Meeting Critical Data Needs for Decision Making in State and Metropolitan Transportation Agencies
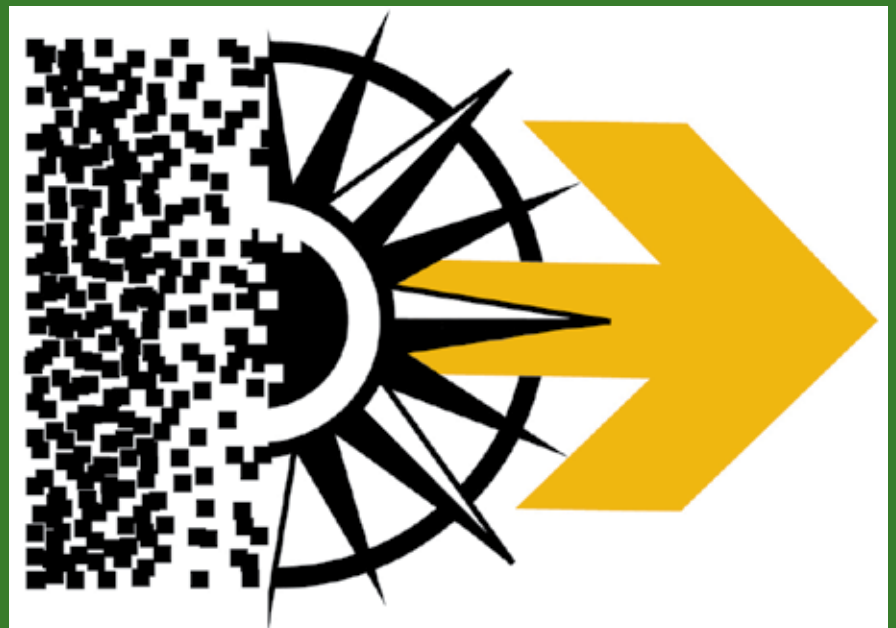
Summary of a Conference

**December 5–7, 2011
Irvine, California**

CONFERENCE PROCEEDINGS ON THE WEB 9

Meeting Critical Data Needs for Decision Making in State and Metropolitan Transportation Agencies

Summary of a Conference

Frances D. Harrison, *Rapporteur*
Spy Pond Partners, LLC

December 5–7, 2011
Irvine, California

Sponsored by
Federal Highway Administration
Federal Transit Administration
Research and Innovative Technology Administration
National Cooperative Highway Research Program
Strategic Highway Research Program 2
Transportation Research Board

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

Washington, D.C.
2013
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Transportation Research Board Conference Proceedings on the Web 9

Committee for a Conference on Meeting Critical Data Needs for Decision Making in State and Metropolitan Transportation Agencies

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Preface

The conference, Meeting Critical Data Needs for Decision Making in State and Metropolitan Transportation Agencies, was held in Irvine, California, on December 5–7, 2011. The objective was to understand the data needs of today's transportation decision makers and to identify and discuss strategies to ensure that essential data will be available to support transportation decisions in the future. Approximately 100 policy makers, program managers, data experts, and analysts from states, metropolitan planning organizations (MPOs), academia, and the private sector came together to establish an understanding of the challenges and opportunities for addressing transportation data needs.

BACKGROUND

In its 2009 update of *Critical Issues in Transportation*, the Executive Committee of the Transportation Research Board (TRB) identified concerns about the ability of traditional transportation data programs to respond to emerging data needs, particularly in light of tightening budgets. Transportation professionals recognized that just as the need for data to support decision making was increasing, support for national data programs appeared to be waning. A growing emphasis on performance management and an increasing level of public interest in topics such as climate change and livability were important drivers of new data needs. In response to these concerns, TRB initiated a conference to convene agency policy makers, program managers, and data experts from states and MPOs to examine key data programs and the ability of the data infrastructure to support critical decisions facing those organizations in the next 5 to 10 years. The conference received vital support from the Federal Highway Administration (FHWA), Office of Highway Policy Information; FHWA, Office of Planning; the Federal Transit Administration; the Research and Innovative Technology Administration; the National Cooperative Highway Research Program; and the Strategic Highway Research Program 2. In addition, the American Association of State Highway and Transportation Officials (AASHTO) was a conference cosponsor.

CONFERENCE PLANNING

TRB assembled a planning committee appointed by the National Research Council to develop the conference program. The committee included policy makers from state departments of transportation (DOTs), MPOs, and county

governments and transportation data experts from academia and private companies. The committee's role was limited to planning and convening the conference and three preconference workshops described below.

CONFERENCE ORGANIZATION

The conference included a mix of presentation and breakout sessions to foster common understanding of issues and allow for exchange of ideas among participants. In the opening plenary session, Deb Miller, Secretary, Kansas DOT, and conference committee chair, welcomed the attendees and gave an overview of the motivation for the conference. Joseph L. Schofer, Professor of Civil and Environmental Engineering, Northwestern University, delivered the conference keynote address. He provided an overview of key themes and observations from three preconference workshops with decision makers intended to identify priority areas of concern and help shape the conference agenda. The three workshops, held during summer 2011, invited participants to bring examples of how they used data in making decisions and to highlight both successes and barriers they faced. Workshops were held in three regions: Northwest (Seattle, Washington), Northeast (Hartford, Connecticut), and Midwest (Kansas City, Missouri).

The first presentation session, Current Approaches to Answering Tough Questions, featured presentations from Carlos Braceras, Deputy Director, Utah DOT; Jim McKenzie, Executive Director, Metroplan; and Jerri Bohard, Deputy Director, Oregon DOT; with Johanna P. Zmud, Senior Policy Researcher, Rand Corporation, presiding. That session provided examples of approaches for assembling and using transportation data for decision making.

The second presentation session, The World Around Us: External Factors Affecting Transportation Systems, featured presentations from Jeffrey D. Holt, Managing Director of Infrastructure Banking, BMO Capital Markets; Donald B. Ludlow, Senior Associate, Cambridge Systematics, Inc.; and David Greene, Corporate Fellow, Oak Ridge National Laboratory; with Charles E. Howard, Director of Transportation Planning, Puget Sound Regional Council, presiding. That session examined three critical areas of interest to transportation decision makers: finance, energy, and freight.

The third presentation session, Case Studies: Effective Use of Data for Decisions, highlighted three case study examples of decision-making processes selected from discussions at the preconference workshops: transit route restructuring, capital program development, and performance management. The presenters were Tina Lee, Principal Planner, Pierce Transit; Julie Lorenz, Senior Strategic Consultant, Burns and McDonnell; and Douglas H. Simmons, Deputy Administrator, Maryland State Highway Administration. Matthew H. Hardy, Program Director for Planning and Policy, AASHTO, presided.

The closing session highlighted key themes of the conference. That session featured presentations from Frances Harrison, Chief Technical Officer, Spy Pond Partners, LLC; King Gee, Associate Administrator, Infrastructure, FHWA; Deb Miller, Secretary, Kansas DOT; and Jacob Snow, General Manager, Regional Transportation Commission of Southern Nevada; with Joseph L. Schofer presiding.

BREAKOUT SESSIONS

A substantial portion of the conference was devoted to working breakout sessions. Those sessions provided an opportunity for focused discussion of key issues and strategies related to various aspects of state and metropolitan transportation decision support. Within an assigned topic area, each breakout group was tasked with identifying key issues, gaps, and opportunities; promising models or research efforts to build on; and future actions to improve the use of data for decision making.

The breakout group topics were formulated on the basis of preconference workshops and are illustrated in the conference graphic below.

Three of the seven areas—Being Proactive, Adapting Tools and Methods, and Getting the Most out of Data Investments—were split into two breakout groups each to allow for exploration of aspects of the topics. A single breakout group was devoted to each of the remaining four areas. The first set of breakout groups covered the following topic areas:

- Future Scenarios: Coping with Broken Trends and Paradigm Shifts (the first of two groups exploring the Being Proactive area);
- Integrating Customer Information into the Decision-Making Process;
- What Works and What Will It Cost;
- Tools and Methods That Support Prioritizing and Making Policy Trade-Offs (the first of two groups in the Adopting Tools and Methods area); and
- Looking Ahead: What Does the Future Hold (the second of two groups in the Being Proactive area).

The second set of facilitated breakout groups covered the following five topics:

- Delivering Data for Decisions: Ingredients for Success (Decision Maker Perspectives);
- New Paradigms for Data Acquisition (the first of two groups in the Getting the Most out of Data Investments area);
- Efficient Strategies for Data Sharing (the second of two groups in the Getting the Most out of Data Investments area);
- Opening the Black Box: Collaboration Models for Effective Decision Support; and
- Data for Transportation Systems Performance Management (the second of two groups in the Adopting Tools and Methods area).

Key recommendations from the breakout groups were synthesized and presented as part of the closing session of the conference. Specific information needs and potential actions to respond to these needs were summarized on the basis of materials prepared by breakout leaders and included as appendix material to these proceedings.

ELECTRONIC POSTER SESSION

At the close of the second day of the conference, a reception and demonstration session featuring examples of effective data presentation and communication tools was held. Several stations were set up with laptops and large-format monitors, which allowed presenters to provide interactive demonstrations. Participants were invited to browse, discuss, and assess these emerging tools.

CONFERENCE SUMMARY FORMAT

This conference summary was prepared by Frances D. Harrison, Spy Pond Part-ners, LLC, as a factual summary of what occurred at the conference. It presents summaries of the conference presentations that are intended to capture the key

points made by each speaker. Speakers were given the opportunity to review and edit the summaries. The views presented reflect the opinions of the individual participants and do not necessarily represent the view of all conference participants, the planning committee, TRB, or the National Research Council. After the presentation summaries, brief descriptions of each application presented at the electronic poster session are provided, with links to follow for further information.

This report includes selected references that were provided to the conference participants in advance of the conference and a list of the attendees.

Appendix A provides a summary of key themes and observations from the three preconference workshops. Appendix B provides a tabular synthesis of the information needs, research questions, and potential approaches discussed by each breakout group. Appendix C presents the results of a postconference survey that was distributed to conference participants to identify what insights they gained at the conference and what follow-up activities they felt were important.

ACKNOWLEDGMENTS

Welcome and Opening Remarks

Deb Miller, K*ansas Department of Transportation, and Conference Committee Chair*

Over the past several years, "we need more data" has been a subtext of many Transportation Research Board and American Association of State Highway and Transportation Officials meetings that I have attended—whether the topic was performance measures, freight planning, land use, climate change, or new transportation modeling methods. During the same period, we have seen big changes in the data landscape. Foundational data that we have come to rely on are eroding, and we can no longer be sure we "know" the things we used to think we knew. We have had to make special efforts to get the census data we need for transportation planning. We do not perform origin–destination studies as much as we used to. And there are new options for getting data—for example, probe data from cell phones and information from cameras for enforcement and toll collection. These new data sources will be core building blocks for the future, but we are still learning how to use them. And we are still exploring what it means to be commingling public- and private-sector data.

In putting this event together, the conference planning committee intended to create a forum for substantive dialogue concerning these issues and opportunities. Through this dialogue, we hope to create a data agenda that will last well beyond the conference.

The program for this conference was shaped through a set of preconference focus groups involving decision makers in three regions. As we listened to them discuss their experiences in using data to make decisions, it became clear that the decisions were the star of the show, with data playing a supporting role. We heard that making good, defendable decisions is not just about having solid data and top-notch technical analysis but also about transforming data into information and presenting that information in a way that will resonate with elected officials and stakeholders. This observation is mirrored in the conference diagram, with "better decisions" at the center, surrounded by a constellation of tools and techniques for achieving them. While there is a common subtext on the data and on the technologies and competencies needed to collect and use data, our main purpose here is to strengthen the influence of data in decision making. At this conference, we will use breakout groups to explore the many facets of providing data for decision making. The case studies and mini–poster session will provide illustrative exam-

ples showing how good, solid data can be presented in a way that resonates with people.

This conference was made possible through the support of the Federal Highway Administration, the Federal Transit Administration, the National Cooperative Highway Research Program, the Research and Innovative Technology Administration, and the Second Strategic Highway Research Program. This was an invitation-only conference. A great deal of thought went into selecting the right mix of competencies, interest areas, roles, and geographic representation. I challenge you all to step up and participate fully in your breakout sessions. My hope is that together we will develop a set of solid recommendations that will help us move forward and make stronger, better decisions as transportation leaders.

We Have a Data Problem . . . Don't We?

Lessons from Preconference Workshops

Joseph L. Schofer, *Northwestern University*

These remarks are based on findings from a series of three preconference regional workshops designed to gain an in-depth understanding of the relationship between data and decisions. Findings from the workshops were used to help structure the agenda for this conference.

PRECONFERENCE WORKSHOPS

The workshops were held in Hartford, Connecticut; Kansas City, Missouri; and Seattle, Washington. Each workshop included state and metropolitan transportation policy makers and the people who "whisper in the ears of policy makers." Participants included cabinet-level state transportation officials; legislative transportation staff; and executive staff from state departments of transportation, metropolitan planning organizations (MPOs), transit agencies, and local jurisdictions. Workshop participants were asked to bring an example of a decision they made and how they used data and information. These brief presentations were used as a springboard for group discussion of information gaps and lessons learned.

ROLE OF DATA IN DECISION MAKING

Transportation decision making is an inherently political process informed by, but not purely driven by, data. Other key influences on decision making include ideology, personal experience, vision, political pressures, mass media, advice from trusted advisors, and public expectations.

Objective data will not eliminate the influence of politics, but in the "scrimmage" between opinions and data, it is important that data be given a fighting chance. Data can fill a vacuum that would otherwise be filled with politically defined opinions. Consistent, trusted data have high value in offsetting favoritism for pet projects. Vision can be thought of as the engine that drives big decisions; data provide the substance that keeps this engine on the right track.

NEED FOR BETTER INFORMATION, NOT MORE DATA

At the workshops we did not hear a distress call from decision makers for more *data*, but they did express a clear need for more salient and actionable *information*. Decision makers are hungry for timely, understandable information that helps them answer the following key questions:

- What is actually happening?
- What are the causes?
- What does the future hold?
- What does it mean for me?
- What actions should I take?

Such information is developed on the basis of data that have been analyzed and structured to inform choices, but source data are largely invisible to decision makers.

IT'S NOT JUST ABOUT TRANSPORTATION—IT'S ABOUT OUTCOMES

Decision makers view transportation not as an end in itself but as a means for achieving broader objectives including jobs, economic development, improved quality of life, expanded access to opportunities, and environmental sustainability. They seek information that helps them understand the relationship between transportation investments and these broader objectives.

However, major factors outside of transportation are important drivers of these outcomes, including public policy, demographics, the global economy, energy, and climate change. These drivers define the environment within which transportation decisions are made. Understanding these factors and how they are likely to change is of great interest and importance to decision makers.

DECISION MAKING UNDER UNCERTAINTY

Workshop participants described the challenges of transportation decision making in the face of major uncertainties in future energy prices and availability and their influence on location and land use decisions, vehicle choice, and travel behavior; climate change and its impact on transportation infrastructure; evolving priorities on quality of life, locational preferences, and face-to-face interactions; and the state of the economy and its impact on what households, businesses, and governments can afford. Major economic, energy, environmental, and demographic changes imply a likely break in past trend lines for travel, revenues, and construction costs. In some instances, local models are being developed with best-

guess assumptions about future trends to support long-range planning and major investment studies. Consistent, up-to-date guidance for states and MPOs on core assumptions that drive transportation models would be helpful.

EFFECTIVE AND RESPONSIVE INFORMATION DELIVERY

Decision makers must act quickly within externally dictated time frames. Information products need to be delivered to fit these time frames. This means that by the time an information request is made, there is typically not enough time to collect new data or to do the kind of careful quality assurance and analysis required to address the question in the best way. Proactive identification of decision maker needs can ensure that quality information is available "on the shelf" when it is requested. Because decisions are time-constrained, waiting for perfect data is not an option. Decision makers either move forward with no data or proceed with imperfect data (ideally with proper caveats attached). It is important not to let the perfect become the enemy of the good enough.

Effective information delivery is critical. The rules are basic: keep it short, simple, and clear. Use pictures, stories, graphs, and examples. Being brief is not easy; delivering clear, direct messages takes work.

TARGETING THE MESSAGE

Clear and effective communication of information involves careful targeting of the information to the consumer of that information. The starting assumptions are that decision makers are smart, are busy, are driven by their own agenda, and have interests and skills different from ours. To meet their needs, we have to gain a solid understanding of who they are and the context within which they operate. We also need to understand our role in supporting them.

POWER OF EXAMPLES

Decision makers want information about what works—real evidence about performance, effectiveness, and success. Rigorous quantitative before-and-after studies and more qualitative case studies that tell the story about a program or project are both helpful. Field trips, videos, and photographs are also effective ways of getting this kind of information to decision makers. We need to take advantage of these varied types of data modalities.

DECISION MAKER INFORMATION NEEDS AND IMPLICATIONS FOR DATA PROVIDERS

Decision makers want the following:

• Information about "big picture" outcomes—impacts on the economy, society, and the environment. Providing this information requires different types of data and models.

• Information about risks to provide an understanding of how factors such as revenues, costs, resource availability, system utilization, terrorism, weather-related threats, and technological changes might affect results and future needs and priorities. Meeting this need requires improved predictive methods, better approaches for characterization of risks, and increased emphasis on risk management and mitigation strategies. Because these types of predictions are difficult and subject to tremendous uncertainty, a highly collaborative process of information development is required in which core assumptions and scenarios are discussed and debated. Where uncertainty exists, we have an ethical obligation to convey that uncertainty without scaring people or causing them to respond in unproductive ways.

• Information about constituent perspectives, values, and perceptions. The challenge here is in sorting out multiple sources of constituent information and ensuring that a balanced and unbiased picture is provided.

MAKING THE CASE FOR DATA PROGRAMS

Even though data professionals understand that data provide the "skeleton" that supports information, data programs are often undervalued. Part of the reason is that data are invisible to decision makers—answers to their questions are based on whatever data are available, and they are willing to move forward regardless of what information is provided. As transportation data professionals, we need to be advocates for data to secure needed data for the future. This means looking upstream to ensure that the data we count on will be provided and staying connected to our customers, the decision makers, so that we can anticipate emerging data needs.

FUTURE ACTIONS

On the basis of what we heard at the workshops, the following actions will be important in meeting the critical data needs of transportation decision makers:

• Strengthen the case for foundational data collection by clearly connecting it to the more visible information end products that decision makers rely on. Make sure that all data sources are tagged and properly referenced.

• Continue to collect and disseminate examples of high-impact data applications to show where data have made a difference.

• Work to advance the state of the practice in data delivery by training analysts in how to prepare, package, and deliver useful information.

• Make use of emerging advanced data analysis and display technologies where they can facilitate understanding.

• Develop and implement improved techniques and processes for supporting decision making under uncertainty.

• Develop consistent approaches to the estimation of broad external trends.

Current Approaches to Answering Tough Questions

Carlos Braceras, *Utah Department of Transportation*
Jim McKenzie, *Metroplan*
Jerri Bohard, *Oregon Department of Transportation*
Johanna P. Zmud, *Rand Corporation, presiding*

ORGANIZED DECISION MAKING
Carlos Braceras

Now more than ever, all of us must respond to expectations that we will make good decisions on the basis of a rigorous and disciplined process.

While the questions we encounter are becoming more complex, they are coming at us from a greater foundation of knowledge. And there is an expectation that we will make decisions in a transparent way and on the basis of a clear rationale.

The following are typical questions that we face in our day-to-day responsibilities:

- How are you spending the public's money?
- How can we be assured that you are making spending decisions that give us best results?
- What outcomes are you trying to achieve?
- Why are our assets in their current condition?
- What is the most cost-effective and safest condition for maintaining an asset?
- How efficient is your organization? How does it perform compared with similar organizations?
- Why do you need so many employees?
- Why is my traffic signal not green all the time?
- Why does getting from work to home take so long?

When people ask a question, they almost always have a bias. In responding, we must be aware of these biases and perceptions and take them into consideration in our response.

The questions we get are always changing. We need to be ready to respond to questions that we have not anticipated.

Like most departments of transportation (DOTs), Utah DOT has multiple information systems—for project management, construction management, pavement management, maintenance management, design and computer-aided design, and so forth. For us, making good decisions has required knowing whom to call for information and support within each area. We wanted to change this and move to an environment in which people can access the information they need on their own. We wanted to find ways to bring data together in cost-effective ways to make consistent decisions.

To this end, Utah DOT decided to move from a collection of individual information systems to a single standardized database. While there was much discussion about which system would be installed, the decision to standardize was more significant than the choice of a target system. Since the 1990s, Utah DOT has been on a path of organizing its large amounts of unstructured data to provide better support for this vision of self-service information access for decision making. The goal is to provide the ability for staff to get on-demand answers easily to information needs as they arise. Utah DOT has pursued a gradual approach. As systems were ready for transition, they were migrated to the standard. This has created an opportunity for breaking down information silos—a process that is ongoing.

Utah DOT has two separate but convergent approaches, called UGate and UPlan, for organizing data. UGate focuses on providing access to internal Utah DOT data sets in multiple formats, whereas UPlan allows the viewing of a variety of data from Utah DOT (supplied by UGate) and other agencies. Development of UPlan has required bringing together many agencies with different missions and helping them share data. It has come together in a way that is synergistic.

Technical solutions for Utah DOT's information management approach include the following:

- A central geographic information system database,
- A set of administrative and productivity tools for data management,
- A data portal to provide web-based access to information, and
- A set of applications targeted to specific business needs.

Georeferenced data are pulled from Utah DOT's key systems (project management, business, financial, operations) into the central data repository. Once in the data warehouse, the data are made available through the data portal and suite of targeted applications. The data portal allows the user to view and download data in multiple file formats. It includes sophisticated query capabilities. Mapping and straight-line diagram tools allow multiple data sets to be overlaid. Seeing data represented like this changes how users make decisions.

For example, a system can have all the information a project manager needs when a project is initiated. Utah DOT staff will definitely be making better decisions

because they will have all of this information at their fingertips, in a well-organized, easy-to-use system.

In the future, we hope to adopt ideas from social networking to facilitate collaborative decision making on the basis of a common pool of information. Consider the case where the governor requests a letter from the DOT to respond to a specific issue. The response might require input from a division director in combination with the regions and maybe a few other people. Imagine putting these people together in a virtual "circle," with access to the latest copy of the response and all relevant information, forms, and data shared within that circle.

In conclusion, for Utah DOT it is not just about the data. It is about organized decision making: bringing multiple data sources together in a disciplined way to make better decisions.

For more information, see http://uplan.utah.gov and http://www.udot.utah.gov/ugate.

THE FUTURE AIN'T WHAT IT USED TO BE: INFORMATION NEEDS IN A CHANGING WORLD
Jim McKenzie

When I served as a local elected official, I was stunned at the lack of information for making decisions. In fact, the more important the decision, the less information we generally had.

Information needs of planners are different from those of system managers. While managers rely on data for making tactical, day-to-day information, planners need more strategic information.

I believe that the first half of the 21st century will be different from the last half of the 20th century. Every metropolitan planning organization (MPO) needs a crystal ball to provide the foundation for long-range plans. In the past, forecasting was relatively easy—we used a straight-line extrapolation of trends. Lately, predicting the future is not as easy as it used to be, and our crystal ball has been coming back cloudy. We are questioning the basic assumptions of our models. Bad assumptions can make good data useless.

Over the past 2 years, I served on the Arkansas Blue Ribbon Committee for Highway Finance. About half the members were state legislators. The committee's function was to make recommendations for adequate revenues to support state, county, and municipal roadways. As we began this process, the former chairman of the Texas House Transportation Committee, consulting for us on another matter, made the observation that since 1950, our transportation system, our cities, and our regional and national economies have been built on three pillars:

- Gasoline will always be cheap,
- Vehicle miles of travel (VMT) will always increase, and
- Fleet fuel efficiency will never increase significantly.

Today, all of these pillars have been broken. The first question the committee had to tackle was, what will the buying power from current motor fuel taxes be over the next decade? To answer this question, we needed answers to the following:

- How will VMT change over the next decade?
- What will the absorption rate of high-efficiency vehicles be in the light-duty fleet?
- What will highway construction costs be?

The state DOT had projected 7 percent annual VMT increases, but the committee's analysis indicated that the rate would be closer to 1.7 percent—consistent with projected population growth.

To address the question of future vehicle fleet efficiency, the committee pieced together an analysis done for Texas DOT by Cambridge Systematics with our own analysis of the impact of corporate average fuel economy standards from the 1970s.

For highway construction costs, we had seen a large spike between 2005 and 2008, but not much since then because of the Great Recession. Which trend line should we use? We observed that there is a high correlation between the price of No. 2 diesel fuel and the highway construction cost index. We decided to base our highway cost assumptions on long-term fuel price projections from the Energy Information Administration. Even though this may not have been the best possible information, it allowed the committee to proceed with a more reasonable set of assumptions.

The committee built an interactive spreadsheet model to bring all of these assumptions together. The model allowed the committee to project a decline in nominal revenue over the next decade, at set tax rates. We used the model to see what it would take to maintain existing purchasing power from both a 2005 and a 2010 base, just to stay even, on the basis of estimated construction cost increases, increased fleet fuel efficiency, and VMT growth projections. The state DOT was already estimating a $1 billion/year shortfall, assuming no change in past trends.

Our interactive model allowed members of the general assembly to set their own revenue targets, specify their own assumptions for a range of taxes, and observe impacts. They were stunned to see all this information—it had never been presented to them before. Despite the value of this model for informing decision makers, the politics of the 2010 elections intervened, and the legislature did not act to increase revenue for transportation.

At Metroplan, we are now working on our Metro 2040 long-range plan. For this we need to answer a set of questions similar to those I posed earlier:

- What will fuel prices do over the next two decades?
- How will fuel prices affect VMT and high-efficiency vehicle ownership?
- Will greater competition for commodities from India and China drive highway construction costs up? Or will higher fuel prices tip the global economy into a recession, thereby lowering construction costs?
- What impacts will higher fuel prices have on urban form?

Our advisory committee is predominantly made up of white male baby boomers, but planning for 2040 means planning for ethnically diverse millennials who will want an urban form different from the kind we grew up with. Changes in urban form could be a game changer, and we may see a big shift from the sprawl of the last half of the 20th century.

As part of the long-range plan, we examined future system preservation needs. The state DOT projects that it will take all available revenues just to maintain the existing state highway system. However, there is little or no understanding of system preservation needs for cities and counties because no data are available on the condition of city and county infrastructure.

Another great unknown is the impact that climate change will have on our infrastructure in the Midsouth. With regard to climate change adaptation, the National Oceanic and Atmospheric Administration has done work on prediction of both desertification and the impact of a rise in sea level on coastal cities and transportation. However, there is no good way for us to know whether the dry line that generally follows the 100th meridian will move east from Oklahoma City, Oklahoma, to put Little Rock, Arkansas, in a semiarid climate or whether there will be about the same amount of rainfall except in a monsoon pattern. If the latter, all of our drainage structures will be inadequate. This year alone, we have had three Interstate highways underwater and shut down in the spring and the fall, with a huge drought in the summer. We have yet to understand fully how these changes in weather patterns will affect our transportation system needs. The uncertainties create major challenges for those of us charged with developing long-range plans.

NEW TOOLS AND DATA TO ANSWER NEW POLICY QUESTIONS: OREGON'S EXPERIENCE
Jerri Bohard

In Oregon, we have found that answering the policy questions that really matter to our decision makers has required new kinds of tools and new kinds of data to feed those tools.

We have seen a shift in policy questions in the era following the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). Pre-ISTEA, the focus was on expanding highway capacity. Transportation and land use were considered separately, and our analysis of alternatives was generally limited to simple choices related to alignments, cross section, and staging. We did not take into account household behaviors or the emergence of policies for influencing those behaviors.

Post-ISTEA, we have shifted to become more holistic and multimodal in nature. We have started to look at land use, economic development, and transportation in an integrated fashion. We are looking more at interactions—across systems, between communities, between urban and rural areas, beyond state boundaries, and even internationally. We have also been more concerned with managing our assets cost-effectively. This shift has affected the kinds of tools and data that we need.

We have just finished our second household survey. We worked with partners throughout the state, including MPOs and universities, and we would like to do this regularly to continue to build longitudinal data concerning household travel. We have been collecting information on commodity flows but need to do this more often to keep up with rapid changes in shipment patterns. The additional data come at a cost, so we need to get our policy makers to understand the importance of the data in answering the kinds of questions that are being asked.

We are developing a new asset management system and just went online with a geospatially enabled database known as the Features, Attributes, and Conditions Survey–Statewide Transportation Improvement Program tool. This system will allow us to view much of our asset data in one place. We are focusing on understanding life-cycle costs and the effects of operational improvements to manage our assets as efficiently as possible.

I will highlight some specific tools that we have developed, the questions they are designed to address, and their data requirements:

• **GreenSTEP:** Our Greenhouse Gas (GHG) State Transportation Emissions Planning model was developed in response to questions from the legislature about how we can reduce GHG emissions and what the consequences of doing so would be. Given a legislative mandate to reduce GHG emissions by 75 percent relative to a 1990 baseline, we had to go back and calculate 1990 emissions and develop a reference case. We then modeled plausible ranges for various inputs to define and analyze composite scenarios. This model required many assumptions about future development patterns, transit service, highway capacity, parking, vehicle fleet composition, pricing, and demographics. Building the model involved not only finding what data were out there but also examining what assumptions can be made to develop plausible future scenarios.

- **Least cost planning (LCP):** We were challenged by our legislature to answer questions about how to make the most efficient transportation choices on the basis of the full costs and benefits of both demand and supply options. In response, we are developing a methodology and tool that can be used for transportation planning and project development efforts. We are about a year into this effort and have developed goals, objectives, performance measures, and performance indicators. We are identifying what data we have and what we need to collect. We are exploring ways to develop tools for LCP that can be applied in communities that have good data and in smaller communities that have more limited data.

- **Statewide Integrated Model (SWIM):** This model allows us to analyze future scenarios that consider land use, transportation, and economic development in an integrated fashion. A few years ago, we faced a bridge cracking problem that required us to put weight limits on many of our bridges. We were able to use SWIM to evaluate economic impacts of these restrictions and develop scenarios for bundling our bridge work that minimized negative economic impacts.

- **Land Use Scenario Developer:** This tool uses microsimulation to model individual household, business, and development decisions. We have used this tool for a study in Jackson County, Oregon, to gain regional consensus on where urban reserves could be designated to accommodate a doubling of population.

In closing, you need to have many tools in your toolbox to respond to questions that arise. Issues change and new questions will emerge, so you need to be prepared to enhance your tools and develop new ones. As questions become more complex, so do data requirements. We recognize, however, that you need to find a way to move forward without all of the data that you want.

QUESTIONS AND ANSWERS

Question: Was there a reason for Utah DOT making its data public, and did opening the data up to the public change the data that could be included?

Carlos Braceras: Because we involved many external agencies in building the database, we needed to use an approach that provided benefits for them as well. Some of the data (e.g., detailed accident records) will be password-protected where there are confidentiality concerns.

Question: How well did making models and data available directly to decision makers work? Were they able to understand the assumptions and limitations of the models?

Jim McKenzie: The decision makers and even the committee members did not use the models directly; we relied on the "whisperers" to run them and provide us with

the information. What we found most important was to anticipate what questions would be asked and frame the arguments—before the decision turns critical. Even though we were unsuccessful in getting our recommended revenue package enacted, we were successful in framing the next debate that is now under way, which is a discussion about structural revenue deficiencies.

Braceras: We have not been successful in getting legislators to use tools, but the power of these kinds of tools cannot be overemphasized. Twice a year I do a report for the legislature on our capacity program. This year, I was able to show project status with live data from the web, with drill downs to individual project details. Using these tools in a public setting was extremely valuable for demonstrating transparency and garnering public trust. We have found that the media make the most use of publicly available tools. They are also used by legislative staff—the "whisperers."

Question: Do agency data analysts have the competencies to move in these new directions?

Jerri Bohard: At Oregon DOT we have competent staff, and we have been able to draw on MPO staff. We have been concerned about where the next generation of modelers would come from. We have been working on this with Portland State University—we recognize that Oregon DOT is an incubator for new models, but universities need to take things to the next level.

Question: Can you elaborate on the comment that "the more important the decision, the less information is available"?

McKenzie: In my experience, people will spend the most time on things that they understand—like the need for new desk chairs and lawnmowers. They will spend less time on things that they do not understand, like industrial revenue bonds.

Question: In Oregon, how did you get legislators to buy into the economic analysis of bridge deterioration?

Bohard: It took us a long time to get there—we spent a lot of time with legislative committees, and we took them out to see some of the bridges. We had done some other research to see whether there was a way to reduce the number that had to be replaced and were able to show that we could rehabilitate and repair some of them. The transparency and accountability were helpful in gaining trust. In addition, we involved stakeholders in the process, including a freight advisory committee—so it was not just the DOT advocating for a particular solution.

Question: Jerri spoke about the need to backcast GHG emissions to 1990. Can panel members comment on the value of ongoing monitoring? Does it help or hinder you?

Braceras: You have to be aware of what you knew and when you knew it. We always try to identify the last time that a decision was made on the basis of similar

information, and we try to cross-walk back to that point. That allows us to say, "This is what we knew then, this is what has changed since then, and this is what we are proposing now." Utah DOT is keeping full histories on projects to facilitate this. Sometimes people are hesitant to make a jump to getting better information because they are worried about correlating it back to the way we have done historical analysis. I believe we need to make conscious decisions to move forward, but we should be able to figure out why we made the change and how we relate to that.

McKenzie: I will just add one comment from another of my other favorite philosophers: "That doesn't make much sense," said Tigger. "I know," said Pooh humbly. "It did when it started out; it's just that something happened to it along the way."

Bohard: We are being more thoughtful now about what our monitoring program will look like. We are anticipating questions that we will need to answer and planning for them as we do our work. We recognize that this needs to be a key component of what we do.

The World Around Us
External Factors Affecting Transportation Systems

Jeffrey D. Holt, *BMO Capital Markets*
Donald B. Ludlow, *Cambridge Systematics, Inc.*
David Greene, *Oak Ridge National Laboratory*
Charles E. Howard, *Puget Sound Regional Council, presiding*

TRANSPORTATION FINANCE
Jeffrey D. Holt

Thanks for opportunity to address some of the financial lessons we have learned over the past few years concerning transportation:

• There is a stunning amount of financial volatility. This will be a key factor over the next few years. Making a project work on the basis of old data will be tough— what we did 6 years ago is no longer relevant.

• There are significant pressures on our revenue streams. Even before the current economic slowdown, we had built up a substantial amount of leverage on existing revenues. It is paramount that we educate legislators about the need for developing new revenue sources and taking the pressure off of what I consider to be our maintenance funds.

• We are seeing volatility in costs of construction materials—this is related to the first comment on the financial markets. For example, we may see oil at both $80 and $300 a barrel within a period of 3 weeks. We also have seen substantial price differentials for steel in the global marketplace.

Everyone asks about how to get into "private funding," but we need to keep in mind that the private sector does not fund; it finances. Big pension funds got burned badly in the technology downturn. Investments are being redistributed, with lower target returns and investment thresholds. Infrastructure investments are becoming more attractive given their "steady Eddie" nature. The United States is coming around to this; the European Union has been there for some time already.

Resetting of the investment threshold lower actually increases the valuation of an asset. When you drop the target return from 18 percent to 10 percent, the value of the asset almost doubles. This revaluation of the entire infrastructure complex has had significant ripple effects. The biggest one is that policy makers have started wondering whether private-sector financing can take the place of some of the ongoing

public funding. They wonder whether they should change standard procurement and operating practices. The bottom line is that the space has been revalued and that these assets are much more valuable. Decision makers should understand the implications of this in terms of their particular asset portfolios.

People ask what the implications of this are for greenfields—is there a way to build new capacity on the back of this? In fact, this potential is limited—not because the private sector does not understand construction but because the private sector is simply not as good as the public sector when it comes to these types of public works projects. But they love existing cash flow and businesses. Several years ago the Utah Department of Transportation was exploring private financing for a new toll road. The project would have involved 2 years of preconstruction, 4 to 5 years of construction, and then 5 years of ramp up on the toll revenues. The private sector simply could not wait for 12 years to begin payment on a big block of bonds. Even with a Transportation Infrastructure Finance and Innovation Act instrument, it is difficult for the private sector to compete with the public sector on developing these types of projects. After considerable study, we concluded that the public sector has a much better interest accrual method than does the private sector. We found that it made more sense for the public sector to finance and develop the project and then sell it to recoup the original investment.

The vision that I would like to convey today is that the core competencies of the public and the private sectors are different. The core competencies of the public sector are development, long-range planning, stakeholder outreach, consensus building, property assembly—both eminent domain and utility relocations—and grant administration. The private sector is good at operating things. It is good at marketing, unions, managing risk, scaling up, buying multiple assets, and operating them together. The private sector wants the public sector to build the assets and then turn them over—the private sector will pay good money for them. But it is difficult for the public sector to give up control of these assets.

Some final comments on data: in my business, data collection is all about getting the bankers satisfied that the project is feasible. The private sector looks at things more on a corporate basis. This may require public agencies to go about collecting and presenting data differently.

On the other hand, the private sector is not at all interested in sharing information. The private sector requires detailed information in evaluating a business, but once the business is sold, the private sector will never talk about it again. If you want the private sector to share back information, you can include provisions for this in your partnership agreements, even if you need to include a confidentiality provision. Finally, there is an interesting case to be made for dynamic pricing of transportation assets. It is difficult for agencies to get a handle on what their assets are worth. Nobody knows what the right price is. The one way to find out that I can suggest is to "put a toe in the water" and test—for selected assets—what the private sector is willing to pay. This can set the tone for negotiations going forward.

GLOBAL ECONOMY AND FREIGHT
Donald B. Ludlow

My presentation reviews global economic and trade trends and domestic freight trends and issues and concludes with a discussion of the implications of these trends for transportation agencies.

Population Growth

The world population is 7 billion now, and the United Nations is projecting growth to 8.9 billion by 2025 and to 9.2 billion by 2075. Population growth rates are slowing after rapid increases over the past three decades. Factors that are pushing population growth are fertility rates, longevity, and migration. More people are living in urban areas. This is true in the United States and especially in the rapidly developing countries. The developed nations are averaging 1 percent per year; the developing nations are growing a bit faster. Of particular interest is that the United States and its trading partners Australia and New Zealand have the fastest-growing populations of developed countries, largely because of migration patterns.

Economic Growth

Among the largest economies, China and India are expected to be the fastest-growing in the near term, with growth rates in the 8 percent range—substantially higher than the 1.3 percent projected for the United States. While there are many economic forecasts, the consensus is that East Asia is growing the fastest, and this has significant implications for transportation decision makers. China is moving toward world economic dominance, and India is becoming a bigger world economic power—which affects our trade patterns for both imports and exports.

Income Growth and International Trade

Global income growth will drive increases in trade demand, which will affect international freight movements. Today, Asia accounts for 28 percent of the global middle class; this share is projected to grow to 66 percent by 2030. China is expected to become the world's largest importer. For example, income growth will affect food consumption and will create higher demands on food distribution networks. To illustrate this trend, the United States and other leading producers of cereal grains, meat, and dairy products will see export demand increase with growing trading partners whose populations are rising to middle-class income levels. Climate change will also affect food production and drive up demand for food imports in susceptible countries.

Globalization of supply chains means that more freight movements and more ton-miles are required to produce something. Growth in trade will be enabled by free

trade agreements as well as by continued low postrecession transportation costs. It currently costs about $700 to get a container from Asia to Europe; the cost used to be $1,500 or $1,600.

Supply Chain Efficiencies

Supply chains globally are seeing efficiency improvements—for example, with new packaging technologies to increase unit productivity. This has driven growth in the size of container ships. The largest vessels have a capacity of 15,000 twenty-foot equivalent units (TEUs) and can be operated with a crew of less than 20 people. Next-generation ships will have a capacity of 18,000 TEUs. Larger ships mean lower transoceanic shipping unit costs and put ports that can handle larger vessels in a better position.

Other Factors

Climate change is likely to affect maritime and coastal infrastructure as well as food distribution patterns in areas susceptible to flooding and drought. Climate change may also create opportunities for new shipping routes because of ice melt. For example, Russia is mapping an Arctic route to get ships from Asia to Europe much faster than the current route through the Suez Canal. Security will likely be an important factor that will drive up shipping costs given the need to mitigate risks related to piracy and international terrorism.

Trade Trends

Despite the recession, growth and expansion are likely to continue. World trade is forecast to grow by 7.7 percent through 2015. All nations will develop and benefit from closer ties to East Asia. The United States will continue to experience growth in imports from and exports to its major trading partners. Growth in trade will be influenced by development of free trade agreements—the United States is working on new agreements with Colombia, South Korea, and Panama.

Key domestic trends to watch include the following:

• Population growth: Twenty-year projections (based on data pieced together from individual states) indicate 20 percent growth overall, with mountain states, Texas, and Georgia experiencing the highest growth rates. These trends will affect both inter- and intrastate freight movements.

• Freight growth: Overall, tonnage is expected to grow by about 29 percent nationally, with several northern and western states projected to experience growth exceeding 50 percent.

- Modal trends: Growth in truck tonnage will be greatest in the western and northern states, but the overall national mode share of trucking will remain nearly constant (at about 70 percent of all tonnage and 40 percent of all ton-miles). The mode share for air freight is expected to increase by 100 percent but will remain a small (less than 1 percent) share of total tonnage moved. The mode shares of rail carloads will fall slightly, while the mode share of intermodal movements (e.g., combined rail and truck movements) will grow by a half a percent to nearly 3.5 percent of the total by 2030.

The forecasts indicate that intermodal shipments—while still a small proportion of total tonnage moved—represent the fastest-growing surface movement. Recent data from the railroads suggest that long-term forecasts might be overly conservative. The strong recent growth we have seen in intermodal shipments is related to containerization of an increasingly diverse range of commodities and to investments in rail mainline and terminal infrastructure to increase speed and reliability for container shipments. Much of the intermodal growth is driven by trucking companies' use of rail to ship containers over long distances, with trucking for local distribution. This growth is helping to counter losses in coal carload business by freight rail carriers. Throughout the freight industry, shippers and carriers are seeking ways to become more productive. For example, pending federal legislation could allow states to set Interstate highway limits on truck size and weight. Allowing larger trucks could increase productivity but could have important implications for infrastructure (especially bridges), energy, and safety.

Manufacturing Trends

A recent Boston Consulting Group study predicted that by 2015, the United States will become competitive with China for manufacturing certain goods, given recent increases in Chinese labor costs. "Reshoring" of manufacturing back to the United States may be a future trend. In particular, South Carolina, Alabama, and Tennessee are among the lowest-cost manufacturing sites when total costs are considered. Another manufacturing trend is "nearshoring," which takes advantage of relatively low labor and transport costs of hemispheric trading partners—especially Latin American countries with which we have free trade agreements.

Energy

Shale gas production is expected to increase dramatically by 2035, and the United States is poised to become a major liquid natural gas exporter given lower production costs relative to other parts of the world. This will have significant impacts on transportation.

Congestion

Increased congestion is a concern for future freight movements, both for major Interstate corridors and within urban areas. Gross domestic product has been outpacing transportation investment for some time, and truck vehicle miles of travel (VMT) has been outpacing automobile VMT. Severe urban congestion is exacerbating truck parking shortages. This has increased transport costs and prompted the development of multiple distribution centers and truck fleets.

Data for Freight

Freight data are critically important in helping transportation agencies make good investment decisions. At the national level there are fairly good data on freight flows by mode, especially between intercity markets. However, data weaknesses exist for many cargo movements, including domestic flow of international goods and metropolitan freight movements. States have been collecting a variety of data (including origin–destination studies) and developing freight models to support their planning activities.

Using Data for Investment Decisions

The big question is how to take available data on current patterns and trends and use them to make the best possible investment decisions. What data are needed to help us determine which investments will boost our competitiveness? There have recently been good examples of using freight data for Topologically Integrated Geographic Encoding and Referencing System analysis and project prioritization that we can build on. Integration of freight data and performance measures in the future will further enhance our ability to respond to freight trends in our transportation decision making.

ENERGY
David Greene

If one thinks about transportation from the perspective of physics, its essence is the application of force to move a mass a given distance—that is the definition of *work*. And you need energy to do work. Without energy, you cannot do work and you cannot have transportation.

The United States and world transportation systems face serious energy challenges that need public policy solutions:

- Energy security,
- Greenhouse gas (GHG) mitigation, and
- Sustainable energy.

This presentation discusses these challenges and some potential solutions.

Petroleum provides 95 percent of the energy for global transport, which accounts for 27 percent of global final energy use. Our transportation sector consumes 6,300 gallons of petroleum every second. Despite efforts to reduce petroleum use, we remain nearly totally dependent on this energy source.

The problem with being dependent on oil is that the world oil market is not a normal competitive market. The Organization of the Petroleum Exporting Countries (OPEC) controls 70 percent of the proven oil reserves. National oil companies own more than 80 percent. OPEC controls more than 50 percent of all the ultimate resources of conventional oil.

Statisticians will tell you that post-OPEC, world oil prices look like a random walk. This means that prices are extremely volatile and difficult to predict. I have estimated that oil dependence cost the United States more than $500 billion in 2008. Much of that cost is wealth transfer—essentially monopoly rent. This was not the cause of the ensuing recession but was part of the triggering mechanism.

U.S. dependence on foreign oil is due in part to peaking of domestic oil production in 1970. Despite technology advances and new discoveries, production has declined since then.

A monopolist's market power depends on its ability to reduce supply. The bad news is that the International Energy Agency foresees a plateau in non-OPEC conventional and unconventional oil production from now to 2030. That means that the rest of the world's ability to respond to OPEC manipulation of energy prices and supplies will be diminished and that OPEC's market power will be increased.

The rate at which the world is using conventional petroleum is large relative to any estimate of ultimate resources. More than one-fourth of all the oil ever consumed was consumed between 1995 and 2005.

Liquid fuels can be produced from unconventional fossil resources (e.g., shale oil) at prices the world has shown it is willing to pay. The problem is that these sources are associated with much higher carbon dioxide (CO_2) emissions. GHG emissions from oil sands are 20 to 80 percent higher than gasoline from conventional oil. Liquid fuels from coal would likely more than double CO_2 emissions (without carbon capture and storage). But we can go there if we want, and this is probably the path of least resistance.

The need for action on climate change is indisputable. We are a big player in this. The U.S. transportation sector contributes more CO_2 than any other country in the world other than China. CO_2 makes up nearly all of transportation's GHG emissions.

What can we do about it? There are four potential levers:

- Activity: passenger miles, ton-miles;
- Shares by mode;

- Carbon intensity (grams of CO_2-equivalent per megajoule of energy); and
- Fuel economy (energy efficiency).

In the near term, improving energy efficiency is the most promising strategy, although we lack scientific data on in-use fuel economy. The original corporate average fuel economy (CAFE) standards had the effect of decoupling the VMT and fuel consumption trend lines. A potential for further improvements can reasonably be inferred.

Proposed 2017–2025 standards will put light-duty vehicles on a path toward an 80 percent reduction in CO_2 emissions through 2025–2030; after that we will need other options. In addition, the European Union, the United States, and China are implementing efficiency standards for heavy-duty vehicles. There are many opportunities here.

We have an ambitious renewable fuel target (36 billion gallons of renewable fuel by 2022), but cellulosic biofuel is off to a slow start. Unfortunately, we have missed the first two targets by two orders of magnitude. Many significant questions remain about biofuels, and whether making biomass into ethanol is the best option is not at all clear.

Even doubling global transport energy efficiency would simply hold energy use to today's level in 2050. We would still need another 50 percent reduction in GHG emissions. In addition, as we make the system more efficient, it will likely be cheaper, and we can expect some rebound effect.

With respect to reducing VMT, I suggest following up on Recommendation 2 of the Transportation Research Board's *Special Report 298: Driving and the Built Environment: Effects of Compact Development on Motorized Travel, Energy Use, and CO_2 Emissions* (more studies of compact land use patterns) to find out whether people prefer living in more walkable, bikeable environments as opposed to others. It is just ideology to say that what we have must be right because the market created it.

Much can be done by changing the way vehicle travel is priced without increasing its cost. A road user fee on energy could be implemented without a great administrative burden: simply tax all energy and index it to the average efficiency of all vehicles on the road and to inflation. This encourages both VMT reduction and increased energy efficiency.

Another conclusion from another National Academies study is that we need an energy transition such as those we have had in past—from animals and biomass to coal, petroleum, natural gas, and nuclear. This poses a major challenge to public policy, since in the past these transitions have been driven by technology and market forces rather than by the public good.

QUESTIONS AND ANSWERS

Question: How has climate change been considered in the demographic projections? What if Florida is underwater and the Southwest is 110 degrees all of the time?

   Don Ludlow: The population projections presented were pulled from individual state analyses; I doubt that climate change was a factor in these models, though that does not mean that it should not have been considered.

Question: On the public-sector side, what are some performance indicators that can be used in assessing the value of our assets, besides just how much money we can make from an asset?

   Jeff Holt: There is no question that valuation is not as straightforward as price. The public and private sectors will have different perspectives on values.

Question: Considering the energy curves over the past 200 years, is there anything in the future that gives us reason for optimism?

   David Greene: There is reason to be optimistic if one looks at progress in energy efficiency and at the cost of alternative energy technologies—for example, the energy density of batteries and the costs of fuel cells. The cost of a fuel cell was $1,000 per kilowatt 15 years ago versus $50 per kilowatt today. This needs to get down to $20 to $30 to be cost-competitive, but we are nearly there. The cost of hydrogen and the cost of electricity from renewables are still higher than the cost of coal or natural gas, but battery or fuel cell electric vehicles are substantially more energy-efficient. Unlike previous fuel economy standards, the 54.5-miles-per-gallon CAFE standards cannot be met entirely by proven technologies. We need more technological innovation; the timeline is longer than for other standards. It provides a framework within which we can push ourselves hard in this direction with checkpoints along the way.

Question: What is the impact of private-sector unwillingness to share data on the public sector and on the end customer?

   Holt: I have to come at this from a freight perspective. The jealousy with which these companies guard their data means that if you sell an asset over which you used to have total control—for example, a freight gateway—you are basically saying goodbye to your ability to monitor traffic through the gateway. This may or may not have a downside.

   On the other hand, if you sell a toll road, you would likely need to have transparency as to safety violations, maintenance, and so forth. This is something that you would write into your contract agreement. Also, since most of the concessions are long-term leases rather than outright sales, you would want to require some reporting on the condition of the assets—you would be able to get that.

Case Studies
Effective Uses of Data for Decisions

Tina Lee, *Pierce Transit*
Julie Lorenz, *Burns and McDonnell (formerly Kansas Department of Transportation)*
Douglas H. Simmons, *Maryland State Highway Administration*
Matthew H. Hardy, *American Association of State Highway and Transportation Officials, presiding*

PIERCE TRANSIT TOMORROW: USING DATA TO GUIDE SERVICE DELIVERY
Tina Lee

Pierce Transit operates in a 400-square-mile area in Pierce County, Washington. Tacoma is our largest city, located 25 miles south of Seattle. We are a municipal corporation funded primarily through the 0.6-cent sales tax. We have a board of elected officials. In 2010 we carried an average of 45,000 passengers on weekdays. We have a fleet of 300 vans and carried 700,000 passenger trips annually. We operate inner-city service under contract to Sound Transit. We also operate shuttle paratransit service, with 8,000 registered users who made 470,000 trips in 2010.

In 2010 we knew that we would need to make service cuts unless more funding became available. In this context, we wanted to examine the agency comprehensively, understand what Pierce Transit should look like, and get community involvement in the process. Our goal was to develop a financially sustainable system that the public would value and use.

We combined technical analysis with an extensive public involvement process to shape a conceptual plan.

Technical Analysis

We worked with the Puget Sound Regional Council and applied travel demand models and other tools. We also reviewed relevant comprehensive plans in the service area to see what projects might be coming that would affect service.

We analyzed ridership on every route in the system by making use of our new automated passenger counting equipment. The analysis provided an understanding of where all of our passengers were getting on and off, as well as ridership patterns by time of day and direction. We used this detailed analysis to identify inefficient areas in our services.

Public Involvement

Our public involvement process reached 30,000 people. It took various forms. Our CEO met with 40 industry leaders. We hosted planner summits. We reached out to city councils, the local media, and employers. We worked with all major employers who have 100 or more employees in downtown Tacoma. They shared employee home address locations. This information was geocoded, which allowed us to use geographic information systems to overlay various service alternatives to help them see how their employees would be affected.

We had community meetings in eight service areas. They involved volunteers from every part of the agency. A total of 80 Pierce Transit staff members participated.

We started each meeting with "PT 101"—a primer on Pierce Transit—the services we offer, where our revenue comes from, and so forth, so that all participants were starting on a level playing field. Then, we conducted an innovative "values board" activity to identify the values that mattered most to the community. Values included the following:

- Social service,
- Livable communities,
- Geographic equity,
- Safety and security,
- Environment, and
- Economic development.

We gave workshop participants eight buttons and had them place the buttons on the values they believed most important. Then we talked about resource limitations and asked them to remove five of the buttons. The remaining three selected values were those that they wanted their system to focus on. We repeated this exercise many times with various stakeholder groups. We used the results to help refine the technical data to emphasize what we heard.

The values activity showed that the highest priorities were related to the ability to get to work, school, and medical appointments and to the servicing of vulnerable populations. As we shaped the plan, these are the priorities we focused on.

In each round of public involvement, we created maps showing service alternatives for various funding scenarios. The maps showed areas of service reductions in red. What came to be known as our "sea of red" map showed elimination of service to entire communities, which generated a lot of attention. This brought home an awareness of the impacts of service cuts and provided the catalyst for a ballot measure, Proposition 1, in February 2011. We brought forward both a preservation plan, which showed what we could do if the ballot initiative passed, and a service reduction plan, which was a modified version of the earlier "sea of red" plan that preserved some level of service to each community.

The ballot initiative failed by a vote of 54 to 46 percent. Results by precinct replicated the proposed service cuts and looked strikingly similar to the "sea of red" map. There was strong support in the Tacoma urban core but not in the more rural areas. The board went ahead with a plan to implement 35 percent cuts, and we set about working with the community on this.

The final service reduction plan focused on preserving the most efficient service areas, maintaining the highest ridership levels, keeping as many regional connections as possible, and connecting to high-ridership corridors. With this reduction plan in place, early indications are that we have been able to save 1 million trips over the prior plan. Furthermore, we have been successful in improving efficiencies. After 1 month, our estimated cost per passenger has been reduced by 59 percent, from $9 to $3.70. Our passengers per service hour went up from 23 percent to 26 percent. We are closely monitoring service indicators and are continuing our engagement with the community so that we can put our resources back into the strongest corridors as we are able.

WHERE ARE THE "WUNDERDATA" FOR MAKING BETTER, SUPPORTABLE DECISIONS?
Julie Lorenz

There is no magic data set on which to base decisions. The key is to identify, develop, and use data that resonate with stakeholders and agency staff in transparent ways. At the Kansas Department of Transportation (DOT), we learned through our long-range planning stakeholder involvement process and through a task force that preservation, economic development, and more flexible and responsive project selection were top issues. From there, we identified data streams needed to support those three priorities. We needed to address a range of data incorporating engineering and economic considerations as well as regional input.

Our strong suit is engineering data, and that is what we started with. A key point is that we had to convince both internal and external stakeholders that we were doing solid analysis. Development of engineering measures was straightforward, since this was Kansas DOT's expertise. We adopted a standard approach examining current and projected volume-to-capacity ratios, with threshold values customized for rural versus urban projects.

Economic analysis was more difficult. We had used consultants to assemble case studies and assess return on investment (ROI) for a handful of projects. That was helpful, but we needed a way to do the analysis prospectively rather than retrospectively. We formed a working group to help us understand what would be important to stakeholders from an economic model. The group indicated a desire for a practical approach to reporting jobs and gross regional product that was customizable to Kansas data. The group also cautioned us against comparing urban and rural projects.

Our consultants talked a lot about travel time savings, but the chair of our working group did not want to hear about travel time; she insisted that economic benefits be presented in terms of jobs and tax base. We followed this advice, being sure from that point on to talk only about jobs and economic impact. This did not change our approach; it only changed how we communicated our results.

We faced many challenges in implementing the economic analysis piece. Staff members were uncomfortable with making assumptions for the economic model. Therefore, we invited assistance from stakeholders. This let our staff off the hook and provided them with a source of external information. It also let our stakeholders look inside the box and participate in the analysis. This process allowed the DOT to develop buy-in for the economic analysis.

Once we had developed the economic model, we presented results for three example projects to those in the governor's office. We reviewed the various data streams, but they were most interested in the ROI results. Since the project costs were similar and the analysis seemed credible, they strongly supported the project with the largest economic impact.

Regional input was a third factor considered in project evaluation. We asked our district engineers to rate projects on the basis of regional stakeholder meetings as well as their "boots on the ground" local knowledge. At first it was difficult to get staff to understand this process, but ultimately we were able to get good, consistent information.

Once the three data streams were established, we had to decide how to weight the various elements. We decided that

• Preservation projects would be weighted 100 percent on the basis of engineering data;
• Modernization projects would be weighted 80 percent on engineering and 20 percent on local consultation; and
• Expansion projects would be weighted 50 percent on engineering, 25 percent on local consultation, and 25 percent on economic impact.

Once we had these scores, we had other things to take into consideration. As we built the Transportation Works for Kansas program, we were clear that scoring was not equivalent to programming. The top 100 projects were all good, but we could not build all of them. We considered overall cost, schedule, and cash flow; existing investments in those projects; and fit within regional spending ranges. We decided to optimize within them on the basis of phasing, location, prior funding, other investments, and regional-level spending range.

Creating the regional-level spending framework required discussions about what the appropriate factors should be (e.g., lane miles versus centerline miles). We analyzed multiple approaches and incorporated stakeholder input. Once the regional

spending ranges were established, we went back to the regions and discussed how to allocate the available budget. We talked about many options for spending the money—for example, two really expensive projects or smaller pieces of multiple projects. We began to see some peer pressure operate across the regions, and people started to work together to compromise. This process was successful—it was not the DOT dictating what would be done; it was communities within a region working together and compromising.

We developed an at-a-glance summary of projects that allowed the governor to see factors that had been considered in proposing projects to be funded by the new bill: engineering, input, economic (ROI), and other factors such as previous investment and corridor completion. This allowed him to confirm quickly that these projects made sense.

In conclusion, the "wunderdata" are actually the process. The key is letting people shape some of the parameters under which you are using that data. The following are key lessons:

- Do not get hung up on the perfect approach—trying is better than not trying.
- Generate solutions that really matter; do not fuss over the details.
- Demonstrate progress.
- Come to the table with good intentions.
- Be patient with staff, stakeholders, and decision makers.
- Have data, analysis, and packaging for each group—technical staff, internal decision makers, and external decision makers.
- Make data part of the decision-making process, not the sole determinant.
- Economic data are key for legislators.

You need to be able to answer the question, what is important for your decision makers? If you cannot answer that, you have more work to do.

USE OF DATA FOR DECISION MAKING IN A PERFORMANCE-BASED TRANSPORTATION OPERATING AGENCY
Douglas H. Simmons

I will talk about some of the internal mechanisms we went through at the Maryland State Highway Administration (SHA) to implement performance management. Maryland is a highly urbanized small state. SHA has 3,000 employees (and shrinking), a $200 million operating budget, and an $850 million capital budget.

Performance measurement has evolved in Maryland. In 1996, we created our first rudimentary business plan based on outputs. In 2002, we followed a Baldrige

approach, with outcome-based objectives. In 2004, we started seeing much more interest in our measures from the state and federal governments, and "managing for results" became a state law.

While outcome measures (particularly in the planning world where you are looking out 20 or 30 years) are important, short-term output measures are often key to decision makers and leaders. This is especially true for elected officials with 2- or 4-year terms. The bottom line is being able to show progress for the dollars invested.

The following have been key elements of building a performance-based approach at SHA:

- Create an agencywide framework.
- Pick meaningful measures.
- Use measures in a meaningful way.
- Collect and share data and performance results.
- Control data quality.

The SHA business plan defines our mission, vision, and key performance areas. The plan is revisited every 4 years but has been largely consistent. Having a consistent business plan with consistent performance measures in place over time has been helpful. Key performance areas are the responsibility of senior managers. We also moved to common operational performance measures across all of our seven districts, despite the unique conditions in each district. This allows for comparison across districts, identification of best practices, and sharing of results across district lines.

SHA meets monthly with governor's staff as part of StateStat. The StateStat reviews grew out of CityStat, which was brought to Baltimore, Maryland, from New York. For this approach, you have to be prepared to cover the full range of work you are involved in at the agency.

It is important to be selective and pick meaningful performance measures. Once you pick a measure and start publishing it, the expectation is set that you will track the measure into the future. You need to consider the time and costs associated with that.

The following are SHA's key performance measures:

- Safety—highway fatalities and injuries;
- Travel time savings due to congestion management—intelligent transportation systems, capacity enhancement, signal retiming;
- Pavement condition;
- Structure condition; and
- Maintenance level of service.

We have been able to make progress in our performance, even in tough budgetary times.

For travel time savings, we have found that adding a service patrol vehicle or extending service patrol vehicle hours may be more efficient than adding capacity since we can get greater delay reductions by addressing nonrecurring congestion.

For pavement condition, our goal is to maintain 84 percent acceptable ride quality statewide, which we have been able to do. However, when we examine the data we see that condition on the rural arterials is much better than on the urban arterials. We faced a tough question: investing in soft fixes on rural arterials was the easiest way to hit our condition target, but that meant that the urban arterials suffered. We have started to shift more funds to the harder fixes in urban areas.

For structures, we track the number of structurally deficient (SD) bridges. Even as revenues decreased, we were able to increase our bridge funding and reduce SD bridges to 4 percent. But there is a question of what the appropriate target is. Even though the target is straightforward, we look at the data behind the data to make our decisions. For example, we understand that working on a small bridge in rural Maryland is not equivalent to a project on the Woodrow Wilson Bridge. We also examine how quickly bridges are becoming SD. Our goal was to address the trend of bridges becoming SD and slow that down, and we were able to do that.

From the perspective of operating budgets, mowing provides an interesting example where we had lots of data and clear targets. Our system looked like a golf course, and everyone loved it. But as revenues got tighter and as we were considering environmental compliance, somebody asked, why are you doing all of this mowing? We reassessed what we were doing and changed performance measures and targets to allow grass to grow higher. Our customers were fine with this, and now we are able to do half the mowing we used to. My point is that the data might be saying you are on target, but you might be asking the wrong question.

Here is another example. We had issues with environmental compliance at SHA shops. We signed a consent agreement with the Environmental Protection Agency (EPA) and agreed to audit all of our operations. We initially found 1,400 violations. We outlined everything we found and reported it back to EPA. We now measure this monthly with quarterly reports to EPA and include action plans.

Once you get the data on hand, you will want to share the data across the organization. This broad exposure will likely generate productive discussion about the purpose of the data and may lead you to refine what data you collect.

Data quality control has become an issue for us as staffing has dropped. While we have a small data management team, we also need to continue to work on instilling data management requirements and understanding across the organization.

The main lesson is that performance management is about management, not just measurement. If you do not examine the data to increase your understanding and make changes, your investment has not been worth it.

QUESTIONS AND ANSWERS

Question: Have you seen a drop or an increase in the number of performance measures you use over time at Maryland SHA?

   Doug Simmons: Performance measures tend to grow like bacteria. But I would say that there has been a leveling off in the number of measures. The challenge is that there is such a broad array of issues to be addressed in transportation, and once an issue arises you search for data and measures to try and understand and address it. But once you accept a measure, it is hard to stop. So I would say that our performance measures have leveled off but will likely continue to increase, not decrease.

Question: Tina, in your talk I heard that geographic equity did not rise into the top three concerns, and yet it seemed like your board made the decision to factor it in. What is your take on that?

   Tina Lee: Some communities did emphasize geographic equity, especially in rural areas. When times were good, we could serve everybody, and when we were founded that is the principle we operated under—we would offer service if it was requested. But our situation has changed. When that "sea of red" map came out, small city mayors got together and asked us to reassess our approach. So we regrouped and developed an option that focused more on geographic equity. After the ballot came back the way it did, we had a basis for pointing out that these communities themselves do not support the transportation services that are coming to them. That empowered us to move to the focus on efficiency.

Question: How did you get through Title 6, which requires service to low-income and minority populations?

   Lee: We did a comprehensive equity analysis and showed that concentrations of these populations were in the urban areas where service was preserved. We did do some mitigation to maintain commuter services that connected to Sound Transit.

Question: Julie, I like the way you converted the congestion measures to economic values. Is that something your staff can do, or do you need to use consultants?

   Lorenz: We bought a software package and ramped up with consultant help. It took about 4 months for analysis, but over the past year our staff members have become much more comfortable with it and are able to do it themselves.

Question: Julie, how did DOT leadership help to get staff to overcome their discomfort in moving to a new approach involving economic analysis and public consultation?

   Lorenz: Staff responded at the direction of the leadership. We found that you can leverage external stakeholder input to shift your internal culture. There was some

resistance to opening up what had been an engineering-driven process, but it was helpful to get staff out to public meetings. When they started hearing things like, "Y'all are nuts at the DOT, you don't understand what is going on in our community," they started becoming much more sensitive. It is not a good idea to insulate staff too much. Let them be a little uncomfortable; it will help with the transition.

Question: Also for Julie—how were the models used? Was there a temptation to just use the results to select the projects with the greatest economic ROI without considering the other factors?

Lorenz: One thing that was helpful is that we worked with stakeholders in developing the weights that said economic analysis should only count for 25 percent. We also put together a list for the governor that showed why a 100 percent ROI-driven process would not work. We showed on the map how projects would be concentrated in two parts of the state, which would not have been politically acceptable. Also, getting regions to agree and lock in spending ranges were critical to the success of the program.

Question: Is there any interest in doing a postproject audit in Kansas?

Lorenz: Yes, absolutely, a commitment has been made to do case studies over time.

Closing Session

Frances D. Harrison, *Spy Pond Partners, LLC*
King W. Gee, *Federal Highway Administration*
Jacob Snow, *Regional Transportation Commission of Southern Nevada*
Deb Miller, *Kansas Department of Transportation*
Joseph L. Schofer, *Northwestern University, presiding*

WHAT HAVE WE LEARNED?
Frances D. Harrison

Big changes are afoot. The data programs we rely on are starting to lose ground, while we are facing new demands for transparency and data-driven decision making. New data sources and data collection technologies are emerging, but we are still learning how to tap into them. As we consider our charge—creating a data agenda for the future—the question becomes whether we need to tweak what we have now or whether we need to make more fundamental changes in how we collect and use data.

Our starting point clearly needs to be an understanding of how data are used for decision making and what is most important for our agency leaders and elected officials to know in the coming years. The preconference workshops gave us a good foundation. The workshops also underscored the point that developing a data agenda is not just about collecting more data. A major part of this is being smarter about packaging and delivering the data that we already have so that the data are useful and actionable.

Prior Work on Data for Decisions

My task is to synthesize what we have learned and discussed here. But we should recognize that this is not the first time that a group has been convened to discuss data for decision making. So I will begin by pointing out a few prior efforts of note that have provided a foundation on which we can build:

• Alan Pisarski's 1999 Transportation Research Board (TRB) Distinguished Lecture, Transportation Planning, Policy, and Data: Inextricable Linkages, discussed the critical role of data to "illuminate the past, provide insight on the present, and provide guidance for the future." Pisarski pointed to a number of major data gaps, particularly in our understanding of freight movements. Many of these gaps remain today, more than a decade later.

- TRB's *Transportation Research Circular E-C109: Transportation Information Assets and Impacts: An Assessment of Needs*, published in 2006, included a framework for classifying transportation data needs and identified several examples in which data were successfully used in supporting decisions. This work emphasized the importance of treating data as an asset. It also identified key information attributes important to decision makers, including timeliness, responsiveness, clarity, and conciseness.
- TRB's *Transportation Research Circular E-C121: Information Assets to Support Transportation Decision Making: Report of a Peer Exchange of State Transportation Organizations*, published in 2007, documented results of a peer exchange held in Kansas City, Missouri. The exchange identified several data gaps and discussed many of the building blocks needed for effectively managing, sharing, and using data. One key observation was the need for strong relationships between data users and data providers, so that data providers could gain the insights necessary to meet important information needs proactively.

In addition to the work that has been accomplished within the TRB community, there is a body of research on the use of technical information for policy making in other domains. The conference reference list includes a citation for a 2011 article on early childhood education by William Gormley published in *Science* magazine. That article includes a number of observations that are pertinent to our discussion. Gormley notes that scientific information is used more to *justify* than to *develop* programs. He cautions information providers not to expect a "hypodermic impact"—direct, immediate, and powerful effects—from information products. He identifies several factors that help information influence decisions, including credibility, brevity, and trust relationships between researchers and policy makers. Key failure points that inhibit impacts of information include fragmentation of decision making, lack of scholarly consensus, and tight budgets that make any response to information problematic. Gormley echoes the observation from the 2007 peer exchange about the importance of strengthening the connection between scientists (information providers) and policy makers.

This takes us back to the present. Let us review what we have heard over the past couple of days.

Opening Session

In the opening session, Deb Miller told us that our purpose here is to strengthen the influence of data in decision making and reminded us that decisions are the star of the show. She challenged us to develop some recommendations that would improve our ability to make stronger, better transportation decisions.

Joe Schofer highlighted key lessons from the workshops that set the stage for this conference. We heard that even though this is a transportation data conference, deci-

sion makers are not aware that they need transportation data. They are most interested in *information* pertaining to broader outcomes, such as economic development and quality of life. This suggests that as data providers, we need to work backwards from the complex information needs expressed by decision makers to identify what kinds of raw data and techniques for transforming and presenting the resulting information are needed. From the workshops, we heard about the importance of relating transportation decisions to broader outcomes. Workshop findings also suggested the need for providing consistent information about emerging trends affecting transportation and for developing improved ways of planning in the face of uncertainties related to climate change, energy costs, transportation finance, and the global economy. We came away from the workshops recognizing the importance of building our capacity to transform data into useful information—both by developing better tools and methods and through training the next generation of analysts. Finally, given the observation that foundational data were nearly invisible to decision makers, it is worth considering new ways to tag and credit data explicitly to help sustain support for data programs.

Answering Tough Questions

In the first plenary session, Current Approaches to Answering Tough Questions, we heard about how three transportation organizations have gone about assembling the data they need for decision making:

- The Utah Department of Transportation (DOT) has focused on building a consistent and integrated data foundation that provides the ability to answer a diverse and changing set of questions.
- Oregon DOT has developed new analytical tools in response to challenging policy questions, which have led the department to redefine its data requirements.
- Metroplan in Little Rock, Arkansas, pieced together available data from both conventional and nontraditional sources to tackle long-range finance and planning issues in the face of uncertainties in energy costs, revenues, fuel efficiency, vehicle miles of travel, construction costs, and urban form.

    Although these examples were all different, they were connected by a common thread that led to success: extensive interaction between information providers and users.

Future Trends

In the session on future trends, we heard three presentations on finance, the global economy, and energy. We were reminded that many dynamic forces will shape the context within which transportation decisions are made. We know that big changes are coming, but the picture is not at all clear.

Case Studies

Case studies of successful uses of data for decision making showed practical examples of how data can be used for transit route restructuring, capital program development, and performance management. Again, use of data within a strong collaborative process of stakeholder engagement was a common theme.

Breakout Groups

Participants in 10 breakout groups drilled down into each of the spokes of the wheel in our conference diagram that collectively contribute to effective use of data for decision making. Here is a quick overview of some of the actions that were identified within each group that can be considered as part of a future data agenda.

- **Coping with broken trends:** Improve scenario planning methods. Advance our ability to understand emerging trends and factors that contribute to uncertainty. Expand use of pre- and postproject evaluation to provide a stronger evidence base for future decisions.
- **Customer information:** Identify and evaluate new information sources and market research techniques for understanding customer values. Develop new methods for synthesizing multiple available sources of customer information and for addressing biases associated with use of social media information.
- **What works and what does it cost:** Build capacity to conduct and document case studies rigorously. Improve methods for assessing applicability and transferability of case studies. Quantify the value of face-to-face peer networking. Consider how to meet the needs of the next generation of professionals, who will tend to seek examples via the Internet rather than through face-to-face exchanges. Develop and pursue knowledge management strategies in transportation agencies.
- **Tools for trade-off analysis:** Improve analytical tools for cross-asset trade-offs and for communicating trade-offs to decision makers. Conduct peer exchanges and best practice scans on tools, methods, and current applications.
- **Looking ahead:** Study the evolving relationship between the public and private sectors in transportation. Investigate the implications of multiple emerging technologies in transportation. Identify strategies to mitigate risks. Strengthen the body of knowledge on the value of investments in transportation relative to investments in other sectors.
- **Delivering data for decisions:** Promote a wider understanding of decision-making contexts and stages, how to tailor products for various audiences, and the value of collaborative processes. Develop and showcase improved processes for supporting effective communication and collaboration. Enhance transportation curricula to include these topics. Provide opportunities for sharing of examples. Hold juried competitions on communications materials.

- **Data acquisition:** Build greater awareness of available tools and inventory emerging tools. Provide guidance for transitioning to new tools, including how to approach legal and contractual issues such as intellectual property and privacy concerns. Document and share best practices for incorporating new data into decision-making processes. Conduct research on data fusion, data certification and quality assessment, and values related to data privacy.

- **Data sharing:** Explore issues concerning data privacy, liability, and confidentiality; management of hybrid data sets incorporating data with usage restrictions; design of data to meet multiple purposes; and metadata to support data sharing. Synthesize data-sharing issues and best practices. Pursue the national travel data program concept suggested in TRB's *Special Report 304: How We Travel: A Sustainable National Program for Travel Data*. Identify a core set of national transportation data for performance measurement.

- **Collaborative forecasting:** Build knowledge and skills on how to conduct a collaborative forecasting process. This requires special skills that engineers may not have, including the ability to understand and consider values and balance stakeholder views with the rigor of engineering and technical analysis. Develop and share examples of interactive sketch planning tools to support and assist in these processes.

- **Performance management:** Develop guidelines on the use of data for performance management. Pursue a U.S.-based transit benchmarking program. Develop data management and warehousing guidelines to support performance measurement. Develop training materials and conduct training on effective data-driven decision making.

What Have We Learned?

Through our breakout discussions, we have established that there are data gaps to be filled—for example, to support performance management. We have discussed the need for a better understanding of the values and preferences of our customers and the value of assembling a stronger evidence base concerning costs and effectiveness of transportation projects and strategies. Improving our ability to harness new data sources and share data within and across organizations is clearly an important part of the conversation about data. But the overarching message from this conference is that we need to operate more effectively within a collaborative decision-making process. Our role is to tap into appropriate data sources and craft a story that directly responds to the questions and concerns of decision makers. We need to anticipate these questions and bring interactive tools to the table that can be used to explore various assumptions and scenarios.

Here are seven specific takeaways to keep in mind as we work collectively to improve use of transportation data for decision making.

1. **Use data to tell the story.** Figure out what the important questions are first and let that drive your modeling and data collection programs. Then craft a story that answers the questions in a clear and direct way. Where possible, be proactive about framing the discussion so that information is immediately available to meet the need when it arises.

2. **Understand and manage risks.** The potential impact of major external factors is enormous but not easily predicted. We need to monitor closely and share information that helps us anticipate what will happen. We also need to get better at scenario planning and develop new approaches to decision making that allow us to be more agile.

3. **Build skills for collaboration.** Recognize that transforming data into usable information requires a collaborative process and specialized skills and experience. There are examples to build on, but we need to improve professional capabilities in this area.

4. **Design data programs to enable sharing.** We have opportunities to design data programs to optimize integration and sharing across agencies, sectors, and juris-dictions. Origin–destination data and asset performance data are two promising areas where this could be done.

5. **Tap into new data sources.** Agencies are finding a cornucopia of new data sources, new sensors, crowdsourced data, and so forth, and it is important to share lessons learned as different sources and methods for integrating these data emerge.

6. **Tailor data delivery for different decision types.** Key decision areas for state and regional agencies have unique data needs. Tailored strategies and models for data delivery for each type of decision should be developed:
   – Long-range planning and smart growth,
   – Program development and project prioritization,
   – Performance management,
   – Asset management,
   – Integrated corridor management,
   – Safety planning, and
   – Transit service planning.

7. **Build constituencies for data.** Given that data are invisible yet provide the skeleton that supports our information, we have to work on developing strong and diverse constituencies for the foundational data that we need (and that may be at risk).

WHERE DO WE GO FROM HERE?

Federal Perspective
King W. Gee

Thank you for bringing your wealth of experience and knowledge to this conference. The questions we face are changing, and we need to break new ground in using information. The business model of transportation agencies has been evolving from a traditional public works mentality to an owner–operator mentality, which affects our information needs. There is growing interest in the outsourcing of transportation services. We are seeing a shift toward the models that have been adopted in the United Kingdom and other countries where the transportation policy function has been separated from the delivery function. Look at the example of the Big Dig in Boston, Massachusetts, where you had a consultant responsible for managing a multibillion-dollar highway program. Is that much different from private management of a state highway program? We are seeing more use of public–private partnerships (PPPs). The metrics used for evaluating PPP performance give us a glimpse into what is important in our enterprise.

There is a growing consensus that we need to be more accountable for how we invest in our national highway program. We are shifting from looking at outputs to outcomes. We anticipate that the next transportation bill will focus on the expanded National Highway System and will include outcome-based performance measures and targets. Specific measures that have been put forward are safety in terms of fatalities and infrastructure in terms of pavement smoothness and bridge condition. We are starting with these measures because we have the data sources to support them; others will be developed in the future.

The Senate bill Moving Ahead for Progress in the 21st Century included three additional measures for road mobile emissions, traffic congestion, and freight movements. The bill calls for state performance targets only, whereas the administration's bill includes national targets. The challenge will be to ensure that targets are meaningful and linked to planning processes. Achievement of targets will not be tied to apportionments, but we envision that if targets are not met there will be constraints on how funds can be spent.

In terms of the larger context of how to advance the practice, we have to go back to basics: our business is about moving people and goods. We need to be able to describe why this is important and how investments in transportation can be balanced against investments across other sectors, including health, education, and welfare. We need to be smarter about how to pull information together that helps us talk about trade-offs and alternative investment models. How can we prioritize across capacity, transit, and preservation projects? Can we afford to sustain the maintenance level of service that we have come to expect? We need a complete picture of what we are

dealing with—at the corridor, network, and multimodal levels. Finally, we need to understand and communicate what we are *not* going to get in the absence of transportation investments.

At the end of the day it is about telling the story. Think about what our stories have been over the past 100 years—first it was "getting the farmer out of the mud," and then later in the Interstate era it was "coast to coast without a stop." What is our current story?

Finally, the federal role goes beyond providing funding. It is also about identifying and disseminating best practices. In the past 50 years, the Federal Highway Administration has worked to advance the comprehensive, continuing, and cooperative planning process; pavement management; asset management; the linking of planning with the National Environmental Policy Act; context-sensitive design; Superpave®; and, most recently, performance management.

We are committed to continuing our work with all of you to advance the state of the practice. Thank you for being part of this conference, and thanks in advance for your collaboration going forward.

Metropolitan Area Perspective
Jacob Snow

The Regional Transportation Commission is a metropolitan planning organization (MPO) responsible for both planning and implementation. We are a street and highway builder and operator. We are also the transit agency and the intelligent transportation systems agency. We are funded from gasoline and sales tax revenues.

Conferences like this one provide important opportunities to collaborate. We recognize all of the work on data being done at the federal and state levels, but our intent is to move forward at the local level and to collaborate with as many partners as we can to make progress.

I was recently asked the following by the press: You have claimed that cycling is up in Las Vegas, Nevada—how much has it increased? Other than knowing that we have had to add more bike racks to our buses, I do not know how to measure this. We appreciate the opportunity to share how to gather information like this with others. Once we get the information, we plan to share that too.

The concept that resonated most with me here is the need to match data with the values of the community. For example, during the past few months we have had a rash of pedestrian fatalities in Las Vegas. We were able to go to the National Highway Traffic Safety Administration database and see where vehicle–pedestrian fatalities have been taking place over the past 10 years—95 percent are on an arterial street with a speed limit over 35 miles per hour. This says that we seem to value going fast more than pedestrian safety. When we share this information with our community, people scratch their heads. The truth is, we are not even getting anywhere

faster since traffic signals are the limiting factor. We really need to take a look at what we are doing with our data and how it matches our values as a community. Once we do, we can focus on how to turn that data into information that can shift our values.

How do we know when we are successful? When we make presentations of these data tied to the values of the community and our constituents are so satisfied with how we have shared the information that when we are done they come up and ask for a cigarette.

State Perspective
Deb Miller

As I look back on the past 20 years, the data issues we have been talking about may still be the same, but that does not mean that we have not made progress. We have in fact made enormous progress. The goalposts move as we evolve and ask and answer more sophisticated questions.

When we started here, Joe encouraged us to get out of our comfort zone. After listening to the level of discussion here, I would say you all do not live in the comfort zone. But I can tell you that many of our colleagues do live in a comfort zone, whether they work at a state DOT, an MPO, a transit agency, or a consulting firm. My takeaway from this conference is that we all have to be responsible for taking our energy, our ideas, and our commitment to stronger, better collaborative decision making out and for creating cultural change in all of the organizations in which we participate. This is what is needed to make progress.

If there were a "word cloud" for this conference, it would feature words like "collaborate," "values," and "decision making." "Data" would show up, but as a little word over here. All of the more technical things that I thought might be our focus have dropped into supporting roles, which is as it should be and is another indication of the level of progress we have made.

I might have anticipated that we would be walking away from this conference with an aggressive and expensive agenda to collect and synthesize a lot more data. Instead, we are walking away with an agenda that is more process oriented: create culture change, learn new skills, and find new ways to use data. If I assess our DOT, we have certainly done some wonderfully collaborative processes, and we have seen their benefit. However, to say that skill set runs deep would be inaccurate. When I look at the emerging issues and the new tools and techniques, they do not match up well with the capabilities in our department. So we have a challenging cultural issue and a transformational issue on our hands.

In closing, we have done a lot of great work here, but we are not done. We will work to sharpen and refine the ideas that we have developed here into a tighter agenda that will resonate with the broader TRB community and that can be put into action. Thanks to everybody for your time and attention.

Delivering Information to Decision Makers
Demonstrations

Scott Gilkeson, *State of the USA*
Nikola Ivanov, *University of Maryland*
John Thomas, *Utah Department of Transportation*
Terry Bills, *ESRI*
Julie Lorenz, *Burns and McDonnell Engineering Company (formerly with the Kansas Department of Transportation)*
David Plazak, *Transportation Research Board*
Rob Tardif, *Ministry of Transportation of Ontario, Canada*

Advanced software and the Internet are bringing new approaches to the tasks of analyzing data and delivering information that is accessible, understandable, and attractive to a variety of users. A number of these applications were made available for viewing and test driving during the conference. Participants were invited to browse, discuss, and assess these emerging tools.

MEASURING PROGRESS IN TRANSPORTATION WITH KEY NATIONAL INDICATORS
Scott Gilkeson

The U.S. Congress has created a Key National Indicators System, which builds on hundreds of state, local, and regional efforts. The National Academy of Sciences is preparing to implement the system, once it is funded, though a process that assures input from various experts and interests. This prototype site explores how transportation statistics might help the American people and policy makers assess for themselves the state and progress of the United States and its transportation system.

See http://www.stateoftheusa.org/.

WEB-BASED MOBILITY PERFORMANCE MEASURES TOOL USING PROBE DATA
Nikola Ivanov

An overview is presented of a powerful and user-friendly web-based congestion-monitoring tool that can deliver road, corridor, statewide, and regional performance metrics in highly intuitive and interactive graphics and tables with a few mouse

clicks. The live demonstration showcases both real-time congestion monitoring and historical performance reports generated through the fusion of vehicle probe, incident, weather, and other data sources.

See http://vpp.ritis.org/suite/screencast.

UPlan: A STATE FRAMEWORK FOR ORGANIZING AND DISPLAYING UNSTRUCTURED DATA
John Thomas

Transportation organizations own a great deal of unstructured data. UPlan is a collaborative effort that is designed to establish a framework for organizing and displaying these data. UPlan is an interactive, web-based tool that brings together data from various state agencies, utility companies, cities, counties, and others. The tool is being developed by the Utah Department of Transportation (DOT) to streamline access to data and analysis. The Federal Highway Administration (FHWA) recently allowed Utah DOT to submit automated reports from UPlan for categorical exclusions; discussions with FHWA are under way to explore how UPlan might be applied to shorten the project delivery process further.

See http://uplan.utah.gov.

GEOGRAPHIC INFORMATION SYSTEM FOR BETTER TRANSPORTATION DATA AND DECISION SUPPORT
Terry Bills

Several examples of the use of the geographic information system are demonstrated for data integration, effective asset management practices, and provision of a framework for more effective decision making. A secondary theme is the ease with which these technologies can now be accessed by everyone throughout the organization, leading to greater productivity and transparency.

See http://mdimap.towson.edu/statestat/, http://www.gettingaroundillinois.com/gai.htm, and http://uplan.maps.arcgis.com/home/.

"DATA MASH-UP" APPROACH FOR MAKING BETTER, SUPPORTABLE DECISIONS
Julie Lorenz

Kansas DOT has created a highly supported "data mash-up" that uses data along a continuum, ranging from highly subjective (regional public input) to somewhat subjective (economic impact) to highly technical engineering data. This display shows how the results of this data mash-up were integral in developing support for a new project prioritization process and an $8.2 billion funding program.

See http://www.kansastlink.com/calculator/.

T-PICS PROJECT ECONOMIC IMPACT ESTIMATION WEB TOOL
David Plazak

This Strategic Highway Research Program 2 product is an easy-to-use, web-based tool for estimating the long-term employment and income effects of highway capacity projects. It uses reasoning by analogy, based on a library of 100 detailed project case studies. It is an online tool that is best used for sketch planning and stakeholder involvement.

See http://transportationforcommunities.com/t-pics/.

DEVELOPMENT OF WEB TOOLS TO PRIORITIZE INFRASTRUCTURE INVESTMENTS EFFECTIVELY
Rob Tardif

Truck Global Positioning System and flow data provide excellent samples for detailed and high-resolution road performance analysis in support of freight infrastructure investment decisions in Ontario, Canada.

See http://icorridor.org/.

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Summary of Preconference Workshops

Frances D. Harrison, *Spy Pond Partners, LLC*
Joseph L. Schofer, *Northwestern University*

T hree regional workshops—in Hartford, Connecticut; Kansas City, Missouri; and Seattle, Washington—were conducted in summer 2011 to explore the use of data for state and metropolitan transportation decision making. Invited policy makers were asked to bring examples of decisions they faced and how they went about getting the data they needed to help in making these decisions. After brief presentations from the participants, the group discussed successful examples of how data and information were used as well as barriers they faced in finding or using pertinent data. On the basis of these discussions, we have compiled the following summary of key themes and observations that were raised by individual participants at the workshops.

KEY THEMES AND OBSERVATIONS
Context for Decision Making and the Role of Data

1. **Decisions are informed by data, but there are many other influences.** Forces and factors other than data and information influence decisions. Information is important, but objective data do not eliminate the influence of politics, public opinion, rules and regulations, and so forth. Despite the multiplicity of factors, "data fill the vacuum that would otherwise be filled with political ideology." Data can be important in "threading the needle" when decision makers must grapple with resource constraints, delivery and implementation factors, budgetary impacts, and prioritization. Many participants noted that objective data—data that are consistent and can be trusted—are of high value in the decision process, to offset favoritism for pet projects. Decision makers are (usually) looking for an objective basis for selecting or rejecting an action. At the same time, leaving decision makers some flexibility to follow preferences and values is useful in data analysis and interpretation. For example, while the use of standard criteria for project prioritization is valuable, purely formulaic approaches do not allow for integration of values, visions, and strategic goals in the choice process.

2. **Decisions are based on a broad array of objectives that go beyond transportation.** The principal objectives driving transportation decisions are no longer primarily concerned with transportation infrastructure, operations, and performance but with the connection between transportation investments and broader and frequently ill-defined outcomes, such as economic development and jobs, environ-

mental quality, financial sustainability, and quality of life (livability). These outcomes were cited as consistently important across all agencies and scales represented at the workshops. Transportation is increasingly a "means to an end," not "the end itself." The fundamental questions are in the form, "What does this project or policy mean for economic development, quality of life, and so forth?" There is a need to understand the full benefits and costs of options in the broadest sense (social and environmental as well as performance dimensions).

3. **Decisions must factor in major economic, environmental, and technological shifts external to transportation.** Many participants observed that the best transportation actions to implement, and their outcomes, are substantially dependent on megatrends that are outside—independent of—the transportation system. They include the future energy picture (price and availability) and its impact on location and land use decisions, vehicle choice, and travel behavior; climate change and its impact on transportation infrastructure; social values—evolving priorities on quality of life, locational preferences, and face-to-face interactions; and the state of the economy and its impact on what households, businesses, and governments can afford.

4. **Decision makers face complex choices and trade-offs.** Decision makers face extremely complex choices across a heterogeneous array of strategies for meeting a diverse and often conflicting set of objectives. Participants noted that they must do this on the basis of limited information. Transportation is inherently multimodal; while some choices—some programs and data—are in silos, trade-offs increasingly cross modal boundaries. Similarly, decisions among actions that rehabilitate and preserve the existing transportation system need to be weighed against investments in new capacity and services.

5. **Vision is a starting point; data are useful for evaluating strategies for getting there.** Concepts of what the future of a region or community should be like were cited as important for guiding planning, selecting alternatives for consideration, and making transportation choices. Visions are influenced by experience, ideology, and knowledge. Data-driven analysis and forecasting can be used to test, guide, and implement visions.

6. **Customer views are an increasingly important input to decisions.** Information about what is acceptable to customers and what customers value greatly facilitates the decision-making process.

Challenges for Addressing Critical Information Needs

1. **Responding to broader objectives.** Increased emphasis on a broader set of objectives changes the game, because it asks transportation analysts to look beyond the specific projects they are studying to consider the broader implications for society and the economy. Many participants observed that this calls for new (or at least different) mind-sets by transportation professionals, for analysis and forecasting skills

and tools, and for discussing and displaying expected outcomes in different and more complex dimensions. This broader perspective goes well beyond narrowly defined transportation data. It involves different data, different and more complex models, and an understanding of how transportation systems and changes in them interact with and affect the environment (context) of that system.

2. **Supporting trade-off decisions.** Many participants voiced a need for measures, data, and tools that support comparisons across modes and across investment categories (preservation, capacity, service improvement). It was noted that we need—and do not have—comparable measures to support them.

3. **Understanding emerging changes in trend lines.** Understanding and anticipating the context in which transportation functions are both important and particularly difficult in these times of rapid change. Most participants held the view that historic trends in travel, location, the environment, and the economy have been broken. The world in which transportation functions is different from that of the past; this is a strong argument for new data to capture and track these critical trends. The absence of a consistent basis—data, knowledge, tools, experience—for anticipating these trends constitutes an information gap that leaves today's decision makers with a high degree of uncertainty.

4. **Providing better regional data.** Participants observed that there is value in data organized at the regional scale (substate, multistate, interregional, and international), because many transportation problems are regional in nature. Many economic regions cross municipal and state boundaries, which makes regional-level data particularly important, but regional data and analyses can be difficult because data are not available at the right levels of aggregation or are not available at all.

5. **Forecasting—opening the black box.** Many participants noted that forecasts are particularly valued kinds of information for supporting transportation choices. Forecasts can narrow the range of future conditions transportation systems might face, and they are particularly important for anticipating the performance and costs of proposed actions and getting answers to if–then questions about options. Forecasts are founded on data and implemented through models, and thus they are themselves uncertain. The challenge is to narrow the range of uncertainty about the future and the incremental impacts of options so that informed decisions can be made. According to many workshop participants, decision makers want and need to understand the data and information they receive, particularly the limitations and assumptions that underlie them. Thus, analysts should communicate such metadata so that their customers can evaluate the informational products they receive. This means "opening the black box," particularly for forecasting tools, so that the quality and reliability of the contents can be assessed and assigned the proper weight in decision processes.

6. **Improving responsiveness to needs of decision makers.** Technical staffs responsible for data collection, analysis, and presentation need to be tuned in to

the needs of decision makers—the consumers of the information. This requires an understanding of decision maker characteristics, needs, capabilities, time frames, and priorities. It may simultaneously require longer-term programmatic perspectives and shorter-term political needs.

7. **Providing timely decision support.** There can be differences between analysts' willingness to release incomplete data and decision makers' immediate need for data to act. Some participants observed that there may be value in better communications so that decision makers understand deficiencies in data and analysts understand the trade-offs between certainty in data and the importance of supporting timely decisions. There is a trade-off between accuracy of data and adaptable designs for programs and facilities. Many participants noted that it is important to consider and control how much information is required before a decision can be made and a program can move ahead. In some cases it makes sense to take more risk—to rely on less information—to address serious problems in a timely manner. The risk that the perfect will drive out the good is, in many cases, real.

8. **Meeting new expectations for public-focused information.** An important segment of the customer base is the general public. Informational products typically need to be designed to be useful to the public. Traditional, objective information and reporting may compete with immediate response, advocacy information, and messages from popular thought leaders. The information needs, skills, and access channels of that public are becoming more complex and diverse. In particular, a generational transformation is taking place, and data and information for state and regional transportation decision making must now respond to an Internet-savvy, graphics-oriented cohort.

9. **Retaining and training analysts with the right skills.** According to many workshop participants, the challenge in supporting good transportation decisions is delivering enough information, in a form that is understandable to the decision makers, to reduce uncertainty and raise decision maker confidence in an option so that an informed choice that minimizes the risk of a major error can be made. A significant concern among participants is the eroding skill base in the technical workforce that assembles and analyzes data, converts the data to information, and produces useful products for the customers. The challenges include significant retirements among the most experienced and skilled professionals, loss of in-house capacity for conducting data collection and analysis through outsourcing, budget cuts and layoffs among specialists who conduct analyses and prepare creative reports, and lack of emphasis on communication and effective presentation in the training of young professionals for these key roles.

10. **Maintaining support for foundational data.** In transportation planning and decision making, data do not seem to be the most important issue. What most participants felt is important to decision making is information—data analyzed and processed into forms that are useful for guiding choices. Information comes from

a mixture or integration of data, analysis and modeling, judgments, experiences, values, and other sources. Information has complex origins, but it is what decision makers need. While data are often foundational, in the decision process data may fade into the background and become invisible. This can make it more difficult to secure support for data programs.

Strategies for Meeting Critical Information Needs

1. **Increased focus on transforming data into information.** The discussion of decision-making needs concentrated on the importance of information, its effective communication, and useful results derived from data. The process of transforming data into information, the analysis steps that make data useful, is essential for effective decision support. Many participants emphasized that analysts need to consider who the users are, as well as their interests and skills, and craft products to meet the needs of the customers. According to many participants, more resources need to be invested in the analysis and development of useful information and in producing reports, graphics, and other products that support decision making. There is demand for high-tech products, visualizations, "eye candy"—products that can be consumed in 2 minutes. Long reports "don't cut it"; people demand short documents, visualization. Executive summaries are all most decision makers read. Some informational products are just not produced in usable forms.

2. **Proactive approach to meeting information needs.** Decisions proceed apace and are made on time schedules driven by needs, opportunities, and the political process. Thus, decisions are made on the basis of the data on hand. This underscores the importance of proactive approaches that anticipate key information needs and ensure that data (and analysis results) are "in the bank," ready to be used for answering critical and time-sensitive questions.

3. **Collaborative approaches in using data for decision making.** Decision making and the use of data and information in decision making are inherently collaborative efforts. Collaboration across political parties, houses of the legislature, and agencies is essential to come to an agreement on what are the right data, what they mean, and what guidance the data offer for the choice process. According to most participants, buy-in to these collaborative processes is critical. Forecasts of contexts, costs, and performance were cited as key decision inputs, and the most challenging and important forecasting problems are often best solved with collaborative processes that mix data, quantitative models, experience, and judgment. Few forecasts are totally objective, and in highly uncertain situations, considerations of values—what we want the world to be like—and experience are essential in producing credible and acceptable forecasts. Improved models, guidance on collaborative forecasting, and forecasts and methods of others were all noted as promising ways to improve fore-

casts. Making forecasting tools available to decision makers and the public in accessible forms can be a way of educating the customers and getting value and preference information from them. The Portland (Oregon) High Capacity Transit Tool is a particularly interesting example of the public use of forecasting.

4. **Refining techniques for customer outreach.** Stakeholder and customer perspectives and assessments were cited as important data sources for guiding planning and decision making. They provide both reactions to plans and proposals and measures of public values and priorities. Outreach to collect customer views necessarily and beneficially includes education and information for the customers as well as queries and responses. According to most workshop participants, getting balanced (representative) measures of public opinions, which is not always easy, is important. It requires proactive data collection, a lowering of the barriers that hinder people in providing inputs (e.g., web-based data collection methods), and controls and incentives to acquire representative views. Public opinions, values, and behaviors change over time, and evidence suggests that they are changing more rapidly now because of conditions in the economy and the environment. Continuous, longitudinal tracking of values and behaviors can provide useful guidance for decision making, and such surveys are economical to collect. The Portland opt-in process offers an interesting example of continuous public opinion polling.

5. **Using experiential data.** An important data source in some cases is experience, firsthand observation, and sometimes the documented experience of others. Experience, study tours, and case studies tell stories that can be especially useful in conveying information to lay decision makers about the design, feasibility, and operation of alternatives.

6. **Tapping into emerging data sources.** New data sources are emerging that may make data less costly and provide new and useful kinds of data, in particular timely data on system performance, traveler behaviors, and public perceptions. Sources cited by workshop participants include traveler tracking by using a variety of mobile devices, a form of crowdsourcing that can also be used for opinion data. Of course, tracking people and goods raises important concerns about privacy, but the types of and uses for these data are growing, and effective ways of protecting individual privacy are emerging.

7. **Cost-effective approaches to collecting and sharing data resources.** Limited resources are the "new normal" and will encourage innovation and creativity in transportation agencies for cost-effective data collection and analysis (e.g., data sharing among agencies and levels of government), greater reliance on technology for communication, the mining of existing public and private data sets, and coalitions among transportation and nontransportation data agencies (e.g., Census, the Bureau of Labor Statistics, private sources). The value and cost-effectiveness of data

can often be increased by sharing among users and by merging various types of data to create new and useful information. According to most workshop participants, this calls for collaboration, which requires both effective communication and shared priorities among data owners.

Expectations

The following were among the expectations of the participants:

- More and better data from both public and private sources through the use of advanced technologies;
- Increased pressures to address new and broader goals;
- Budgetary constraints on professional staff resources; and
- Technology skills gap, coinciding with natural generational shift in the transportation community and its leadership.

SUMMARY OF PARTICIPANT STORIES

The following sections summarize the specific stories told by workshop participants. For each workshop, participants are identified and participant stories are summarized in tabular form, indicating the following:

- The type of decision that was described,
- The types of data and information that were sought to support this decision, and
- Issues that were faced and lessons that were learned in finding and applying information within the decision-making process.

Diverse decisions were discussed in the three workshops. Several stories were related to development of long-range plans and capital programs; others covered specific investment types: major transit or highway projects, transit route restructuring, traffic management strategies, asset management, and safety countermeasures. Other decision types included design of tolling strategies and passage of legislation to prohibit texting while driving.

Information needs for supporting these decisions included (*a*) baseline data on current supply and demand (traffic, ridership, commodity flows, origin–destination patterns), system performance data (congestion, safety, asset inventory and condition), and demographic and land use data; (*b*) evidence of strategy effectiveness based on case examples and before-and-after studies; (*c*) projections of key factors influencing transportation decisions such as energy prices and implications for construction costs and vehicle fleet composition; (*d*) analysis of proposed

strategy costs, impacts (both direct impacts on the transportation system and broader economic, environmental, and social impacts), and effectiveness; and (*e*) public opinion and values.

Many issues and lessons learned were considered. Much of the discussion focused on specific gaps in readily available data to meet decision maker needs, but there was an emphasis on how information is used within decision-making processes. Several successful models were offered for collaborative decision-making processes involving multiple stakeholders. The summary of key themes and observations above covers both gaps and process-related observations.

Hartford, Connecticut (July 21, 2011)

Participants:

- Anne D. Stubbs, Coalition of Northeastern Governors;
- James Redeker, Acting Commissioner, Connecticut Department of Transportation;
- Thomas Maziarz, Chief of Planning, Connecticut Department of Transportation;
- Karen Songhurst, Policy Analyst, Vermont Agency of Transportation;
- Timothy Brennan, Executive Director, Pioneer Valley Planning Commission;
- Stephanie Dawson, Chief of Staff for the Chief Operating Officer, Port Authority of New York and New Jersey;
- Stacia A. (Stacy) Ritter, Assistant Executive Director, Committee on Appropriations, House of Representatives, Commonwealth of Pennsylvania;
- Thomas Palmerlee, Transportation Research Board; and
- Joseph Schofer, Northwestern University.

Data and information stories from participants:

Decision	Data Sources and Needs	Issues and Lessons
Legislation on texting while driving	Research—causal relationship between texting and crashes Nature of the problem within each legislative district Public opinion polls	Resolving conflicting results, gaining consensus Accessing locally specific data from Federal Highway Administration and state department of transportation Getting quick response to questions in clear and simple terms

(continued)

Hartford Data and Information Stories (*continued*)

Decision	Data Sources and Needs	Issues and Lessons
Border crossing infrastructure and procedure planning	Border crossing counts	Data sharing among public agencies (U.S. Customs, Border Patrol) Access constraints and costs for private data Perceived value of border crossing data by interior states
State investment programming	Impacts of transportation investments on broader outcomes—for example, quality of life Asset life-cycle costs; full cost of ownership Long-term benefits	Alignment between broad state and federal performance measures and selection criteria—engineering-oriented versus broader outcomes Gaps in data and models to analyze non-engineering outcomes of transportation investments Limitations of tools in predicting long-term investment benefits—needed to present balanced view Loss of professional staff for preparing useful decision briefs
State multimodal investment trade-offs	Economic impacts of investments in rail versus highway versus airport Opportunistic studies for understanding economic consequences of facilities and services (e.g., from short-term service disruptions)	Lack of accessible economic impact data from actual projects Inability to share economic impact data at useful level of geographic resolution due to confidentiality concerns Access and cost are barriers to use of economic impact models
Regional pavement management program	Pavement condition data	Data originally collected due to federal mandate but continued as agency saw value, used for project scoring Availability of local data made a difference in funding
Regional transit improvement program	In-house survey of nontransit users	Value of market-tracking data for decision making about transit service improvement Value of locally specific, timely, focused data collection

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Hartford Data and Information Stories (*continued*)

Decision	Data Sources and Needs	Issues and Lessons
Multiple regional analysis services	Regional land use, economic activity, housing, air quality	Provision of useful, integrated information to multiple customers, including media Demonstrates value of data as a resource when effectively transformed into information
Asset and portfolio management	Information to support cross-modal trade-offs Security technology investment life-cycle costs Performance data for investments	Limited or nonexistent data for making decisions across modes Limited internal agency capacity to evaluate and manage security technology life-cycle costs Differing and sometimes incompatible performance data requirements for transportation and security investments

Kansas City, Missouri (August 17, 2011)

Participants:

- Deb Miller, Kansas Department of Transportation;
- Dana Majors, Kansas Department of Transportation;
- Dick Jarrold, Kansas City Area Transportation Authority;
- Todd Ashby, Des Moines Area Metropolitan Planning Organization;
- Mell Henderson, Mid-America Regional Council;
- Jim McKenzie, Metroplan;
- Paul Mullen, Metropolitan Area Planning Agency;
- Dave Nichols, Missouri Department of Transportation;
- Tim Norton, Sedgwick County;
- Dean Palos, Johnson County, Kansas;
- Brian Shields, City of Overland Park;
- David Warm, Mid-America Regional Council;
- Joeseph Schofer, Northwestern University;
- Tom Palmerlee, Transportation Research Board; and
- Frances Harrison, Spy Pond Partners.

Data and information stories from participants:

Decision	Data Sources and Needs	Issues and Lessons
Project prioritization for long-range plan	Project impacts: economic development, traffic flow, system connectivity, regional traffic connection, business center connection Baseline system-level information	State department of transportation leadership influenced regional adoption of data-driven approach Use of iterative, highly interactive process involving decision makers (8 months) instrumental in getting the right information on the table and building confidence in the data Data are just the beginning of the "6D process": data, disseminate, debate, dialogue, discernment, decision Making it clear that good data were needed for projects to advance helped motivate sponsors and engineers to participate and provide information

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Kansas City Data and Information Stories (*continued*)

Decision	Data Sources and Needs	Issues and Lessons
Long-range plan update—cost and revenue forecasts	Future rate of absorption of fuel-efficient vehicles into the fleet given permanently high energy costs—used old studies from the 1970s on impacts of fuel-efficiency standards Future highway construction costs—used information from Energy Information Administration Asset preservation needs for local government infrastructure	Break in past trend lines given likely future energy prices; peak oil was an assumption—straight-line extrapolation not valid for either revenues or construction costs
Long-range plan—growth scenarios	Infrastructure costs, vehicle miles traveled, trip distance, trip travel time, road congestion, transit ridership associated with different growth scenarios Current densities for other regions for use as comparables Current local comprehensive plans	Need for approach to understanding true cost of transportation investments from holistic perspective, including norms for analyzing economic impacts Need for better tools to analyze impacts of new development, particularly redevelopment in the core Need for better comparables to understand relative infrastructure costs for redevelopment versus outward expansion
Beltway project	Implications of alternative land use patterns and mixed developments for feasibility and need Impacts on inner city Alternative highway or transit investments Public opinion surveys Simulations of speed and travel time and comparison with peer regions	Need for more accurate tools to forecast costs for redevelopment of infrastructure Need for better tools to analyze transportation–land use relationships Need for a better understanding of impacts of changing demographics and energy prices on future development patterns and travel—no accepted norms or approaches for this Key challenge—data not systematically collected but on an as-needed basis—not efficient No norms or conventions on measuring broader objectives

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Kansas City Data and Information Stories (*continued*)

Decision	Data Sources and Needs	Issues and Lessons
New transit corridor	Impacts of proposed transit investment: land use, travel time, economic development Will new service meet Federal Transit Administration thresholds for new starts Onboard surveys Baseline population and employment data	One valuable use of data is to refute proposed investments that are not likely to have benefits worth their costs Need to consider transportation investments in concert with other supportive policies—difficult to analyze in isolation Need for better methods of assessing economic development impacts
New highway link	Impacts of proposed new north–south connector Current land use Projected economic impacts Benefits and costs from regional perspective	Reconciling differences across state, regional, and local models and assumptions; building confidence in projections Need for education process to help decision makers understand differences Use of land use data to address concerns about impact on virgin forest Use of data to challenge functional classification given that rural versus urban classification determines interchange spacing standards
Roundabouts	Advantages of roundabouts relative to traffic signals Business impacts Pedestrian safety impacts—current traffic volumes, incidence of speeding, crash history, likely future growth Experience with roundabouts near schools	Value of site observation to allow decision makers to see new types of designs in operation and envision a different approach to a problem Importance of presenting information that is responsive to citizen concerns (e.g., answers to common questions) Use of Internet and Listservs to gather information quickly on comparables (examples of roundabouts near schools)
Safety countermeasures	Crash data with precise location (including Global Positioning System coordinates and lane identification)	Cooperative relationship between local police department and city traffic engineering—traffic engineering adds value by assigning precise location; provides level of granularity important to design of effective countermeasures (new lighting, ramp location, etc.)

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Kansas City Data and Information Stories (*continued*)

Decision	Data Sources and Needs	Issues and Lessons
Performance management	Customer surveys to determine expectations, perceptions of project results ("did it make things better?") Road rally to get customer input on roadway design features and conditions Multiple performance areas including pavement and bridge condition, on-time and on-budget performance	Value of customer input in focusing agency priorities; customer surveys have been institutionalized Need for cross-state agreement on measures to allow for comparative analysis; agencies pay attention to how they rank, and this drives change
Statewide program development process	Project impacts on safety, preservation, and economic growth Use of Transportation Economic Development Impact System model for economic impact assessment Use of TRANSEARCH data for commodity mix information to feed economic model Community outreach to develop assumptions	Shift from engineering-based priority formula to add economic impacts and local consultation elements was valuable for ensuring program was forward-looking and not just looking at incremental improvements to the existing system Getting a handle on permanent job creation was a challenge—relied on consensus judgment approach Communicated that economic model projections could be used to assess relative project strength only, not to set expectations for actual results

Seattle, Washington (August 19, 2011)

Participants:

• Gene Baxstrom, Senior Policy Analyst, Washington State Joint Transportation Committee;
• Jerri Bohard, Deputy Director, Oregon Department of Transportation;
• Rex Burkholder, Councilor, Portland Metro;
• Jessyn Farrell, Pierce Transit, Tacoma, Washington;
• Paula Hammond, Secretary of Transportation, Washington State Department of Transportation;
• Charles Howard, Director of Transportation Planning, Puget Sound Regional Council;
• Lynn Peterson, Sustainable Communities and Transportation Policy Advisor, State of Oregon;
• Beth Redfield, Coordinator, Washington State House Transportation Committee;
• Thomas Palmerlee, Transportation Research Board;
• Joseph Schofer, Northwestern University; and
• Frances Harrison, Spy Pond Partners.

Data and information stories from participants appear on the following pages.

Seattle Data and Information Stories

Decision	Data Sources and Needs	Issues and Lessons
Transportation investments	Impacts on safety, public health, economic growth, clean air Case examples of impacts and effectiveness	Substantial measurement gaps in nontraditional areas Crash and fatality rates do not indicate how safe a facility is—need for a risk-based approach Need for better information on how transportation affects the economy—for example, retail sales Lack data to make trade-offs across various investment types (e.g., vanpool program, rail service, sidewalks to school)—but this is a complex endeavor Filling gaps in pedestrian and bicycle data—using volunteer approaches with some success Need to understand incremental impacts of new facilities on public health and how to mitigate Need to backcast rather than forecast—start with community goals, use forecast to understand effectiveness of alternative investments Institutional silos prevent holistic analysis of investment impacts and benefits, integrated cross-modal analysis Need for models to differentiate trips and consider targeted strategies rather than treating the problem as a simple "flow through a pipe"
Highway system operations	Impacts of active traffic management strategies on throughput, congestion, and travel time Travel time—probe data (Inrix)	Need for early indication and communication of impact of traffic management strategies before completion of rigorous data-gathering and assessment process Making efficient use of resources by blending available data from various sources—state department of transportation capacity data, detector data, and purchased probe data Need to address concerns about use of private data sources—proprietary algorithms, standards

Seattle Data and Information Stories (*continued*)

Decision	Data Sources and Needs	Issues and Lessons
Ferry service	Ridership forecasts—based on regional models	Demand curves are bending; cannot rely on past trends Need to be able to tell a story about what is happening and why, but lack the information to do this
Transportation investments to support econom-ic recovery	Relative effectiveness of invest-ments from economic impact standpoint Before-and-after studies—trans-late travel time improvements to freight shipping costs and movements	Need for more conclusive methods for assess-ing long-term economic impacts of invest-ments Given today's resource limitations, difficult to justify expense of developing new models, methodologies, data sets Without good data, the result is "pet proj-ects"; decisions are based on perceptions about what is effective
Asset manage-ment	Asset inventory, including road-side and safety assets	Cost of collecting data—need to be efficient and make sure the data add value; hard to justify expense when budgets are being cut Importance of establishing agreed-on data elements and consistent statewide data collec-tion approach Have realized benefits from asset data in mul-tiple areas—project scoping (can do 50 to 60 percent of work without going into the field); identification of locations for safety upgrades Practical issues with regard to combining data from different sources and vintages

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Seattle Data and Information Stories (*continued*)

Decision	Data Sources and Needs	Issues and Lessons
Least cost planning	Most cost-effective mix of supply and demand options to meet policies and goals—livability, safety, equity, economic vitality, environmental stewardship, capital costs Relative benefits of diverse investment types: bicycle and pedestrian, transit, highway, livability Literature search—work in other states, countries New household survey—longitudinal approach	New paradigm—establish desired outcomes and objectives independent of current data available Learning process is required to take on this challenging process Have tapped into multiple new data sources at several agencies—departments of transportation, metropolitan planning organizations, departments of environmental quality, human services Importance of data sharing and statewide data foundations (geographic information systems, governance) Collaboration across metropolitan planning organizations and state departments of transportation on household survey sampling approach to meet collective needs
Transit service restructuring	Passenger counts Travel demand data, supplemented with origin–destination information from downtown employers Customer values survey National Transit Database	Major investment in technology for passenger counting and vehicle tracking (made prerecession) paid off later when the agency needed to make substantial service cuts to address a severe budget gap Detailed passenger information and supplemental market data enabled strategic restructuring that allowed agency to cut service by 35 percent and achieve only a 10 percent ridership decrease and a 44 percent reduction in cost per trip, from $9 to $5 Customer input was used to help make difficult trade-offs between accommodating special needs and equity versus system optimization; decided to focus on preserving service for trips where users have no other options Use National Transit Database to benchmark efficiency, but not useful for understanding how to capture new markets

(continued)

Seattle Data and Information Stories (*continued*)

Decision	Data Sources and Needs	Issues and Lessons
Tolling	Design of tolling strategy for new highway link Tolling committee study—traffic and revenue modeling of scenarios for alternative toll levels and strategies Financial planning document from state department of transportation included analysis of how much bonding would be required	Timing and responsiveness and transparency of assumptions were critical factors in value of information for decision making Information provided was valuable, but given likelihood of increased use of tolling, there was concern about the cost and time-consuming nature of putting this type of analysis together Importance of proactive, interactive approach in understanding the issues and questions and tailoring information to address these issues—up-front investment in a good process paid off later Importance of objectivity in presenting the relevant information without specific recommendations
New transportation revenue sources	Consultant studies examining future outlook for gasoline tax revenues and alternative revenue strategies (indexed gasoline tax, tolling, cargo taxes, etc.) Considered diversion of trips, geographic incidence of benefits	Criticality of examining underlying assumptions—fuel prices, use of alternative fuels, changes in vehicle mix, economic health Even when information does not directly lead to action, it is still valuable for heightening awareness and building confidence in pursuing strategies
Light rail investments	Achievement of required efficiency (cost per new rider) to qualify for funding	Successful use of online High Capacity Transit Tool allowing public to test alternative scenarios for new transit investments together with policies for increasing densities
Regional transportation plan	Preservation—based on available asset inventory and condition Improvements—based on projected benefits and impacts, considering social equity, environmental effects, job access, freight movement, travel time benefits, non-single-occupant-vehicle use Use travel demand model	Transition to performance management creates the right context for decision making but presents challenges for analysis Critical to be clear about desired outcomes, but challenging to define them and get consistency Gaps in ability to assess projects in several areas, including social equity and environmental justice Difficult to get good asset information from localities (cities and towns) Skepticism exists about using modeled data

Breakout Group Summaries

Participants in the 10 breakout groups were asked to identify key information needs, research questions, and potential action items for their assigned topic areas. This appendix presents an overview of the breakout group discussions, followed by a tabular summary for each group. These summaries should not be construed as reflecting a consensus of the planning committee, the breakout group participants, the Transportation Research Board (TRB), or the National Research Council.

OVERVIEW OF BREAKOUT DISCUSSIONS

Group 1: Future Scenarios—Coping with Broken Trends and Paradigm Shifts discussed key areas of future uncertainty that will affect transportation decision making. Participants identified four critical topic areas: energy, urban form, technology, and finance. They posed 10 important research questions and identified five possible actions to improve how we consider and incorporate these major factors within transportation planning and decision making.

Group 2: Integrating Customer Information into the Decision-Making Process discussed both the kinds of customer information required to support decision making and the sources of customer information. Potential action items identified by individual participants were the formation of an advocacy group to facilitate a better collective understanding of what information is needed, market research on customer values, and development of a customer information management function to identify and assess existing data sources.

Group 3: What Works and What Will It Cost discussed use of case studies, site visits, and peer exchanges in supporting the decision-making process. Strategies for knowledge sharing as well as barriers such as increases in travel restrictions were covered. Possible action items identified by members of this group included the dissemination of guidelines for conducting case studies to facilitate assessment of transferability and a study of the value of networking that could inform decisions about funding travel to conferences and other forums for face-to-face exchange of information and experience.

Group 4: Tools and Methods That Support Prioritizing and Making Policy Trade-Offs began with a discussion of gaps in analysis capabilities for prioritizing candidate investments and making trade-offs across program areas. Participants also discussed the importance of communicating technical information so that it can be understood by policy makers. Finally, they talked about analytical tools for

supporting trade-offs—how to ensure that agencies are aware of the tools that exist, how to assess their adequacy for today's decision-making needs, and how to determine whether investments to improve tools are warranted. Members of this group identified four potential actions to improve existing tools, applications of tools, and communication of information on investment trade-offs.

Group 5: Looking Ahead was charged with identifying emerging policy issues and data, information, and methods that will be needed in responding to these issues. The group covered four topic areas: (*a*) changes in agency governance structures, including increased outsourcing and commingling of public- and private-sector interests; (*b*) changes in technology and their impact on travel, energy, air quality, and revenue collection; (*c*) increased competition for public resources and declining trust of government, which create the need for better positioning of transportation investments within a broad policy context; and (*d*) changes in freight travel patterns based on global economic shifts and restructuring of the domestic energy industry. The group identified possible studies to explore each of these areas.

Group 6: Delivering Data for Decisions identified key ingredients and strategies for effective packaging and communication of information. Participants discussed the importance of understanding the audience and the decision process; answering the right questions; and making effective use of language, data layouts, and visuals in presenting information. Several potential actions were identified for disseminating information on best practices for information delivery. Participants also noted the contributions that might be made by additional research related to using information about customer values to "tell the story" and exploring the use of social networking for collaborative decision making.

Group 7: New Paradigms for Data Acquisition covered a variety of techniques including videologs, digital tags, Global Positioning System (GPS) capture, automated vehicle location (AVL), and automated passenger counting (APC). Participants discussed strategies needed to support adoption of these new techniques, including data fusion, cloud computing, and data management plans. A variety of issues related to data quality assessment, privacy, legal and contractual concerns, and staff capacity were also discussed. Individual participants identified several possible actions for synthesis and dissemination of best practices and for promoting continued research on data fusion.

Group 8: Efficient Strategies for Data Sharing discussed models and opportunities for data sharing across agencies to make the best use of already available data. Several models for data sharing and cost sharing were identified, including regional traveler information systems and geographic information system–based portals. Key questions were raised about how to identify what data should be shared for different purposes and how to take advantage of emerging private data. A number of barriers to data sharing were discussed, including blending of public and private data, privacy and liability issues, and assessing transferability. Among the possible

action items were a synthesis report on data sharing models and practices and efforts to develop both a national travel data program and a national performance data program to promote consistency and better leverage data collection resources across governmental levels.

Group 9: Opening the Black Box—Collaborative Models for Effective Decision Support talked about models, tools, and skill sets for collaborative decision-making processes. Participants discussed the adequacy of existing transportation models and tools and how to determine whether improvements in model sophistication are warranted. They also considered whether open decision processes yield "better results." Potential action items were enhancing capabilities for collaborative forecasting and initiating new research on knowledge, skills, and abilities (KSAs) for collaborative forecasting processes.

Group 10: Data for Transportation Systems Performance Management discussed how to improve use of performance measurements in agency decision-making processes and help agencies better align measures with decision maker concerns. The group also discussed use of benchmarks, improvements in data management capabilities, and the need to ensure data integrity and minimize opportunities for data manipulation. Individual participants identified the need for guidance and training in performance management, data management, and negotiation skills for influencing decision makers. Other possible action items included a new transit benchmarking program and continuation of the existing American Association of State Highway and Transportation Officials (AASHTO) Comparative Performance Program.

INDIVIDUAL GROUP REPORTS

Group 1
FUTURE SCENARIOS: COPING WITH BROKEN TRENDS AND PARADIGM SHIFTS

Identify critical uncertainties in external factors affecting transportation and ways to address them in decision making.

Information Needs and Research Questions
Energy

• How will consumers adapt or respond to higher and more volatile energy prices over the long term?
• What are the implications for key planning assumptions such as vehicle miles of travel (VMT), vehicle fleet mix, mode choice, and trip length?

Urban Form

- What new urban development patterns can emerge over the next 20 to 30 years given the unsustainable nature of automobile-centric, decentralized patterns of the past?
- How will changes in demographics (e.g., aging population) influence these patterns?
- What types of development will the marketplace support in the future?
- Where will future job growth occur?
- What local policy changes are supportive of alternative urban forms?

Technology

- How will technology advances affect travel patterns—what current assumptions will need to be reexamined?
- How will travel be affected by changes in social interaction, availability of real-time travel information on mobile devices and in vehicles, and availability of new alternative propulsion vehicles?
- How will technology change the nature of the economy—the mix of industries and associated transportation needs?
- How will technology advances affect provision of transportation projects and services—how can we take advantage of smart equipment and infrastructure to develop and deliver projects and to operate systems?

Finance

- How can revenue forecasts be improved to reflect reasonable assumptions about VMT on the basis of likely absorption rates for energy-efficient vehicles and use of alternative fuels?
- What alternative methods are available for revenue forecasting and scenario analysis?
- How can construction cost estimates be improved to reflect changes in petro-leum costs, labor costs, and other key inputs?
- What is likely to be the future role of the federal government in transportation finance?
- Are there new institutional mechanisms we can put in place for transportation finance (e.g., regional institutions)?
- What has experience to date from public–private partnerships (PPPs) shown us (including public-sector risks) and how can this experience be factored into future PPP decisions?
- How can we reach a consistent approach to asset valuation between the public and private sectors?

• The public sector does not have investment-quality information in terms of either asset valuation or demand estimation. How can we get there?

Potential Actions
Evidence Base

Build an evidence base on implications of key factors driving uncertainty in transportation. This would involve compilation of and provision of access to existing studies on issues such as how seniors make residential choice decisions, public risks of PPPs, and methods for forecasting construction cost. Studies would need to meet a defined standard of rigor for inclusion. There have been many studies on these topics, but there is no well-organized body of research on which to draw.

Next step: A research needs statement on developing a framework for building this evidence base—draw on experience in the medical field [TRB, National Cooperative Highway Research Program (NCHRP)].

Postproject Evaluation Program

Build a database of "after" experience with major transportation investments to ascertain what actually happened. This would enhance understanding of real-world variations in key planning assumptions and allow us to learn from both successes and mistakes.

Next step: Discuss with stakeholders and issue guidelines.

Scenario-Based Planning Synthesis

Document existing scenario planning models in other industries (e.g., energy, defense) making large-scale investments in long-lived assets, with consideration of uncertainties. Identify transferable approaches that can be applied within transportation to account better for uncertainties.

Next step: Develop a research problem statement for a study (TRB, NCHRP).

Research on Housing Choice

Develop a research needs statement on preference in housing choice, assess what types of development will be "bankable" (potentially including stated preference survey data).

Next step: Identify lead to develop research needs statement.

Research on Growth Policies

Develop a research needs statement to examine conflicts in existing public policies

related to growth and urban development (e.g., building large consolidated schools in rural areas versus transportation demand management).

   Next step: Identify lead to develop a research needs statement.

Group 2
INTEGRATING CUSTOMER INFORMATION INTO THE DECISION-MAKING PROCESS

Identify strategies for improving use of traveler and shipper needs, behaviors, and values to support decision making.

Customer Information Needed for Decision Making
Information Needs and Research Questions

   • What are travelers willing to pay for various transportation options?
   • Are we asking the right questions about customer satisfaction or price preferences?
   • How will travelers respond to changes in travel time reliability and cost—work or home location choices, mode choices, time of travel, and so forth—what trade-offs are they willing to make?
   • What will it take to influence travel behavior? How do preferences vary across rural versus urban settings?
   • How can we better understand trip purpose?
   • How can we better identify final destinations of heavy freight shipped via air and water modes?
   • How can we better assess the full costs of transportation incurred by travelers and shippers?
   • How can impacts of transportation system changes be better assessed and evaluated from a customer perspective, considering economic impacts, health, lost time, safety, and so forth?
   • How can we better understand changes in perception among travelers about a transportation decision or project—compare before versus after implementation.
   • What is the nongovernmental (private industry) perspective on what transportation agencies do?

Potential Actions

   • **Customer information community of interest**: Form an advocacy group—a community of local and state agencies to represent their collective views on the need for customer data and information synthesis to aid local and state agencies.

Next step: Suggest national coordination for the collection and synthesis of data from federal and state and local sources, including formation of stakeholder data user groups.

• **Market research**: Design model market research program to better understand customer values and trade-offs, potentially leveraging real estate industry knowledge of customer values with respect to housing choices.

Next step: Identify lead to flesh out this concept.

Acquisition and Management of Customer Information
Information Needs and Research Questions

• Multiple sources for customer information exist at the federal, state, and local levels—economic census, National Household Travel Survey (NHTS), customer surveys. How can we build on these data?

• How can customer data be shared more effectively to avoid inefficiencies associated with one-time, single-purpose data collection?

• How do we synthesize multiple sources of information and data collection efforts across agencies?

• Are there data sharing–synthesis–coordination models from other areas in government that can be applied?

• How can new information-gathering methods be best used: social media, opt-in panels, online communities, traveler information sites, focus groups?

• What are the biases associated with use of social media as a data source and how can they be controlled?

• How can the NHTS be made more useful?

• How can we maintain "decision records" as to what kinds of information were used?

Potential Action

Develop a customer information management function for identifying information sources and assessing what will be useful to local and state agencies, including the reliability and accuracy of various data sources.

Next step: Identify lead to flesh out this concept or identify existing established functions.

Group 3
WHAT WORKS AND WHAT WILL IT COST?

Identify strategies that can facilitate the use of case studies and examples in supporting decision making.

Knowledge Management: Information Needs and Research Questions

• How can we improve knowledge management structures to provide efficient access to "know who" for different questions?

• How can we utilize social media, newer technologies, Listservs, and other methods to frame opportunities to interact with peers?

Peer-to-Peer Networking
Information Needs and Research Questions

• Given today's tight travel restrictions, how can we quantify the value of networking (attending conferences and peer exchanges) and demonstrate how this interaction improves decision making and ultimately saves money?

• Information gets stale quickly—how can we use networking to ensure access to timely or real-time information?

Potential Action

Conduct a value of networking study to address quantifying the value of networking.

Next step: Identify lead to develop research needs statement.

Cases
Information Needs and Research Questions

• How do you translate data from case studies to information tailored to the questions that decision makers are trying to answer?

• How can we assess and describe both applicability and transferability of case study experience to maximize value and avoid misuse of cases?

Potential Actions

• **Case study methodology knowledge sharing**: Identify a body of resource materials on standard methodologies for conducting case studies and disseminate to contractors and others who develop case studies.

Next step: To be determined.

• **Case study assessment checklist**: Develop a checklist for assessing and compiling metadata on case study applicability and transferability.

Next step: Identify lead to develop research needs statement.

Group 4

TOOLS AND METHODS THAT SUPPORT PRIORITIZING AND MAKING POLICY TRADE-OFFS

Identify strategies for improving tools, methods, and data for investment prioritization and trade-offs.

Analysis Capabilities
Information Needs and Research Questions

- How do we incorporate behavioral and business aspects into our tools and into predictions of the future? For example, how do we consider cultural factors, travel demand versus telecom, and trend taking versus trend making in decisions? We are missing key data on behavioral and economic impacts and tools (for example, tools that consider the large-scale impacts of a family of projects on a region).
- How do we monetize, or otherwise measure the value of, alternatives or trade-offs (e.g., safety, value of time)? Traditional methods of evaluating impacts have been in terms of conditions and levels of service, and those factors alone are not adequate to address the needs of decision makers.
- How can we incorporate equity issues into trade-off decisions?
- How can we improve the data and tools used to analyze nonmotorized modes (e.g., pedestrian and bicycle)?
- How can tools better support cross-asset trade-offs?

Potential Action

Requirements analysis: Assess approaches for incorporating behavioral issues into analysis tools and develop a set of requirements for improvements to existing tools.
Next step: Identify lead to develop research needs statement (TRB, NCHRP).

Communication of Trade-Offs
Information Needs and Research Questions

- How do we communicate in a way that is meaningful to decision makers?
- Could we make better use of visualization of large data sets, geocoding of available data, for example? This may lead to data and tools different from those we have used in the past, since the adequacy of available data depends on consequences of the decisions to be made and our ability to communicate with the public.

Potential Action

Communication tools: Develop guidelines for and examples of effective communication of transportation investment impacts.
Next step: Identify lead to develop research needs statement (TRB, NCHRP).

Investments in Better Tools and Data
Information Needs and Research Questions

- How can we evaluate whether it is worth investing more in better data or tools?
- Will the improvement in decisions be worth the extra investment? Or should we be collecting different information?
- How can we help agencies be better aware of which available tools and data sets can best meet different types of needs?
- Given shifts in transportation agency roles from builders to operators–maintainers and information providers, do current trade-off tools meet decision-making needs?

Potential Actions

- **Tool impact assessment**: Analysis of impact of better data and tools on decisions—a procedure for evaluating effectiveness is needed.
  Next step: Identify lead to develop research needs statement (TRB, NCHRP).
- **Best practice guide**: Compile best practices using data and tools to support decisions and disseminate.
  Next step: Define project and secure funds.

Group 5
LOOKING AHEAD

Identify critical emerging policy issues and data, information, and methods that will be needed to respond to them.

Roles, Governance, and Finance
Information Needs and Research Questions

- What are the implications of the commingling of public- and private-sector interests, data, financing, operations, and so forth?
- What are the implications of changing governance and decision-making structures in transportation—outsourcing, jurisdictional coordination, interagency coordination?

Potential Action

Scoping study on public–private roles: Develop scope for a study to explore the full ramifications of the growing integral relationship between the public and private sectors in financing, designing, operating, maintaining, and monitoring transportation infrastructure and services.
  Next step: Identify lead to develop research needs statement (NCHRP, TRB).

Technology
Information Needs and Research Questions

- What impacts will technology changes have on travel (e.g., communications substitution, more information to affect travel logistics)?
- What are the implications of new technology deployment for energy and air quality revenue collection, and so forth?

Potential Actions

- **Scoping study on technologies**: Develop scope for study to explore role of evolving technologies in transportation.
  Next step: Identify lead to develop research needs statement (NCHRP, TRB).
- **Study on benefits of clean energy**: Quantify the value and long-term benefits of transitioning to clean energy. Consider both energy and environmental benefits; produce results that can mitigate existing barriers to adoption of new technologies related to uncertainties about future demand and energy costs.
  Next step: Identify lead to develop research needs statement.
- **Pilot projects**: Pilot new technologies or innovations and develop case studies of the experience that include assessment of transferability.
  Next step: Identify lead to develop more detailed plan.

Positioning and Financing Transportation
Information Needs and Research Questions

- Given likely future increased competition for public resources and changing political landscape (demand for more transparency, less support for public investment, less trust of government), what information and communication strategies will be required to better position transportation investments within a broad policy context?
- How can such communication strategies account for challenges related to ideology-based decision making?
- How can we improve methods for quantifying long-term benefits of transportation investments?
- How can we make more effective use of techniques such as case studies, story telling, scenario planning, social media, and performance dashboards?

Potential Action

Research framework for positioning transportation: Develop framework and conceptual model for communicating the role of transportation in the context of the critical issues facing decision makers and the public. Framework would define a stream of research leading to a better understanding of relationships between national

critical issues and transportation (energy, jobs, environment, etc.).

Next step: Identify funding and members of panel to scope the effort, to include private-sector representatives.

Travel Demand: Information Need and Research Question

How can we anticipate changes in freight travel patterns related to anticipated economic shifts, restructuring of the domestic energy industry, Panama Canal expansion, and so forth?

Group 6
DELIVERING DATA FOR DECISIONS

Identify ingredients for effective information delivery and strategies for improving how information is packaged for decision makers.

Effective Information Delivery
Information Needs and Research Questions

- Define clear goals for the presentation and make sure you are answering the right questions.
- Understand your audience—both your immediate audience and your ultimate target audience—and their values and concerns, and tailor your presentation accordingly.
- Understand the stages of decision making and where your audience is in the process.
- Engage the right people in the process of producing a data package or presentation for decision making; use peer reviews to build trust; utilize the information within a collaborative process for decision making, scaled appropriately to the size of the problem; involve stakeholders with different perspectives in the process of reviewing the data; anticipate multiple, potentially competing, sets of messages.
- Understand when tactical information (hard data, used for managing) is needed versus strategic information (explain a change, the reason for it, and its benefits and impacts).
- Decision makers want to know whether the recommended decision is a continuation of "current status" (in which case not that much information is needed) or a change of course (in which case more information is needed). What are the costs, benefits, economic and political consequences, impacts on different constituents, flexibility and reversibility of the decision, contingencies, intended and unintended consequences?
- Include a range of information: multiple views rather than a single advocacy view; be aware of own biases that can go into data and information. Be transparent

and clear in communication. Provide high-level information but make more detail available; provide appropriate context.

• Use effective data-mining techniques; aggregate data to an appropriate level.

• Carefully design presentations, including visuals and effective layouts; consider data presentation methods (e.g., time-lapse series of visuals).

• Pay attention to the language that is used to communicate the message (use quantities and budgets in a scale that the audience will understand the quickest—for example, use football analogies).

Strategies for Improving Information Delivery
Information Needs and Research Questions

• How can a better understanding of customer values be used to construct more effective "stories" for decision makers?

• What are the components of value?

• What can travel data reveal about values (what people say versus what they do—stated preference versus revealed preference).

• What are the values of the consumers and key groups—and how do they relate to the values of the decision maker?

• What private-sector data sources exist for gaining insights and relevant support for transportation decision making? What is available? What can be done to gain access to it?

• How do we teach effective communication techniques to staff?

• What curriculum needs to be established to teach students and young staff so that they can come up to speed more quickly?

• How can we turn "best practices" for information delivery into "standard practices"?

Potential Actions

• **Research—public perceptions and values**: Scope a study to define the components of value and how to measure and use them in packaging information for decision makers.

• **Research—collaborative decision making**: Scope a study to describe how social networks "work" and create trust for collaborative decision making. What are the networks? What are the barriers?

• **Curriculum development**: Incorporate effective communication (e.g., use of graphics presentation) and collaborative processes in academic transportation and planning curriculum.

• **Best practice dissemination**: Develop a library of good examples of effective packaging and communication of information; identify strategies and barriers to adoption of best practices.

- **Contest**: Create annual juried contest for effective presentations—TRB (award, categories, recognition, cash award). Focus workshops on effective presentations and webinars from them.
- **Workshop on delivering data for decisions**: Develop a joint TRB session–workshop on delivering data for decisions. Include the Public Information, Strategic Management, and Visualization committees.
- **Webinar on delivering data for decisions**: Build on the workshop to develop a webinar to allow for greater participation.
- **Survey**: Conduct survey of decision makers on "values" and effective communication—what they want and what works.

Group 7
NEW PARADIGMS FOR DATA ACQUISITION

Identify promising new data acquisition methods and strategies for overcoming existing barriers to their adoption and use.

New Acquisition Methods: Information Needs and Research Questions

- Video logs for asset management.
- Digital tags (radio frequency identification), with georeference.
- Digital information capture (GPS coordinates, digital pictures, electronic forms).
- Traffic flow information combined with systemwide volume and class samples.
- Dual use of legacy systems (e.g., real-time and planning data support).
- Camera data for bicycles and pedestrians.
- APC, transit AVL.

Strategies Supporting Adoption of New Acquisition Methods
Information Needs and Research Questions

- Data management plans and practices incorporating cloud strategies, data fusion.
- Strategic planning for transformation or evolution from current to new sources; rely on good metadata to merge formats.
- Data quality assessment; data validation.
- Overcoming data privacy concerns.
- Overcoming legal and contractual concerns and usage restrictions.
- Staff capacity, new KSAs.

Potential Actions

- **Data acquisition best practices guidebook**: Similar to Federal Highway

Administration (FHWA) work for congestion management and visualizations.

• **Call for papers** on data fusion applications, challenges, and opportunities (TRB).

• **Case studies**: NCHRP synthesis of successful applications—canvass users and vendors for showcase examples (TRB, NCHRP).

• **Webinar series** on new data sources and information systems.

• **North American Travel Monitoring Exposition and Conference sessions**: Share best practices—sources and platforms.

• **Report on integrated corridor management pilots** addressing multimodal data sources.

• **TRB session** on private-sector and crowdsourced data (TRB).

Group 8
EFFICIENT STRATEGIES FOR DATA SHARING

Identify models for data sharing across agencies and specific strategies that should be pursued to make better use of available data.

Information-Sharing Models: Information Needs and Research Questions

• Standardized sets collected by state and local agencies and aggregated to the national level (e.g., National Bridge Inventory, National Transit Database, Highway Performance Monitoring System, Fatal Accident Reporting System).

• Cost-sharing models (e.g., Census Transportation Planning Package).

• Regional traveler information systems (e.g., the Regional Integrated Transportation Information System)—based on data standards; utilize data fusion methods; can provide access to data that would not be made available to individuals.

• Geographic information system data applications (e.g., Utah Department of Transportation's UPlan; Chicago Regional Transit Authority's Regional Transportation Authority Mapping and Statistics)—integrate and provide access to data from multiple agencies and jurisdictions—technology can be used to allow multiple data owners to share their data in a controlled way.

• Web data-sharing portals—Data.Gov (including data communities: energy.data.gov, health.data.gov); Databasin.org (conservation-related data-sharing site).

• Metropolitan planning organization data-sharing agreements.

• Models in other industries (such as health).

• Freight examples.

Information-Sharing Opportunities
Information Needs and Research Questions

• What is the core set of data that is worth sharing—for what purposes?

- What have been the motivating factors for successful data-sharing initiatives—limited resources and opportunity for cost savings, improved regional operations across jurisdictional boundaries, helping individual agencies to understand the broader context of their work?
- Where is it useful to share local data up to state and national levels?
- Can a national system allow us to take advantage of the flood of data emerging from private electronic sources?

Potential Actions

- **National travel data program**: With support from the Bureau of Transportation Statistics and FHWA, develop a national travel data program that is nationally coordinated and defined, assumes current national travel data collection products, and is supported by consistent state and metropolitan planning organization data. Data will be regularly updated.
- **Core performance data program**: Identify a core set of national transportation performance areas and develop a complete data plan to support decisions, across government levels, for achieving performance goals to prepare for a reauthorization that may include a national performance-based planning process.

Overcoming Barriers to Data Sharing
Information Needs and Research Questions

- To what extent are behavioral travel data transferable across regions, reducing the need to collect new data?
- How can we ensure that available data can be identified by agencies and organizations with an information need?
- How can we deal with point-level data that have associated confidentiality issues? What are current privacy issues, and are they changing with new generations? What are the liability issues associated with sharing data to be used by others for their decisions?
- How do we effectively get and use private data and other proprietary data?
- What are the essential metadata that are needed to assist sharing?
- How can we ensure resiliency of formatting so that longitudinal data sets do not become stale?
- How to understand the issues associated with hybrid data—shared public and private data. What meets the test of "public interest" or nonbiased?
- How to overcome technical issues with breaking through firewalls that allow agencies to share data.

Potential Action

Synthesis report on data sharing: Initiate synthesis covering data-sharing models, best practices, value and benefits, and strategies for overcoming barriers including privacy issues.

Group 9
OPENING THE BLACK BOX: COLLABORATIVE MODELS FOR EFFECTIVE DECISION SUPPORT

Identify good models for collaboration in forecasting and strategies for improving the state of the practice.

Workforce Development
Information and Research Needs

Identify KSAs for collaborative forecasting; the skill set is not typical of a technical–modeling–engineering background. Involves understanding how to take decision makers through the forecasting process and how to have a substantive public policy discussion using the outputs of the model. Requires bringing forward the information that is needed and can be fed back into the educational and training process.

Potential Actions

• Research on KSAs for collaborative forecasting processes, leading to development of training materials and a training program for existing professionals. Training should recognize multidisciplinary nature of skills and importance of values for shaping interpretations of model results.
• Enhance capabilities for collaborative forecasting

Tools: Information Needs and Research Questions

• What new tools are needed to support collaborative decision support?
• What can we learn from existing examples (e.g., the interactive transit planning tool of Portland, Oregon, and the bicycle planning tool of Mercer County, New Jersey)?
• While new tools are emerging that allow for greater participation in the process of defining data inputs, assumptions, and decision criteria, will this open process yield better results?

Models: Information Needs and Research Questions

• How to balance transportation model requirements against the decision categories they support—that is, when is investing in more sophistication worthwhile?

- Is a group consensus more valuable to the process than an objective and quantifiable model, and what are the appropriate roles for the public and the planners in transportation modeling?

Group 10
DATA FOR TRANSPORTATION SYSTEMS PERFORMANCE MANAGEMENT

Identify data and information needs to support more effective applications of performance management for state and metropolitan area decision making.

Shifting from Performance Measurement to Management
Information Needs and Research Questions

- How can agencies make better connections between performance data trends and actions taken?
- What standard practices are available for systematic analysis of data trends, strategies deployed, and results realized to make the relationship between actions taken and performance results clearer?
- Given proliferation of performance measures, how can performance measures be better aligned with decision-maker concerns?

Potential Actions

- **Performance management guide**: Develop a "how-to guide" for evaluating the relationship between action, strategy, policy, project implemented, and results (e.g., how to address externalities). The guide should include case studies on how agencies changed their management processes, guidance on before–after studies, evaluation methods, and assessment of both successes and failures. Disseminate the guidance via webinars, a National Highway Institute course for upper management, and executive leadership programs.
  Next step: Write a research needs statement [AASHTO, American Public Transportation Association (APTA), Association of Metropolitan Planning Organizations, U.S. Department odf Transportation).
- **Book clubs**: Explore informal mechanisms for disseminating and implementing performance management (e.g., book clubs on research results) (AASHTO, TRB).

Benchmarking and Comparative Performance
Information Need and Research Question

How can agencies use benchmarking to learn about best practices without being "graded" and unfairly compared with dissimilar agencies?

Potential Actions

• **AASHTO comparative performance program**: Continue existing AASHTO comparative performance measurement efforts, in which standardized data from multiple agencies are collected and used to identify good practices. Build on this program to outline criteria and steps for identifying peers.

• **Transit benchmarking program**: Create a U.S.-based transit benchmarking program modeled after international efforts. This would involve formation of a benchmarking group that would share data and exchange best practices.

Next step: Explore Federal Transit Administration interest.

Impact of Performance Data on Decisions
Information Needs and Research Questions

• How can performance data be better communicated to have a greater influence on decision making?

• How can we overcome "barriers to yes"—negative relationships, poor credibility, communication mismatches, hostile belief systems, and conflicting interests?

• How can we ensure a good understanding of the decision-making process and ensure that we are answering the right questions with our data?

Potential Action

Training course: Develop a short course on negotiation and effective data-driven informed decision making. Model this on the Wharton class sponsored by AASHTO for transportation executives ("The Art of Woo").

Next step: Write a proposal (AASHTO, APTA).

Data Integrity Information Needs and Research Questions

• How can we minimize the potential for manipulation of performance data? Under what circumstances is this manipulation most and least likely to occur?

• What can we learn about best and worst practices from past experience (e.g., CityStat, VMT reporting)?

Data Needs and Management
Information Needs and Research Questions

• How can we fill data gaps for performance measurement: output-level data versus outcome-level data (for example, vehicle occupancy versus human behavior and safety)?

• How can we avoid "drowning in data so we can swim upstream to spawn performance measures"?

• How can we assess when investments in new data collection are warranted, considering trade-offs between cost and usage?

Potential Action

Guidance and pilots: Develop a data management and warehousing guidebook and an online guide for making trusted data accessible. Conduct pilots demonstrating techniques and document with pilot program reports.

Next step: Draft research needs statement (NCHRP, Transit Cooperative Research Program).

Follow-Up Survey Synthesis

Johanna P. Zmud, *Rand Corporation, preparer*

T he Strategies for Meeting Critical Data Needs for Decision Making in State and Metropolitan Transportation Agencies Conference was held December 5–7, 2011. A week later, the 99 participants[*] were asked to respond to three open-ended questions via a web-based survey. Responses were synthesized by using qualitative content analysis to determine key perceptions and observations of the respondents. The findings from the synthesis were listed, not in priority order. In addition, individual responses were used as specific examples below each finding. They are identified by small letters and roman numerals.

Question 1. **What was the most important insight that you gained from the conference?** (*N* = 43)

1. Aligning data with areas of most interest to decision makers.
    a. We should rethink what we mean by "effective delivery to decision makers."
       i. It is knowing the type of data and information that decision makers need to choose among alternatives.
       ii. It is not the techniques for outreach to various constituencies.
    b. It is not a matter of collecting more data but of determining what data are most important and how to convert those data to useful information to drive decisions.
       i. Collaboration between analysts and policy makers is critical if we want data to influence decisions.
       ii. Decision making is complex, but most decision makers want or would like simple, transparent solutions.
       iii. Many analysts and providers do not know how best to communicate to decision makers the good data that they do have (need for sharing of best practices).

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[*] This total includes TRB staff, last-minute cancellations, and speakers who attended only their sessions and did not fully participate in the conference.

iv. Decision makers do not fully understand how to use tools (e.g., performance measures and data) correctly or in conjunction with other tools such as policy trade-offs.

c. Rapidly changing conditions in the real world make predicting and planning for the future much more difficult. This requires moving from data collection and manipulation to using data to tell stories about possible futures to inform decision making.

i. Decision makers not only rely on case studies but also demand them and prefer to make decisions on the basis of their interpretation not of data but of experiences shared by others. This puts a burden on how we do and report case studies.

ii. Decision makers need to make decisions that do not lock them into a path—to make decisions to maximize learning.

2. Changing environment for data and performance measures.

a. Data issues have risen above the level of the day-to-day practitioners and are on the radar at strategic and leadership levels.

b. Evolution from public works (build, maintain, replace) to owner–operators (outcome-based decision making) has fundamentally changed our data and information needs, and we must catch up.

c. The data community is profoundly ill-prepared for the pending collapse of traditional data collection (analysis) strategies.

i. Performance measures are just one of many decision tools.

ii. Data are only one component influencing decision making.

iii. Data need to be connected to people's values.

iv. Models and analytical tools need to catch up to rapidly evolving data sources that are becoming available.

v. Private data sources are becoming at least as important as public-sector data sources.

d. Human capital (knowledge management) is incredibly important in the data-driven decision-making process.

e. Consistency among and across data is as important as accuracy—beware of the perfect driving out the good. There is a need to coordinate among federal, state, and local agencies and the private sector.

3. Learning from other fields.

a. Extent to which transportation planning is affected by the activities of other enterprises within a broad system.

b. Transportation is increasingly multimodal, and decision making is done in a context of land use patterns, housing, energy, economy, and technology.

c. There are good business processes that transportation data can emulate (NCHRP Report 666).

    d. Learn different ways others compile, organize, report, and convey data and information.

        i. Presentation on global energy resources provided insight into the discussions—as an operations-oriented professional, I found the presentation on energy extremely educational and eye-opening.

Question 2. **In what way did the presentations and discussions alter your thinking on this topic?** (*N* = 43)

1. Thinking was not typically altered but reinforced, strengthened, or clarified.

    a. My thinking was not altered much, but some needed work on the national level was emphasized.

    b. "Alter" might not be the best word in my case. Many of the presentations reinforced many things that we talk about in considering data for decisions—good to hear others not necessarily in the data world saying it.

    c. Reaffirmed the limitations of modeling and data—more than ever we must make decisions on the basis of outcomes that are derived from core values.

    d. Strengthened understanding of the importance of creating collaborative decision processes.

    e. Reinforced the feeling that we have a poor grasp of the translation of data to decisions and that we are not particularly knowledgeable in understanding the sensitivity of decision making to data quality or quantity.

    f. Reinforced the idea that the decision being addressed must be clarified and that we cannot simply provide information in the same old way.

    g. Sharpened my understanding of outcome-based data needs. We have talked about geographic information systems as a panacea for 20 years; maybe it is not the solution we think it is.

2. Emphasize knowledge sharing, communications, and collaboration as part of addressing the needs.

    a. Increased complexity and accelerating rate of change mean that we can no longer plan on the basis of experience and understanding.

    b. Data, communication, transparency, and understanding the context are all equally important for effective decision making.

    c. Technologies and data exist to support more robust decision support tools, but many agencies are not aware of the advances.

    d. Emphasized the need for data connectors—people within a transportation organization who know not only where data reside but also how to use the data and how decision makers will perceive the results.

    e. Need to give more of a holistic picture of our data and collaborate more with people outside of transportation. For forecasting, we need to be aware of various influences (e.g., how trends in technology affect trends in transportation).

f. The presentations on Monday were real game changers for me.

3. Develop information in ways that are meaningful to decision makers.

a. It is more about information and the need for it than about the data per se.

b. Softer analysis and findings that can be developed in a timely framework, such as carefully designed alternatives analysis and case studies, are useful to decision makers.

c. The way information is presented is key.

d. Need to focus on telling a story in a way that is compelling for a specific audience.

e. Insufficient data availability is not the issue; communication of information is more the problem.

4. Focus on practical questions and choices that decision makers need to address.

a. We spend much effort in collecting data and doing analysis that does not in the end answer the most important questions.

b. Notion of including cobenefits in outcomes, incorporating nontraditional transportation areas of benefit that resonate with decision makers (e.g., job growth).

i. What are transportation and nontransportation impacts and outcomes? What are the consequences of action or inaction (political, transportation, economic, budgetary impacts)?

c. Data must be used to convey messages and make decisions that resonate with people.

5. There is no "one" solution, nor is there a quick solution.

a. The issues have been around for many years and will remain.

b. New data sources are narrow spotlights.

c. Better ways to use the existing data.

d. Data are just one of many factors and may not even be "a" factor in decision making.

6. Need to shift from business as usual.

a. Appreciate the need for substantial changes in how data are collected and packaged.

b. Communicating what is needed and what is provided for decision making is just as important and difficult as acquiring and analyzing data.

c. States and metropolitan planning organizations have reached a point where they can accept some national coordination and consistency, as long as the process is carried out in a collaborative manner.

d. Increase awareness and importance of scenario planning and aligning performance measures with the decision-making process.

Question 3. **What is the single most important follow-up activity to be accomplished?** (*N* = 43)

1. Prepare proceedings and bring the conference discussion to a broader audience in other ways.

    a. Capture discussion and takeaways in a document for distribution outside the attendees at the conference and then publicize it with a short abstract to attract readers.

    b. Publish a proceedings so that we have something on paper to share when others ask what happened in Irvine.

    c. Present conference results to as many conferences and groups as feasible.

    d. Link recommendations to various Transportation Research Board committees for further work.

    e. Follow up on the many meritorious research proposals presented.

    f. Develop a concise description and synthesis and take them to real-world decision makers for their feedback and suggestions on what they need most.

        i. Consider reconvening the individuals who participated in the regional workshops; seek opportunities to speak at meetings of decision makers engaged in transportation (Northeast Association of State Transportation Officials; Southeastern Association of State Highway and Transportation Officials; Western Association of State Highway and Transportation Officials; and similar meetings of transit or port and airport officials, regional planning organizations and metropolitan planning organizations, state legislators, etc.).

    g. Develop a centralized portal where resources are available and post the activities that are being conducted by various entities.

2. Highlight and share best practices.

    a. Share best practices relating to the nexus of data, performance analysis, communication, and application, such as performance journalism as practiced by the Washington State Department of Transportation.

    b. Develop a report of best practices from the group.

    c. Share successful examples where complex transportation data were turned into easy-to-understand and rational information allowing for transparent decision making.

    d. Design and develop a compendium of case studies, starting with areas we know are hot topics and where there is a group of professionals organized around the idea of sharing information and approaches. Safety might be such an area.

    e. Document case studies of successful data-centric organizations with careful attention to the "data connectors" to help others emulate success.

3. Highlight new technologies and data sources to support better decision making.

    a. Pool the sources of data in a cost-effective manner—particularly system performance information in metropolitan areas with public and private sources.

   b. Raise awareness of possible solutions for data sharing.

   c. Look at moving toward more shared data systems.

   d. Get a better handle on where private data sources are in the works or are likely to emerge. Example: crowdsourced data from mobile applications.

   e. Provide the opportunity to address uncertainty created by increased complexity and the acceleration of change. Need to test and learn how to use simulation tools to evaluate the potential of alternative plans and future scenarios.

4. Pursue the national travel data program and the national performance data program founded on common architecture allowing for multiple levels of government to contribute.

   a. Collaborate across jurisdictions to define national performance areas and associated data needs.

   b. Develop an integrated worldview, both for freight and for personal transport, that includes multiple measures.

   c. Data framework in terms of definition and responsibility.

5. Foster organizational and culture change.

   a. Adopt a culture of persistent experimentation, starting with resurrection of the Service and Methods Demonstration Program, applied beyond transit to all surface transportation.

   b. Continue to foster coordination among stakeholders.

   c. Further develop the area of values and decision making through collaboration.

6. Understand the data.

   a. Gain a better understanding of how the existing wealth of data can or should be used by decision makers.

   b. Mine existing data to establish a common baseline to tell a performance story on where the nation is and where it is going.

   c. Develop and improve techniques for data analysts to communicate to decision makers what data are available, the cost of acquiring and maintaining the data, and the process used to analyze data. Explain the significance of what the data are telling us.

7. Staff training.

   a. Get this information in the hands of the next generation of planners and designers.

   b. Identify the new skills sets that are needed—data management and an out come focus require new skills and understanding. Government information technology needs to become more nimble, flexible, transparent, open, and faster.

8. Proceed in a way conducive to provisions included in the upcoming transportation bill. Avoid reinventing the wheel.

   a. Consider the financing of the transportation system and internalization of externalities.

  b. Shift focus to the transportation system as an asset and uses of that asset such as revenue generation.

9. Find ways to put the ideas into practice. Pilot projects are more valuable than additional research and workshops at this point.

  a. Examine the state of practice at the national level and define some pilot programs that can show how data can be used to provide information.

  b. Data and information opportunities in the connected vehicles program.

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