan is its linkage to the programming process. While different performance measures are used in the long-range plan and 5-year program, the “planning to programming” aspect of MoveAZ formalizes

the connection between the planning and programming processes through common goals and procedures, and the system needs set forth in the LRTP are better linked to the performance impact of selected projects.

A clear connection between statewide goals and project selection has also been pursued by the Montana Department of Transportation, where the Performance Programming Process (P³) is used to distribute funds and select projects for the State Transportation Improvement Program (STIP) on the basis of congestion and pavement management systems (5). P³ was started in 1995 with the Montana Department of Transportation’s new LRTP, TRANPLAN21, which emphasized the linkage between policy goals and project selection. Before the implementation of P³, funding allocation to Montana’s infrastructure was based on lane miles or roadway attributes. P³, on the other hand, evaluates project selection options on the basis of the attainment of the performance objectives outlined in the LRTP and resource constraints. By adopting the P³, funding is allocated to ensure that overall system goals are met. Currently, approximately 70 percent of the state’s capital program is designated under the P³ process. The Montana Department of Transportation believes that the P³ system keeps the planning focus on the customer, helps unify the various divisions under common goals, and enables the department to monitor its progress and thus improve accountability (6).

Although the application and degree of integrating performance measures in program development vary across transportation agencies, the clear benefits of measures ensure that they will continue to play an important role in transportation system management.

USE OF PERFORMANCE MEASURES IN PROGRAM DELIVERY

In addition to developing a sound transportation program, agencies are confronted with the difficult task of delivering highway and transit projects within expected scope, time frame, and budget. The combination of funding shortfalls, continual demand for additional capacity, public perception of construction delays, and cost overruns has intensified the focus on project delivery management. Some agencies must demonstrate suc-

Goal	Objective	Performance Measure	Target: Percentage of Miles Rated Poor Reduced to		
			2002	2005	
Maintain, upgrade, and improve the transportation system	Improve pavement ride quality	International roughness index for Interstates			
		National Highway System	Interstates	<5%	<1%
		Other department roads	National Highway System	<10%	<5%
			Other department roads	<20%	<15%

FIGURE 1 Connection between goals and performance measures in PennPlan (4).

successful project delivery before receiving additional funding. Political pressure is a driving force behind the increasing demand for performance reporting. For example, as a result of legislative and public opinion, a blue ribbon panel was created to evaluate Missouri Department of Transportation fiscal management. One result of this assessment was the production of a semi-annual report, *Dashboard of Performance*, to document project delivery performance data (7).

Project costs and schedules inevitably change for a variety of reasons including environmental mitigation requirements, utility relocation, right-of-way acquisition, inconsistencies regarding contingencies, and design errors (8, 9). Several transportation agencies also report that work is sometimes added to a project (“scope creep”) after approval (10). Although these changes to project scope and schedule and cost are likely to occur, performance-based management of program delivery will help an agency to assess and understand the reasons for the changes and to take assertive, corrective action where warranted. Applying performance measures to project delivery can lead to more effective utilization of funds.

Performance-based management of program delivery relies on measures to summarize project costs, track changes in project scope, monitor changes in delivery schedule, and minimize negative impacts of individual project-level changes on the overall program. Transportation agencies can use the performance measure data to explain project changes to elected officials and the public and thus improve accountability for public funds. Maintaining accurate project delivery information assists in the estimation of future human resources and cash flow needs across multiple years. In addition, regular reporting of project delivery performance increases its strategic importance with senior administrators and highlights the vital role of effective project management procedures and staff.

The role of performance measures in project delivery can be summarized as follows:

- Promote efficient program management and delivery.
- Minimize unnecessary or avoidable changes to scope, cost, and schedule to maintain the integrity and intended impact of the approved program.
 - Track the number, extent, and cause of scope, budget, and schedule changes and use these data over time to identify process improvements.
 - Communicate results both internally and externally.
 - Demonstrate accountability.

The concept of monitoring the delivery of projects is simple in theory but can be difficult to execute. In 1997

the General Accounting Office (GAO) reported that data on the cost of highway and bridge projects were not readily available from the Federal Highway Administration or states. Without sufficient data, it was difficult to understand the magnitude and cause of cost increases, which highlighted the need for better project cost management (9). The true timing of project delivery can also be unclear because of various delivery phases in which schedule tracking begins, revised “baselining” of schedules, and completion date adjustments during construction (8).

Since the 1997 GAO report was released, several state DOTs have enhanced their project management practices through the use of performance measures. For example, the Arizona Department of Transportation created the Program and Project Management Section (PPMS). This group tracks several project delivery performance measures on a monthly basis, including percentage difference of final contract cost from original bid, planned versus actual construction projects advertised, planned versus actual construction projects awarded, and percentage difference between actual days worked and original contract days. An important aspect of the PPMS system is that the Arizona Department of Transportation has set targets for several of these measures (e.g., 90 percent of the STIP projects should be awarded). Establishing performance goals for project delivery is an important element in further improving accountability and cost containment (9).

A few state legislative mandates requiring transportation agencies to improve the documentation of project delivery performance have been passed recently. In 1995 the California legislature required the California Department of Transportation (Caltrans) to

provide a report to the Legislature that proposes and evaluates performance measures for all major capital outlay support functions, including project studies, project development, right-of-way acquisition, and construction oversight. The department shall propose measures that 1) provide an accurate measure of annual efficiency, as well as 2) provide a consistent basis for year-to-year comparisons, and 3) evaluate both the department’s cost and its timeliness in completing work. Furthermore, the department shall demonstrate that each measure that it proposes can be accurately generated from the department’s existing or planned information systems. (11)

Since 1995, Caltrans has released annual project management reports that document 12 performance measures evaluating capital outlay functions. The reports summarize the status of the measures and where available present historical data and agency progress toward established targets. Figure 2 is an example of the annually reported performance data Caltrans uses to

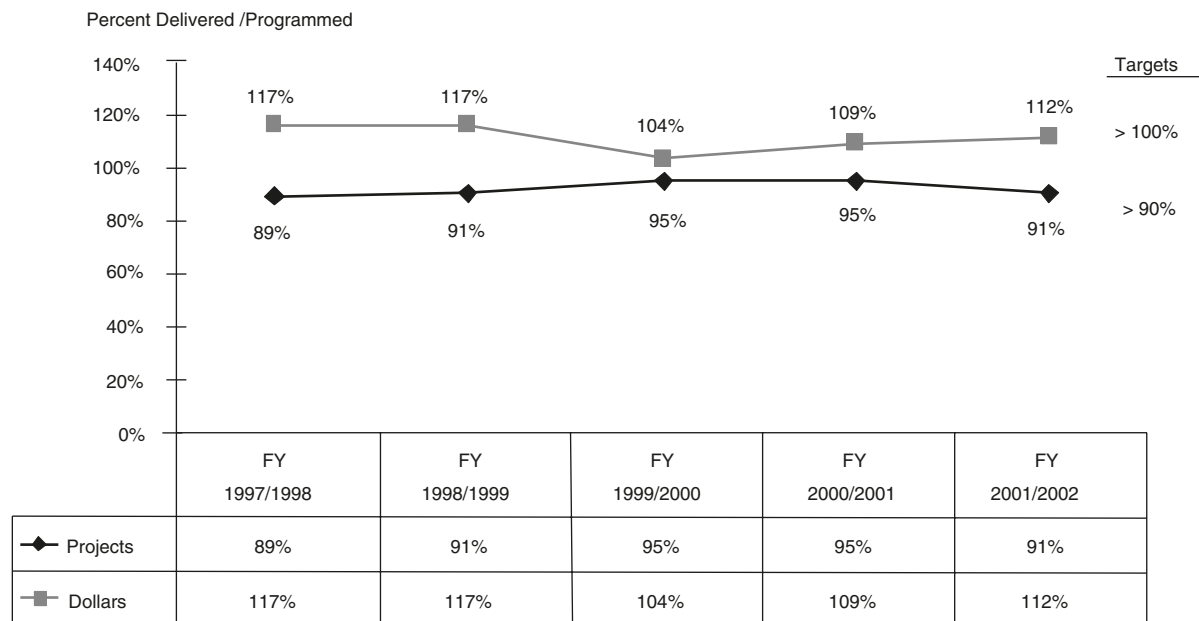


FIGURE 2 Caltrans project management measures: time growth (12).

evaluate the timing of projects. The measures tracked in Figure 2 indicate Caltrans's success in completing the design of programmed projects within or ahead of schedule.

Several states have implemented systematic tracking protocols to monitor various aspects of project delivery. The New Jersey Department of Transportation performance-based project management procedures were highlighted in the 2003 American Association of State Highway and Transportation Officials (AASHTO) report *Strategies for Reducing Highway Project Delivery Time and Cost* (8). The department's cost accounting system tracks all expenses associated with the delivery of highway projects including indirect costs eligible under the Transportation Equity Act for the 21st Century. Its tracking and scheduling system sets a baseline schedule that cannot be changed and monitors the project budget. In addition, the department has created a performance-based rating system that evaluates a project on the basis of completion time, safety, environmental compliance, pavement smoothness, and air voids. The rating system is designed to reward or penalize contractors on the basis of project completion time (8). The combination of a cost accounting, project tracking, and rating system provides the New Jersey Department of Transportation with the tools to manage project delivery effectively.

The Virginia Department of Transportation tracks the delivery of its 6-year program through an interactive web-based tool, the project dashboard. The dashboard system evaluates project delivery efforts (advertisement, construction contract deadlines, construction contract

awards, and construction contract work orders) on the basis of a three-point scale: green (on track), yellow (warning of potential problems), and red (problem exists). The straightforward presentation of project delivery data makes this information accessible to a wide audience. The performance trends for project delivery (on time and on budget) are also documented in the quarterly report card. The dashboard was created in response to legislative and public questioning of the department's fiscal management practices. The enhanced transparency of operations produced by the dashboard and the report card has not only improved the agency's project management practices but also improved the assessment of the Virginia Department of Transportation as an accountable agency.

Even though the use of performance measures for project delivery management varies across transportation agencies, there are several commonly used performance measures. The majority of measures address cost and time elements; however, some agencies are also tracking the safety and quality of project work. Table 1 presents several performance measures currently used by agencies to monitor project delivery.

Most existing performance-based project delivery systems focus on current and historical performance data to evaluate progress over time. A few agencies set targets for selected performance measures to help focus project delivery improvements. It is uncommon to use project delivery measures to compare agencies, and a recent AASHTO report cautions against benchmarking project delivery measures without an in-depth analysis of how project costs are categorized (8). For example, a

TABLE 1 Project Delivery Performance Measures (13, 14)

Category	Sample Measures
Cost	Ratio of preliminary engineering, environmental, design, right-of-way, or construction costs to total project costs Administrative cost by project Actual project cost versus award costs Dollars per project mile Percentage of unprogrammed costs (e.g., errors in materials) Number of contract change orders and costs
Schedule	Percentage of construction projects completed on time Actual versus planned project award or advertisement schedules Additional days required to complete project Percentage of STIP delivered by year planned
Safety	Number of accidents in construction zones
Quality	Evaluation of contractor's work by certification acceptance (field review of project) Percentage of engineering work requiring rework Survey of contractors evaluating construction process Project manager evaluation of contractors

state with a more sophisticated cost accounting system that captures all costs charged to a project may register a higher design and construction inspection/engineering cost than a state with a less comprehensive system.

Compared with the development and use of performance measures in transportation planning and programming, only a small body of research currently documents performance-based project delivery. Questions concerning the selection of appropriate measures, reporting cycles, and data sources remain. Agencies are under increasing pressure to track and communicate project delivery performance, and they have access to a limited number of tools. Although the “dashboards” produced by a few agencies such as the Virginia Department of Transportation have been received well, it is unclear whether this approach will be able to provide project delivery details required by some oversight agencies (7). In addition, existing project delivery measures fail to address the impact of a project on transportation system performance (7). Agencies may also be interested in the cost savings associated with implementing performance-based project delivery. Useful insights may be provided soon by some recently initiated studies (e.g., National Cooperative Highway Research Program Project 8-49, Procedures for Cost Estimation and Management for Highway Projects During Planning, Programming, and Preconstruction). However, the absence of project delivery performance guidebooks, documentation of the state of the practice, and calculation of potential cost savings and the lack of postproject delivery evaluation tools clearly expose the need for further research.

LINKING PROGRAM DEVELOPMENT AND DELIVERY

Performance-based management of a transportation system is made up of three components: program develop-

ment, program delivery, and system monitoring and reporting. The focus of this paper has been on the first two components, and we have documented in the previous sections how performance measures have been applied to program development and program delivery. The next level of sophistication and benefits occurs when existing performance-based program development and project delivery processes are linked.

The linkage of performance-based program development and program delivery in an agency is rare. In fact, many agencies are engaged in only one of these processes, which reduces the overall effectiveness of their performance-based management. For example, a performance-based program development process in isolation may identify the best projects to fund but may not guard against excessive scope creep, schedule slippage, or cost escalation. As a result, the program as delivered may cost more than promised and deliver less in terms of system condition and performance. If costs rise and the amount or quality of work diminishes, the benefit–cost ratio of the program is almost certain to be measurably lower than expected. Conversely, a performance-based delivery process in isolation may result in the efficient delivery of a program that includes marginal projects, and again the ultimate effectiveness of the program may be reduced. By executing both performance-based program development and project delivery, the most effective set of projects is not only selected but also implemented efficiently.

We have documented how the implementation of performance-based program development and delivery varies across transportation agencies. Although there are some similar benefits to using performance measures in both processes, there are also distinct differences. A recognition of how performance measures vary between program development and delivery is important in beginning to understand the benefits and how to link the two processes. Table 2 provides a comparison of characteristics of performance measures for program development and delivery.

A graphical display of a performance-based management structure further illustrates why agencies should link program development and project delivery (see Figure 3). Component 1, program development, typically begins with establishing agency goals and objectives that are in turn monitored through performance measures. On the basis of resource constraints, performance targets are set and projects and programs are identified and selected on the basis of performance criteria intended to lead a transportation agency toward its goals and objectives. For example, a state DOT could identify the goal “preserve the existing system,” with the related performance measure “percentage of highway miles with acceptable pavement condition.” In turn, a project selection (or program budgeting) crite-

TABLE 2 Comparison of Performance Measures for Program Development and Delivery

Process Characteristics	Planning and Program Development	Program Delivery
Key objective	Allocating resources to programs and projects to achieve system performance goals	Delivery of selected programs and projects as efficiently as possible with minimal impact on cost, scope, and schedule
Types of measures	System condition and performance (pavement condition, congestion, safety, etc.)	Address costs, scope, schedule, and work safety and quality
Data reporting frequency	Data collected and reported over long periods of time. The impact of selected programs and projects on the transportation system often not known for several years	Project delivery information tracked on a regular basis (annually, monthly, and even weekly)
External factors	Existing external factors (driver behavior, demographics, etc.) affect performance	Unexpected changes in external factors affect performance
Challenges	Selecting measures Data availability Analytical tools to predict performance External factors Defining expenditure impacts on system performance Monitoring over time	Selecting measures Data availability Tracking project changes External factors Assessing impact of program/project changes on system performance

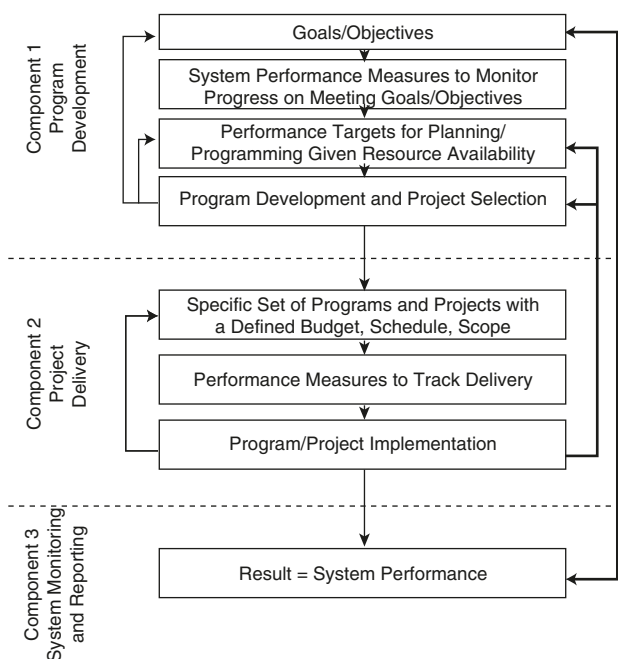
tion would be the project's estimated impact on highway pavement condition. The relationship between performance targets and project selection is an iterative process based on changing needs, available resources, and political support.

Component 2, project delivery, begins when preselected projects are passed off to the delivery team. A performance-based process uses measures to evaluate and monitor project implementation (e.g., percentage of construction contracts completed on time). Figure 3 illustrates not only that selection and delivery of project and programs are separate processes but also that there are two distinct groups of performance measures.

Measures in one group relate to project selection and are linked to agency goals and objectives, while those in the other focus on delivering projects. Typically, different groups of people are involved in developing each set of measures, which further separates and works against effective linkage of the two processes.

Although there are different performance measures and procedures associated with program development and program delivery, it is the delivery of projects that produces the result (i.e., system performance). The third performance-based management component, system monitoring, reports on the performance changes that are due to implemented projects and programs. Although the delivered projects and programs are ideally selected through performance-based program development, the delivery of the program is what forms the foundation on which transportation goals and objectives will be met. This fact highlights the importance of linking program development and delivery.

To date, there are few examples of successful linkage between performance-based program development and delivery. However, agencies' past experience with the two components of performance-based management highlights several effective approaches. To form a connection between program development and delivery, transportation agencies need to communicate the value of selected projects to the delivery team and clarify how these projects were chosen. Although the performance measures that guide program development and delivery are different, a worthwhile exercise would be bringing together planners and project managers to discuss how the two processes enable an agency to reach its goals or even to discuss potential common measures. In creating this type of strategic linkage, the balanced relationship between program development and delivery should be emphasized; both are necessary components of a successful approach.

**FIGURE 3 Performance-based management structure.**

An important aspect of a strategic linkage between program development and delivery is that the criteria for evaluating and accepting scope changes need to be consistent with the criteria used for selecting the projects in the first place. In this way, the effect and benefits of the project with respect to system goals remain consistent with the original intent and assessment of the project. For example, if benefit–cost ratio was a criterion in selecting a project, it would be prudent for project managers to reevaluate this criterion when proposed scope changes are considered. If the revised scope and cost would result in a substantially different benefit–cost metric, this should be considered before accepting the scope change. While often the sunk costs and momentum of a large project dictate that work must progress, reevaluation of the cost-effectiveness may result in further scope (or overall program) refinements that minimize negative impact on the program. This information should be gathered with the assistance of, or at least be communicated to, the program development team.

The sharing of knowledge during and after project delivery is also vital to this strategic linkage. Information needs to flow not only from the program development team to the project delivery team but also from the project delivery team back to the program developers. To select projects and programs effectively in the future, an understanding of why a program changed or why the individual projects within a program changed is vital. Did cost issues derail a project or was there politically facilitated “queue jumping”? Another important piece of information is the impact of project delivery changes. If only 75 percent of the project was able to be delivered because of cost escalation, how were the necessary scope changes determined? If, for example, one or more of the proposed direct connector ramps had to be deferred or dropped entirely in a major freeway-to-freeway interchange reconstruction project, how were the most desirable scope changes (i.e., those with the least impact) determined? If only some of the projects in the overall program were delivered, how was it decided which projects would be deferred, and what was the impact on the original program goals? While such compromises and sacrifices are not uncommon, the lessons learned during the delivery of a project could provide useful information for future program development cycles if the details are tracked and reported.

A good example of the benefit associated with the “knowledge linkage” between program development and delivery is the impact of the Washington State Department of Transportation quarterly performance report, *Measures, Markers, and Mileposts* (also known as the Gray Notebook). This report includes performance measures that address program development as well as project delivery. The combination of reported measures has helped diminish agency and program silos

and create a new level of collaboration throughout the agency (15). The Gray Notebook has given project managers and senior managers the means to discuss and diagnose the department’s transportation program. Recently, the department underwent a reorganization that resulted in programming, system analysis, system planning, and strategic assessment responsibilities being housed under one division. This change further improves links between planning and programming. In addition, the information presented in the Gray Notebook will be the foundation for the next statewide transportation plan.

Another means of connecting program development and program delivery to each other is to make efficient project delivery itself a high-level agency goal. The goals and objectives that guide program development typically do not address the delivery of projects, just as measures used to evaluate project delivery do not often link back to agency goals, other than in terms of general efficiency and accountability. The goals established at the highest level of performance-based management should be influenced by both program development and delivery decisions and actions and therefore create a natural link between the two processes. For example, the Missouri Department of Transportation produces a semiannual report documenting the department’s progress toward three goals: “take better care of what we have,” “finish what we’ve started,” and “build public trust” (16). The department’s progress is evaluated on the basis of 16 performance measures that are linked to one of the three goals. The majority of the reported performance measures are common program-oriented indicators (e.g., fatality rates, deficient bridges). However, the department uses four project delivery measures to assess how well it is “finishing what we’ve started.” Including a project delivery objective as an element of broad agency goals or vision elevates project delivery performance to a departmentwide level. This helps raise the awareness of project delivery and communicate its importance to the staff and the public.

CHALLENGES TO LINKING PROGRAM DEVELOPMENT AND PROGRAM DELIVERY

To link program development and program delivery effectively, several issues need to be addressed, including time and resource constraints, internal organization restrictions, external factors, and internal and external communication challenges.

A successful connection between performance-based planning and project delivery will require a joint effort between those involved in each process. Since transportation agencies are struggling to implement existing programs and projects, it will be a challenge to dedicate resources (funding and staff time) for this effort. Initial steps, such as jointly reporting and publishing program

development and delivery data as in the Washington State Department of Transportation's Gray Notebook, will facilitate the essential process of knowledge sharing. Ideally, the end result of linking the two procedures will be a more efficient use of resources, although reaching that point will take time and reallocation of internal resources.

The organizational structure of a transportation agency will also affect performance-based management. Some agencies have firewalls, intended or not, between the various functions such as programming, project development, environmental clearance, procurement, and construction management. The separation of the activities can lead to some cost efficiencies but may negatively affect the flow of information necessary for a comprehensive performance-based process. A recent AASHTO report focusing on project delivery concluded that states whose employees could perform many functions and understood the project delivery process experienced more efficient handling of workloads. Multifunctional staff would be a key component in linking performance-based program development and project delivery.

As in setting up any aspect of a performance-based management system, support from top management and buy-in from those who must implement the system are essential. If it is perceived as a cumbersome but nonessential reporting process, a performance management system will fail to achieve its central objective (i.e., efficient delivery of an effective program of projects). To increase employee support for performance-based management, many agencies have carried out training and meetings to further explain the benefits (e.g., the Minnesota Department of Transportation). Other agencies have established a more direct link between staff and performance outcomes to create ownership over an agency's success (7).

External factors that influence the development of performance-based programs and project delivery will also affect an agency's ability to improve the connection between the two processes. For example, the relatively short time frame for results expected by elected officials in many states influences project selection and delivery. Elected officials may be impatient to show immediate results in terms of project completion, regardless of whether the projects deliver the magnitude of improvement that was anticipated during the planning and selection phases. Furthermore, as legislative turnover occurs because of term limits or other factors, changing priorities can undermine the longer-term objectives of a coordinated performance-based programming and project delivery process. Practitioners report difficulty in balancing the short-term interest of elected officials with the longer-term perspective they have as system owners and conservators. Similarly, there is always pressure to spend the allocated funds even if available projects are not the most ideal. Thus, the shorter time frame for project budgeting and construction relative to the planning and pro-

gramming processes may work against linking program development and delivery. A clearly articulated agency goal such as "efficient program delivery" supported by a culture of performance-driven decisions will help agencies to stay the course even as they respond to external change forces and wavering political support.

Improved communication and data management are both requirements and key benefits of connecting performance-based program development and project delivery. Internally, agency staff need to improve the speed and quality of information transfer between program development and delivery functions. For example, the lag time between construction activities and receipt of accurate cost-to-complete data inhibits the process of reassessing project cost-performance metrics. If agencies are to assess the potential impact of changes to the delivered program (e.g., deciding which projects to defer to allow completion of a project in significant overrun) in advance of making the decision, they need current information on cost to date and cost to complete. The time frame for making decisions on scope changes is constrained by the high cost of keeping construction crews and equipment fully utilized; it is no doubt difficult for most agencies to reassess program impacts on short notice because of data limitations and staff availability, even if this level of cooperation and coordination exists between the development and delivery functions. Creating a more open dialogue and free exchange of timely information between planners, program developers, and the project delivery team will enhance an agency's overall performance management.

An equally important element of communication is a frank and honest presentation of information to high-level decision makers, external stakeholders, and customers. Even though the data may show some inefficiencies or problems, it is important to convey the full story to create a lasting atmosphere of trust and credibility. However, there can be resistance to documenting problems with either program development or delivery. Effectively communicating technical aspects of the two processes can be challenging, and the means of communication may vary according to the audience (e.g., internal program managers, policy makers, lay public, stakeholder agencies). On the whole, explaining system performance expectations and results may be easier than the more technical project delivery data, but decision makers and stakeholders would benefit from a better understanding of the major factors that contribute to delays and overruns in project delivery.

SUMMARY

Performance-based management is grounded in three components: program development, project delivery,

and system monitoring and reporting. The degree of implementation of these three components varies across transportation agencies. However, a large number of agencies have incorporated performance measures of some form into their transportation system management. As this practice expands, the benefits of improving connections between program development and program delivery become more apparent and significant. Performance-based program delivery will increase the likelihood that the selected program of projects has the capability to improve the *effectiveness* of the system. Performance-based project delivery ensures a more *efficient* delivery of those program benefits. And ongoing monitoring and reporting of the results lead to incremental improvements in both processes, greater awareness of the benefits of system investment, and improved agency accountability to the public and elected officials.

By building the relationship between program development and program delivery, agencies will guide transportation decisions from conception to implementation more proactively and consciously. As the relationship between program development and delivery strengthens, goals common to the two processes will become clear. Even though program development measures will differ from project delivery measures, common agency goals will help link the processes. In addition, linking program development and delivery will improve communication across the agency (e.g., between planners and programmers) as well as with external stakeholders.

A number of internal and external challenges exist in linking the program development and delivery processes. As is often the case, the best approach to addressing these challenges varies from one agency to another, depending on their key objectives, organizational structure and governance, and resources.

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Issues and Challenges in Using Existing Data and Tools for Performance Measurement

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Many transportation agencies seek to improve business processes by expanding the use of performance measurement without making significant additional investments in data collection and analysis tools. The purpose of this paper is to highlight technical issues associated with the use of existing data and tools for performance measurement in a transportation agency. Common challenges are identified and recommendations are included so that agency staff can anticipate and address the challenges in a proactive manner.

INTRODUCTION

Transportation agencies seeking to implement performance-based planning and budgeting methods rarely have the luxury of embarking on completely new data collection efforts and acquiring new information systems and analysis tools in support of these efforts. Agencies must rely, for the most part, on existing data and tools. This is not necessarily a hardship—most agencies that provide transportation facilities and services typically collect considerable amounts of data about system condition, performance, supply, and demand. The challenge is how to take best advantage of the data collection resources and tools that are in place.

Implementing or improving a performance measurement system need not be costly, time-consuming, or resource intensive. A simple initial program can be established by using a single indicator that is of interest

to an executive-level sponsor, with targets indicating whether performance ratings are satisfactory or need improvement. The program can evolve incrementally over time as the agency learns from the initial experience. It can add more measures; improve the sophistication of measures; further integrate the use of the measures into strategic and tactical decision-making processes; and communicate results to a wider group of customers, partners, and stakeholders. This evolutionary model of performance measurement improvement (as opposed to a “big bang”) is typical in agencies with successful programs.

One common misconception is that performance measurement is synonymous with data collection: “If only we had the resources to collect better, more detailed data, then we could implement performance-based budgeting properly.” While the importance of good data cannot be ignored, there are many examples of agencies that have plenty of data but cannot or do not put the data to good use. The success of a performance-based planning and programming effort in an agency depends on a host of “downstream” activities. Among them are processing and quality checking the raw data, integrating data from different sources for mapping and analysis, transforming raw data into meaningful information to be reported as performance measures, developing trend information, projecting into the future for purposes of target setting and what-if analysis, and providing tools to decision makers to give them access to performance information in a convenient and useful way.

There also are challenges on the business side with respect to using performance data effectively for decision making and ensuring that the more mundane but critical processes and responsibilities for data processing, analysis, and distribution are working as well as possible. Each of these elements of performance measurement—data collection, processing, integration, management, analysis tools and methods, dissemination, and use in the business process—is important to the ultimate success of the effort. Agencies should determine which elements need more attention and develop a balanced strategy for improvement. Typically this strategy will require effort on multiple fronts:

- Measuring the right things at a level of detail appropriate to what they will be used for;
- Taking advantage of current technologies and tools for data collection, processing, and analysis;
- Making the best possible use of existing data and legacy systems;
- Enhancing tools over time to provide better decision support; and
- Building the staff capability and commitment required to ensure quality information and analyses that are actually used to make decisions.

The scope of this paper is limited to performance measures related to the transportation system and service provided to system users as opposed to the performance of transportation agency personnel or organizational units. The paper also focuses on those measures used for high-level strategic (rather than tactical) decision making. Such performance measures allow executives and managers to identify key trends and conditions, understand causal factors, and act on the information.

DATA AND TOOLS FOR SPECIFIC TYPES OF MEASURES—EXAMPLE APPLICATIONS

This section discusses four categories of performance measures:

- Infrastructure condition and deficiency measures,
- Mobility measures,
- Safety measures, and
- Customer service measures.

For each of these four categories, common types of measures and current issues related to the use of existing data and tools are reviewed briefly. Then an example is provided to illustrate how agencies are making effective use of existing data and tools for performance measurement. The examples provide the background for the more general guidance provided in the following section of the paper.

Infrastructure Condition and Deficiency Measures

Condition is often included as a key performance measure to indicate how well the agency is preserving the substantial investments that have been made in infrastructure. It also is often used as a proxy measure for the quality of service provided to transportation system users. Examples of infrastructure condition measures are average ride quality, percentage of asset length or count by condition range or category, remaining life, bridge health index, and bridge deck condition.

Measures of functional deficiency are used to describe how well transportation facilities are serving their intended purpose. Examples of infrastructure functional deficiency measures include number or percentage of load-posted bridges, percentage of miles not meeting shoulder width standards, and percentage of underpasses with height postings.

Measures of backlog or need can be derived on the basis of standards for condition or functional deficiency. For these type of measures, it is best to establish precise criteria for what constitutes a need so that identification of a need can be an automated process. Because agency policies change over time, it is useful to provide tools that can derive deficiency or backlog measures from physical characteristics of facilities (lane and shoulder widths, load ratings, sign reflectivity, etc.) on the basis of varying definitions for what constitutes a deficiency.

The use of remaining life as a performance measure is one approach that allows agencies to compare performance across different classes of assets. This requires reasonable estimates of the expected life of different types of assets under varying circumstances (traffic, environmental conditions, construction methods, maintenance practices). Agencies using this measure will need to address the eventuality that regardless of the expected life values they set, there will be some facilities in operation with a remaining life of zero (or less than zero), which may be difficult to explain to the public.

Asset management systems are indispensable tools for performance measurement in this area, with capabilities to maintain inventory and inspection data and to store condition trends over time. Some systems also provide capabilities for performing analysis to understand how future investment levels and patterns could affect system performance.

Example: The Montana Department of Transportation's Performance Programming Process (P³) establishes pavement performance targets for different portions of the roadway system (Interstate, National Highway System, and primary). Performance measures for pavement are the average ride quality and the percentage of system length in poor condition. The department's Planning Division makes extensive use of a

pavement management system (PMS) to report current pavement performance and to develop resource allocations to work types and systems that will allow the department to meet the established performance targets for each system in each district.

The PMS already was in use within the department's Materials Bureau before the implementation of P³ in 2000. Its primary application was for site-specific analysis and determination of appropriate pavement treatments. Pavement condition data collection procedures were well established, and the system had performance curves and decision rules needed to predict future performance and simulate performance impacts of alternative budget levels.

The department undertook several activities to make use of this tool for performance-based planning:

- Coordination and agreement with the Materials Bureau on data updating protocols and schedules, including responsibilities for updating the list of programmed pavement projects to be considered by the simulation;
- Minor modifications to the software to provide reporting of aggregated performance results by the three system categories used for performance reporting;
- Development of new spreadsheet-based tools that take the system's outputs and produce charts and graphs needed for P³;
- An annual quality assurance process consisting of running the simulation, reviewing network-level results against prior trends, and correcting the modeling parameters and data as needed; and
- Iterative runs of the system to determine the best allocation of resources across work types and districts to meet established performance targets.

This example shows how infrastructure management systems can be used to provide technical information and analysis that are needed to support a performance-based planning process. It illustrates how systems that are implemented by one organizational unit (e.g., one concerned with facility inspection and development of maintenance, rehabilitation, and repair strategies) can be adapted by the unit responsible for performance-based planning.

Safety Measures

Examples of safety measures are number and rate of fatalities, injuries, run-off-the-road crashes, pedestrian crashes, heavy-vehicle crashes, impaired driver crashes, repeat offender crashes, uninsured driver crashes, and unlicensed driver crashes.

In view of a new federal strategic goal to reduce by 9,000 the number of annual deaths attributable to high-

way crashes, safety data needs and new levels of data integration must be given more attention before the 2008 implementation target. More than half of the fatalities are on rural two-lane roads, and half of those are off the state highway system. Effective design of a program to reduce fatalities will require accurate crash records to be readily available in context with highway inventory and built environment attributes in a geographic information system (GIS) analysis framework across multiple government functions and levels of jurisdiction.

Lack of standardization of crash data collection criteria and methods within and across states and changes to these criteria and methods over time have made it difficult to benchmark one jurisdiction against another and to develop valid trend information for nonfatal crashes. Time-consuming manual data entry procedures for police crash reports also have presented problems of timeliness and accuracy in safety data, particularly with respect to establishment of reliable accident locations that can be correlated with highway design and condition attributes. Progress is being made in all of these areas, however, as states implement uniform crash-reporting procedures and automated processes.

Example: The New York State Department of Transportation's safety goal is to reduce deaths, injuries, and total accidents. Three intervention strategies are safety capital projects; safety enhancements implemented within capital projects that are programmed for other purposes; and highway maintenance actions such as signs, delineation, traffic control devices, and other low-cost accident countermeasures. The accomplishment target is an average annual reduction of 1,500 accidents occurring at identified high-accident locations (HALs) on the state highway system, which would result in annual reductions in accident costs of \$80 million. The project selection criteria are to address and treat HALs cost-effectively, reduce severe accidents at the lowest possible cost, and engineer accident countermeasures into all capital projects.

HALs are identified by comparing prevailing accident rates with average rates for similar facilities. Sites with rates at least three standard deviations above the mean are then evaluated in detail with the use of collision diagrams. Expected accident reductions attributable to engineering countermeasures are calculated from historical before-and-after studies. Benefit-cost analysis is required for all safety capital improvements. Those with benefit-cost ratios greater than 1.0 are programmed for implementation within 5 years of problem identification. Tallies of expected accident reductions and accident cost savings are kept in the program and project management system database. Postimplementation monitoring is used to refine accident reduction factors. Regions that do not propose sufficient safety goal accomplishment in their

biennial program update proposals are directed by executive management to rebalance their program proposal appropriately.

A web-enabled safety information management system is the technological centerpiece for conducting network-level statistical analysis. Linear referencing of crash locations with data from the traffic-monitoring and highway inventory systems is essential for calculation of accident rates. Availability of HALs in a GIS environment is one of many mappable attributes of the highway network.

This example illustrates many successful techniques for using existing data and tools for effective performance measurement: linkage of an outcome-oriented performance measure to targets and specific project selection criteria and procedures, monitoring of program impacts through a combination of output-oriented measures (projects implemented) and modeled impacts, use of the existing GIS tool to disseminate crash information widely within the agency for use by decision makers, and use of GIS to perform integration of existing data sources (accident data and traffic data) needed to derive useful performance measures (crash rates) from raw data (crashes).

Mobility and Reliability Measures

Examples of mobility and reliability measures are annual average daily traffic per lane mile, average travel rate (minutes per mile), nonrecurring delay, incident-related delay, travel time index (median reliability measure), planning time index (95th percentile reliability measure), and percentage of vehicle miles of travel under congested conditions.

Rapid progress and change are occurring in this category of measures as a result of the congestion management systems implemented by states in response to federal Intermodal Surface Transportation Efficiency Act legislation during the early 1990s, standardization of archived data user services information flows from intelligent transportation systems, and advances in theoretical understanding of how agency interventions to address mobility issues change transportation system performance. Reliability of expected travel time through a metropolitan area is being articulated by the logistics industry as its principal performance concern.

Determining the locations, magnitudes, and durations of disruptions to expected travel time patterns requires processing of extensive data flows. Interval binned vehicle classification, speed, and volume continuous and coverage counts are routinely stored and made available in traffic-monitoring systems. Results of macroscopic and microscopic travel simulation models and associated two- and three-dimensional visualiza-

tions are in widespread use in metropolitan areas for areawide and project-level analysis.

Current challenges include capturing, quality checking, and archiving data flows from traffic management centers and ensuring that traffic simulations and visualizations are an accurate portrayal of performance for the scenario being modeled. Both occur upstream in the work flows that lead to reporting of transportation system performance.

Example: Simulation modeling of recurring and incident congestion is at the heart of mobility performance measurement in the New York State Department of Transportation. Primary data sources are the highway inventory (containing both physical and administrative attributes) and weekday hourly directional traffic counts from the coverage count data collection program. Evaluation of strategies to reduce congestion is accomplished by modifying policy variables in the simulation models, such as incident detection, response, and clearance times. Excess delay incurred by persons and goods traveling on the highway system and wasted fuel are the primary simulated performance measures. The economic losses associated with excess delay are monetized and estimated at more than \$4.3 billion annually for state highways. The simulation model is implemented on a desktop computer. Input data files for the model are updated on an annual cycle, and output results are linearly referenced for use in GIS.

Cost-effectiveness ratio criteria are the basis for programming projects. In the greater New York City metropolitan area, projects must reduce simulated excess delay for the opening year of the project by at least 75 person-hours per day for each \$1 million of initial investment. The criterion is 35 for Upstate New York. Congestion is growing in New York, and the current funding constraints necessitate a modest goal of reducing the growth in excess person-hours of delay by the end of the 5-year program period to 10 percent less than the simulated base case forecast.

Other selected aspects of the mobility program and performance measures for it in New York are as follows:

- **Travel demand management:** Actions that reduce single-occupant vehicle travel during peak hours must be funded to at least a level of \$3 million during the 5-year program. The performance measures used are percentage increase in peak-hour average vehicle occupancy and percentage reduction in growth of peak-hour vehicle miles of travel within the first 5 years of the program period.
- **Transportation system management:** Each of the 11 regions must program investments for at least 10 of the most congested spot locations where peak-hour recurring queued conditions (Level-of-Service E or worse) can be addressed with relatively low-cost short-

term strategies. The performance measures used are number of spot locations eliminated and person-hours of delay and truck-hours of delay reductions by the end of the 5-year program period.

- **Bicycle–pedestrian facilities:** Programming projects to implement approved bicycle–pedestrian facilities to increase use of nonmotorized transportation in congested corridors. The performance measures used are new miles of on-street bicycle facilities, quantity of new or upgraded sidewalks and crosswalks, miles of multiuse paths, number of transit facilities and activity centers accessible to bicycles and pedestrians, and the increase in bicycle and pedestrian usage by the end of the program period.

This example shows how existing data from roadway inventory and traffic counts can be combined with traffic simulation tools to calculate mobility performance measures. Like the safety example, it demonstrates the value of integrating a high-level outcome-based measure with targets and project selection criteria and the establishment of specific monitoring measures (some modeled and some output based).

Customer-Oriented Performance Measures

Most existing performance measurement efforts have focused on performance from the facility or supplier point of view. There is growing interest in reflecting the customer point of view and in using customer perceptions of transportation service as a performance measure. Examples of sources from which perception performance measures can be gleaned are random sample surveys of travelers and the public, web feedback, phone calls to 311 municipal services, phone calls to 511 traveler information services, press clippings, and media editorials.

Not surprisingly, transportation user advocacy groups frequently use customer-related performance measures in their publications. The Road Information Project (www.tripnet.org) and the American Highway Users Alliance (www.highways.org) express the backlog of needs in terms of the excess cost of travel per highway user on an annual basis. The costs attributed to condition and performance shortcomings are likened to a hidden tax, which is a drag on regional and national economic efficiency in a globally competitive marketplace. The Texas Transportation Institute's annual *Urban Mobility Report* (mobility.tamu.edu), which is a leading national source of congestion information, also focuses on customer-based measures.

The following are challenges in using customer-oriented measures:

- Routine collection of customer perceptions to establish valid trend data may be costly.

- A relationship between customer perceptions and actual facility or service characteristics must be established.

- Customers typically cannot distinguish facility ownership, and therefore poor customer ratings of the road network collected by a state transportation department could reflect conditions on the local street network.

Example: One of the most active state departments of transportation in the collection of information from customers has been Pennsylvania's. Customer data have been used for business planning and program development processes. Customer data sources have included annual statewide telephone surveys to measure customer perceptions of highway services, focus groups, and interview data gathered during the long-range transportation plan development process.

A number of techniques have been used to refine customer data collection over time to improve its usefulness:

- Survey sampling plans and question design that are sufficiently detailed to provide accountability at a district level—county-level surveys addressing topics that are easily related to the perceived mission of district engineers are more useful than surveys designed to track overall statewide customer satisfaction;

- Inclusion of questions that distinguish among different types of routes (e.g., Interstate versus other);

- Survey designs that assess the perceived importance of a given performance element, the customer's rating of that element, and the range of ratings the customer considers acceptable;

- Focus group methods that assess willingness to pay—for example, by asking respondents to allocate \$100 to various strategic focus areas; and

- Focus group questions to ascertain customer perceptions about whether performance indicators are improving over time.

Customer data have been used to conduct strengths, weaknesses, opportunities, and challenges analyses during the strategic planning process. Strengths are defined as department products and services that have high customer approval and that are perceived as important (high importance, high grade). Opportunities are products and services that have low customer approval but are still perceived as important (high importance, low grade). Weaknesses are internal policies that could limit the department's ability to meet customer expectations, and challenges are external factors that could limit the department's effectiveness.

Recent initiatives at the Pennsylvania Department of Transportation have been pursuing the establishment of tighter linkages between data from operational systems

(e.g., roadway inventory and pavement management) and customer data. Operational data can help interpret the importance of customer satisfaction and importance ratings and avoid simple reliance on these measures. A 2003 research report (1) sponsored by the department identified “break points” in the international roughness index where customers perceived pavement condition to shift from acceptable to unsatisfactory. The department also is working to develop predictive models (2) that estimate changes in customer satisfaction that would result from changes in operational performance targets. The results of these efforts will be used to inform the establishment of performance targets and guide resource allocation decisions.

GENERAL GUIDANCE: MAKING THE MOST OF AVAILABLE DATA AND SYSTEMS

Challenges in using existing data and tools for performance measurement can be divided into three categories:

- Defining performance measures—deciding which performance measures and data sources to use,
- Collecting and managing the data, and
- Using performance data to support decisions.

Guidance for each of these areas is provided below.

Defining Performance Measures and Identifying Data Sources

Defining performance measures and gaining consensus on which performance measures to use is the first challenge faced by agencies that are starting or expanding a performance-based planning program. An agency should establish clear goals for what is being measured and how performance measurement is being used in the agency’s decision-making process. At least initially, deciding how to measure performance should not be based on what data are now being collected but on what the agency is trying to accomplish, the framework of policy goals and objectives that have been established, and the expectations of customers and partners. With these goals established, the following strategies can be used to define a performance measurement effort that makes the best use of already existing data and tools.

Build on what already is in place. Consider the information and tools that already are being used to make decisions at both the strategic and tactical levels of the organization. Recognize that establishing data programs and analysis methods for performance measurement is not an overnight process. It takes a significant amount of time and often years to refine data collection

techniques, smooth data, and establish trends to ensure reliable results. Therefore, build on the already established data collection practices and procedures to the extent possible.

Measure what will be used and use what is measured. Data items should not be collected just because they are available—they should have a critical business process use. It is best to select a small set of performance measures that can be tracked realistically and used. Ideally, performance measurement is integral to an agency’s business processes. Managers depend on the information for both strategic and tactical decisions, and external partners and customers demand it. When performance information is in active use, errors in data and modeling results are quickly recognized.

Assess the need for data quality improvements. Where existing data sources are to be used, evaluate their accuracy, precision, timeliness, and consistency and consider the ways in which the data will be used in performance measurement. Data quality improvements may be warranted, particularly for data that support multiple performance measurement processes or that will be used for critical decisions. Developing a strategic data plan for the agency is one way to assess whether it makes sense to reallocate existing data collection resources to support the performance measurement program. It may be cost-effective to make incremental improvements in existing data collection programs that will yield quality improvements essential to the credibility and value of the performance-based planning process.

Check for inconsistencies across systems. It is particularly important to ensure accuracy and consistency of fundamental measures, such as system mileage and vehicle miles of travel, that are used to calculate many types of performance measures (e.g., weighted average condition or condition distributions). Inconsistencies in these types of measures across data sets and analysis tools can sometimes arise because of the use of different data sources and data estimation methods. Sometimes the problem relates to data definitions. For example, many pavement management systems treat a 1-mile section of a divided highway as 2 centerline miles, whereas Highway Performance Monitoring System data sets may treat this as 1 centerline mile. Other times, the problem is due to the lack of data integration and updating procedures, with the result that some systems do not have up-to-date information. Whatever the source of the problem, it is important to perform basic consistency checks on fundamental measures before combining or comparing data from different analysis tools or data sources.

Measure or model the agency’s contribution to improved performance. Agencies have tended to rely on output-type measures rather than on outcome-type

measures because what they do can be controlled, but the impact of what they do is not always easy to assess, let alone control. However, agencies need to demonstrate how expenditures of public tax dollars are in fact making things better for customers than they otherwise would have been. Benefits of operational improvements are particularly difficult to isolate for performance measurement. Frequently correlation can be established but not causality. Exogenous factors (such as fuel prices) that affect the result are difficult to predict. This performance measurement issue is the most challenging from a data standpoint. Several strategies can be used to address the issue of causality. First, agencies should strive to maintain consistent data collection methods over time in order to have valid trend information. Second, well-planned before-and-after studies can provide some level of control over certain variables. Third, groupings of performance measures can be set up that combine broad customer-oriented measures with measures that are more directly related to an agency's actions. Finally, modeling tools can be used to estimate the impacts or benefits of agency actions, as illustrated by the New York State examples above.

Identify trend data. Investigate the availability of trend data for the measures that are selected. Have consistent trend data been established for the data sources to be used? How far back in time? Have measurement methods or computation methods that affect the validity of the trend line changed? If changes in data collection methods or schedules are under consideration, consider the impacts of these changes on the agency's ability to maintain valid time-series information for key performance indicators.

Anticipate data integration and quality-checking requirements. Calculation of many performance measures requires integration of data from multiple sources. For example, accident rates are derived from crash statistics and vehicle miles of travel. Integration is even more crucial for display and analysis of monitored data—for example, to allow district engineers to view pavement condition, accident rates, and congestion hot spots on the same map for use in project development. Therefore, it is important to look at the location referencing methods and the level of accuracy in location for the data to be used in performance measurement. Temporal referencing also is important for data integration and quality checking—for example, to correlate measured improvements in infrastructure condition with capital projects or maintenance activities.

Define performance rating scales and establish a feedback loop. Knowing whether goals are met is insufficient information for a leader to use in making decisions about how to improve agency performance. It is helpful to define a quantitative performance rating scale for each goal, with an upper and a lower bound and

ranges such as “excellent,” “satisfactory,” and “needs improvement.” It is also helpful to track whether the current performance rating is better or worse than an expected value and the value for the prior reporting period. Feedback that may be considered to adjust goals is also critical to a continuous process of performance measurement.

Use peer comparisons. When viewed without context, quantified performance targets are often hard to evaluate. How is an executive to know whether an organization is performing well, marginally, or unacceptably? Benchmarking or comparison with peers is one method validating whether the targets set for an agency make sense. Viewing the agency's performance as a share of national activity is another technique. As an example, the U.S. goal to reduce annual highway deaths by 9,000 by 2008 compared with the 2002 baseline was motivated by a comparison of U.S. fatality rates with those of other nations with extensive rural and metropolitan highway systems.

Collecting and Managing the Data

Once the agency has a plan for what measures are to be used and what the data sources are, much work remains to be done to ensure a smooth process from collecting the raw data to making the data available in the form of performance measures for decision makers. Guidelines for data collection and management are provided below.

Manage performance data as an enterprise asset. If a data element is judged to be a critical input for the performance measurement process, it should have a data owner, a data element definition, a schedule for updating, and a fixed amount of precision. Processes should be developed for quality-checking the raw data and turning the data into an aggregated and value-added information asset accessible to the whole enterprise. The details of data transformations should be clearly documented to avoid downstream problems with use of inconsistent methods. The definition must be clear to end users and decision makers and applied consistently throughout the agency. Enterprise-level data elements must be accessible throughout the data-owning agency and for authorized uses among business process partners in cooperating local, state, and federal agencies. Data owners must provide metadata alerting users of data limitations and variability, and data access providers should prominently display metadata as notes in data transmittals and presentation graphics.

Nail down data definitions. Particularly where data from secondary sources are being used to derive performance measures, it is important to obtain and document precise data definitions. To take the example of employment data, figures could vary widely on the basis

of data sources and adjustment methods [e.g., adjusting for proprietors, adjusting for persons who work two jobs, and determining the location for which data are reported (i.e., the payroll office, the work site, or the residence of the worker)].

Recognize and plan for data management costs. Adequate resources must be provided to collect, store, archive, analyze, and disseminate critical data elements. Data- and analysis-intensive areas such as mobility and reliability require explicit resource allocations. Separation of the data production function from the data analysis and dissemination function may ensure that neither function consumes a disproportionate share of resources.

Adjust data collection, analysis, and reporting responsibilities. It is common to find similar data being collected and analyzed for different purposes in varying parts of the agency. Implementing an enterprise-level performance measurement program that uses existing data sources will often reveal this duplication and the inconsistencies that go along with it. Once data sources for the performance measurement program are clearly defined, accountability should be assigned to specific functional areas within the agency for the various data support functions. Responsibility and expectations should be clearly communicated and understood by all stakeholders in the process. Be sure to include time and resources to coordinate across organizational units and adapt existing systems and processes to meet new requirements. To reduce the likelihood of bottlenecks in the delivery of performance information, use a decentralized approach. The business processes of producing data, analyzing data in a single subject area, and providing integrated views of data across systems should be separated. Trying to do everything for everybody in a single step is too risky in terms of cost and schedule, especially when technology leaps occur as frequently as every 18 months.

Put data quality controls in place. Location and temporal validity and integrity control systems for all enterprise-level data elements must be compatible. When data from multiple pieces of equipment are collected by way of multiple methods or from multiple sources, consistency of the measurement must be ensured. For example, quality control methods such as measurement of roughness by one state for a sample of segments near the border in a neighboring state (while repositioning the equipment for more work in its own state) can enable each state to ensure that equipment is measuring consistently with equipment used in the neighboring state. Other information quality factors that must be considered include relevance, correctness, accuracy, precision, completeness, timeliness, usability, accessibility, data life, and conformity to expectations.

Avoid linear referencing pitfalls. Trying to join aged linearly referenced highway attribute data with an up-

to-date cartographic model of highways is a sure formula for loss of data integrity. The real-world highway system and the current cartographic model of it are changed frequently by route retirements, route additions, and route measurements that occur whenever geometric changes are included in a project. Archived linearly referenced highway attributes can only be mapped correctly in a GIS application either by joining them to the matching archived cartographic model or by spatially transforming the archived attributes to be measured in the linear referencing datum that is current. Failure of GIS users to account for this temporal aspect of linear referencing systems is a major data integrity issue. One solution is to establish a business rule that requires all linearly referenced data enterprisewide to be transformed to the current cartographic model and to enforce the rule each time the cartographic model is updated.

Plan for smooth transitions as legacy systems are replaced. New or upgraded systems should be planned in order to have a common method for locating assets and for recording events that happen in a temporal dimension. Metadata about the legacy data in terms of gaps, quality, and integrity should be maintained. Any differences between the results of performance measures calculated by the legacy system and the modern system should be identified before ending the phase of the conversion during which the systems run in parallel. Migration of the historical values of data elements that are critical for time-series analysis and presentation of performance measures from the legacy system to the new system should be specified as part of the upgrade process. This includes data quality checks, transformation of data code values, and transformation of the legacy record format to the modernized record format. Loading only the most recent data value into a new system has miniscule cost savings compared with loading all the data that have been archived as a part of the legacy system operation.

Consider outsourcing data collection. Many data elements are commodities and can be procured from private-sector vendors by low-bid methods at unit costs that are competitive with costs for provision of the same services by a public-sector work group. For example, privatized data collection is commonplace for automated pavement condition surveys, periodic bridge inspections, and highway traffic counting programs.

Evaluate the use of new data collection technology. Transportation agencies need to keep up with technology. For example, a common method for video logging in large counties involves periodic digital photo logging of assets with three pairs of cameras (left looking, right looking, and forward looking) from a van equipped with a differentially corrected Global Positioning System. Staff at desktop workstations are able to use the

photos to locate existing assets accurately by triangulation from the stereo images of the camera pairs, add attributed assets to an inventory database, identify damaged or missing assets, and assign condition ratings to assets. Agencies with a larger base of assets are lagging far behind metropolitan counties in developing comprehensive GIS-based, enterprisewide databases and associated user interface tools. Large agencies appear to be having difficulty in quantifying and communicating the benefits of this and other technology as well as in competing for resources alongside other information technology proposals.

Develop a data business plan. A data business plan can be undertaken to address issues of customer needs, return on investment for data collection, assessment of which data types are most beneficial to collect relative to resources invested, data stewardship, metadata, how to address changing agency needs, data definitions, and many other critical elements that have been discussed above.

Using Performance Data to Support Decisions

The performance data, once in place, must be disseminated to decision makers in an effective manner, and analytical tools must be available to assist in development of performance targets and investment analysis. The guidelines below focus on the use of office productivity, GIS, and specialized tools for performance-based planning.

Provide methods and tools for drilling down and rolling up. It is best to focus only on a small set of performance measures for external reporting and strategic budgeting. However, more detail is needed for decision making at the staff level. Ideally, the few high-level performance measures can be derived from more detailed measures, and a drill-down capability will be available to allow staff to see detailed data and assumptions behind aggregate measures (e.g., whether pavement condition is poor primarily because of rutting). Desktop database, spreadsheet, and GIS tools as well as more specialized analysis tools should provide capabilities to summarize performance measures for different parts of the system (e.g., district and functional class) and from a user-oriented perspective (e.g., percentage of vehicle miles of travel on poor roads). They can provide a drill-down capability to allow a user to explore conditions at different levels of geographic aggregation. A hierarchy of measures also ensures that measures are backed by adequate detail, since systemwide aggregation does not always lead to meaningful decisions.

Make use of GIS software and office productivity applications. Use of a desktop GIS application by well-trained staff can be an efficient means of preparing input

data for a legacy system to process. The same is true of use of a desktop database application. Minor modifications to legacy system source code are usually worth the effort to enable the system to produce comma-separated variable (CSV) output files of legacy system results. CSV files can be easily read into desktop spreadsheet and GIS applications, which can then be used for analysis, presentation, and printing. The open database connectivity method enables staff who have been trained to use desktop database applications to import or link to data stored in enterprise-level relational database management systems. The File Transfer Protocol is a frequently used method for moving legacy data sets among computing platforms. Use of desktop tools keeps staff training costs low by avoiding the need for workforce skills in the use of antiquated mainframe programming languages and editors. Mission-critical files created by desktop application users should be uploaded to agency file servers at least daily and from there backed up periodically. The process should include off-site disaster recovery protection of information assets.

Make use of simulation tools. Fact-based what-if analysis of alternative funding scenarios and policy choices is a fundamental part of performance-based planning and programming. For many types of performance indicators, simulation tools can be used to help provide an understanding of how future performance may be affected by the quantity, timing, and type of agency interventions and by variations in factors outside the agency's control (e.g., growth patterns). They can analyze future needs and provide an indication of the performance that can be achieved at various investment levels. This type of analysis is valuable for setting realistic performance targets and guiding budget allocations consistent with these targets. Pavement and bridge management systems are important resources to tap for performance measurement. However, agencies should anticipate and plan for some effort to make best use of these systems, particularly when they are being used primarily for inspection data management and project-level decision making. To be credible and useful, these systems require calibration and validation against actual experience in a particular locale. Comparison of predicted trends against measured past trends provides a good reality check. Sufficient time and resources need to be allocated for this activity, and ideally, a technical champion should be designated to exercise the system and ensure that it is producing reasonable results. Agencies should be sure to look at performance predictions both at the site-specific level (i.e., individual pavement sections or bridges) and at the network level (i.e., predicted average Interstate pavement condition compared with past trends).

Be aware of prioritization methods used by tools. Tools that provide the capability to predict system performance as a function of investment levels use a variety

of methods for identifying needs and determining how the available budget is allocated. These methods should be well understood in selecting or configuring a tool and in determining how to make best use of an existing tool in the performance target-setting process. For example, an agency trying to determine the investment necessary to reduce the percentage of poor pavement miles in a district to 20 percent may make several runs of its pavement management system but find that even with fairly high investment levels, it cannot reduce the percentage below 30. The reason may be that the management system is not allocating resources on a “worst-first” basis; it may be allocating the available budget to more cost-effective investments in preventive maintenance. This raises several questions—for example, whether the target should be reconsidered since it may imply an inefficient use of funds over the long term and whether the management system’s models adequately reflect the user costs of poor pavements in its calculations. This type of debate is valuable and arguably a necessary part of determining how to use simulation tools in the context of performance targeting and investment analyses.

Integrate project and program data. Tools that predict future condition should reflect work that is scheduled or programmed. Keeping infrastructure management systems in sync with program/project databases is often a challenge. Efforts to ensure that data structures are consistent so that information can flow between management systems and program/project databases would be worthwhile in most agencies. At a minimum, specific work flow processes should be defined to update management systems as program/project databases change.

Ensure consistent cost assumptions. When tools to do investment versus performance analysis are used, it is important to pay attention to the costing side. Tools and inputs should account for inflation and reflect proper use of discounting methods. Budgets and work costs should be consistent. For example, if work costs do not include indirect costs, the budgets should be reduced accordingly.

CONCLUSIONS

This paper has provided examples of successful approaches in the use of existing data and tools to sup-

port performance measurement applications for four critical categories of measures (infrastructure, mobility, safety, and customer service). Each example was selected to show how performance measurement programs can be built by using available data and standard tools (GIS, desktop applications, management systems). In each case, the key to success was not the sophistication of the individual measures that were selected or the level of detail of the data collection effort but the way in which different data sources and tools were used in combination and the processes that were developed for using the performance measures to establish priorities and allocate resources.

General guidance was provided for major steps in the process of performance program definition and implementation. The guidance is intended to help agencies successfully navigate the array of technical, process, and organizational issues that can be anticipated as they undertake performance measurement. The general guidance and examples lay the framework for a practitioner; they are not meant to be exhaustive and answer all questions associated with the topic. [Additional guidance concerning the use of data and tools in performance-based planning can be found elsewhere (3, Chapter 4).] They do suggest, however, that a systematic approach to performance program design that considers the interrelated issues involved in measure definition, data management, and business process can help agencies avoid major roadblocks and anticipate the nature and extent of the effort that will be required for success.

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