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Conference on Performance and Data in Transportation Decision Making

September 15–18, 2019
Atlanta, GA

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Conference on Performance and Data in Transportation Decision Making

September 15–18, 2019
Omni Hotel at CNN Center
Atlanta, Georgia

Organized by
Transportation Research Board

Sponsored by
American Association of State Highway and Transportation Officials (AASHTO)
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Preface

On September 15–18, 2019, more than 350 professional transportation planners, consultants, industry experts, and academic researchers, from 42 states and three countries, participated in the Conference on Performance and Data in Transportation Decision Making, in Atlanta, Georgia. Robert Hazlett, Senior Engineer with Maricopa Association of Governments, chaired the planning committee for this conference with assistance from Debra Miller, former Secretary of Transportation for the state of Kansas. The planning committee members were solely responsible for organizing the conference, identifying the themes, preparing the call for abstracts, reviewing the submitted abstracts, and developing the sessions. Catherine T. Lawson, Associate Professor at the University at Albany, State University of New York (SUNY), served as the conference rapporteur and prepared this E-Circular of what occurred at the conference.

The four themes of the conference included: multimodal planning; performance and data; programming and investment prioritization; and communications and stakeholder engagement. The multimodal planning sessions focused on how data and performance measures are affecting the development of transportation plans (e.g., investment decisions, tools for monitoring performance measures and decision-making, processes, and the expanding effectiveness of transit as shared mobility and automated transportation modes evolve). The performance and data sessions explored collaborative processes for employing data throughout the planning processes, including private data, business intelligence (BI), and data governance (DG). The programming and investment prioritization sessions examined trends in project selection, focusing on mode-neutrality, current evaluation techniques, and political realities. The communications and stakeholder engagement sessions highlighted the effectiveness of tools, including dashboards and other methods developed to foster involvement of elected officials at state and local levels.

Plenary panel members provided perspectives at the regional, state, and local levels, including how data is changing the structure and staff roles in public agencies. The poster session featured recently completed research. Keynote speakers highlighted how data is changing public agencies and private corporations. In addition to the formal sessions, this summary includes audience questions, presenter responses, and reflections. Presentations and audience participation varied in length and depth, based on the interactions among audience members, panelists, presenters, and moderators. In addition, some of the topic areas (e.g., SMART SCALE) are featured in several sessions. Any mention of proprietary products is for descriptive purposes only and should not be taken as an endorsement by TRB. A copy of the program with links to the presentations is available at
http://onlinepubs.trb.org/onlinepubs/Conferences/2019/PerformanceData/program.pdf.

Special thanks to American Association of State Highway and Transportation Officials (AASHTO) and the Association of Metropolitan Planning Organizations (AMPO) for their leadership and sponsorship of the conference. The views expressed in this summary are those of individual conference participants and do not necessarily represent the views of all conference participants, the planning committee, or the Transportation Research Board. This publication was not subject to the formal TRB peer review process.

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Chapter 1

Welcome and Plenary Session

WELCOME

Robert Hazlett, *Maricopa Association of Governments*, Co-Chair, *presiding*

Robert Hazlett, Senior Engineer at Maricopa Association of Governments (MAG) and co-chair of the planning committee for the conference, welcomed participants and explained the structure of the sessions. The conference is organized into four tracks covering major topic areas including: multimodal planning; performance and data; programming and prioritization; and communications and stakeholder engagement. In addition to the topic sessions, the program includes several plenary sessions, with panels of federal, state, local agency representatives and private sector experts, two lunch speakers, a poster session, and a final session to discuss take aways from the conference.

PLENARY SESSION

Patricia Hendren, *I-95 Corridor Coalition, presiding*
Matt Hardy, *American Association of State Highway and Transportation Officials, recorder*
Russell McMurry, Commissioner, *Georgia Department of Transportation*
Kyle Schneweis, Director, *Nebraska Department of Transportation*
Jody Bare, Director Advanced Mobility & Innovation, *Regional Transportation Commission of Southern Nevada*
Jacob Tzegaegbe, Senior Transportation Policy Advisor, *City of Atlanta*
Yvonne Carney, Director of Strategic Performance, *Washington Suburban Sanitary Commission*

WHAT PERFORMANCE-BASED DECISION-MAKING LOOKS LIKE FROM STATE, REGIONAL AND LOCAL LEADERS

State DOT Perspective

Russell McMurry

At Georgia Department of Transportation (GDOT), our attention is focused on performance indicators and how to use them. These metrics are not like a bad report card, they help guide agencies to a better understanding of their operations. A performance management story tells us why, where, and when we need to improve. These metrics can assist us in knowing what we should do more of, or what we should stop doing. For example, here in Atlanta, performance evaluations helped us get ready for the Super Bowl. Altanta traffic is always a major concern, requiring us to think differently about how best to manage our traffic to get the most from our transportation system. Using a team approach, we were able to accommodate the 2 million visitors and deal with surface streets. Having a special event focus allowed everyone to work

together, including the City of Atlanta staff and their real-time traffic operations. They assisted us in our understanding of speeds, making it possible to move more traffic successfully.

A key to our success is listening to the public. For example, citizens want assistance with their Thanksgiving travel. Using data that provides color-coded times to avoid traveling was pushed out to regular media and social media to keep everyone informed. Another area of need is human resources (HR) and how to understand retirement patterns. We mapped employees to assist workforce planning through the development of a comprehensive HR database. The knowledge management aspects and need for knowledge transfer became more transparent through this approach. Newer employees were linked to resources where retirements would result in loss of knowledge. Mapping retirements across the state made it possible to back-fill appropriately. We conducted a network analysis, using employee information in context with other jobs, to produce a better understanding of connectivity across our workforce for planning purposes.

State DOT Perspective
Kyle Schneweis

In our programs in Nebraska, we want to use more data in decision making. Data experts might say they want more data, but don't incorporate it because they don't have the time. New data tools take on this challenge to make analysis possible, using Business Intelligence (BI). For example, in Nebraska, one area where they use data analysis is for hiring and other areas of workforce management. With these new tools, HR can easily create spreadsheets with data that was previously hard to analyze. Another area where data and tools are assisting us is with our letting schedule (e.g., when we make our contract bids available). New analyses aimed at understanding how projects are "squeezed into the pipeline" revealed that more bidders were needed. By analyzing the data, we found a tipping point that drove the reorganization of projects, leading to better bids. We talked with contractors to learn more about the issues they were facing. Having the data made it possible to be a better partner, resulting in more efficient and effective planning.

Regional Government Perspective
Jody Bare

In southern Nevada, data assists us to deliver services more efficiently. Mobility on demand is one of our emerging transportation elements. Crowd-sourcing is a new avenue for gathering information for planning. Lidar, connected vehicles (CV) with enabling artificial intelligence (AI), and smart work zones, are all affecting transportation planning. The challenge now is making these data useful for decision making. Many of these new resources can be fused together to provide a more holistic database for planning. For example, data aggregations from construction sites, telematic data, and messaging, make operations more efficient. Using data to identify historical hotspots contributes to better outcomes. We are looking forward to using Dashcam technologies and other technologies to provide commuters with better information.

Local Government Perspective
Jacob Tzegaegbe

Data is essential to capital programs for the City of Atlanta. In 2015–2016, $500 million were available for infrastructure, but there was still a shortfall of $400,000. Data was needed to conduct a spatial analysis to enable all the projects to be scored to provide transparency for making decisions with limited resources. In addition, scenarios were developed and shared with the public to assist in decision making. Using data makes our programs better.

Local Agency Perspective
Yvonne Carney

In my previous employment at the Washington Metropolitan Area Transit Authority (WMATA) and now with water services in Maryland, I am finding similarities regarding the maintenance and control of assets. For example, when WMATA was faced with declining ridership (e.g., 20% ridership reduction affecting overall revenues), they needed to restabilize services. Covering the agency's revenue shortfall by raising rates would have led to further reductions in ridership. Instead, we used data to better understand travel trends with travel profiles to bring options to leadership for a decision on what to do next. For the water agency, customers are now using low-flow toilets and showers, resulting in the conservation of water, but for the agency, this means a reduction in revenues.

To achieve greater efficiency, we are deploying Global Positioning Systems (GPS) to gather data from our 600 service vehicles. In both my transit and water experiences, an overarching theme is emerging that realistically, just providing people with good information will not be effective unless it is accepted and acted upon. Finally, benchmarking is an excellent method for comparing outcomes and practices, making it easier to accomplish goals. There is a need for more assessment tools to facilitate more effective management.

Audience Dialogue

Question: How do you turn an organization into a performance management organization, but not become the performance police?

Russell McMurry: Organizations moving to performance-based management make it possible for people to know what is expected to be successful and how they will be judged. Having measures allows us to know what success looks like.

Kyle Schneweis: Measurement works to understand effectiveness of employees and to find opportunities to manage staff and resources. It is actually easier in the private sector to do this type of management because it can be directly tied to monetary rewards. In the public sector, it is harder. You need to let people know know what goals they are expected to meet.

Jody Bare: Where we are trying to make sure we are using agile technologies, using incremental implementation, it is important to have the right stakeholders to provide guidance.

Question: How do you use performance incentives for stakeholders?

Jody Bare: We engage metropolitan planning organizations (MPOs) and departments of transportation (DOTs) with performance information that needs to be shared among our planning partners. For example, we can create innovative programs using monthly calls to share information with sister organizations.

Jacob Tzegaegbe: Our stakeholders are city residents and council members. They need metrics on operations. It is important to understand what can be accomplished. For example, we cannot solve all traffic issues, but we could try to solve 5% of the issues. When these specific issues are solved, then we have a success.

Question: What is the role of pothole reporting apps?

Jacob Tzegaegbe: Apps make it easier for the public to participate in the planning process. We learned that having a website was not a successful strategy for information dissemination as most people consume information on their mobile devices. It is important to get the right media for communication.

Kyle Schneweis: On holidays (e.g., Thanksgiving), we use icons and social media to communicate with the traveling public.

Question: Indicators for potholes are part of pavement conditions. How do you handle the data to make sure it is correct?

Kyle Schneweis: It is difficult to get the data right. For example, during a flood, people might want to know the latest information on a particular bridge, or on all of our 27 bridges. The press announces a particular number of closures, but then it changes, giving the appearance of chaos to the public. This type of uncertainty is difficult to manage. During stressful times, it is a challenge to have different information from different sources.

Yvonne Carney: Data quality is always a concern. WMATA found they were under-reporting rail car mileage due to a software problem. It required the identification of the problem and reexamining the calculations from past data to learn important lessons about our data.

Russell McMurry: If data doesn't match, you have to clean it up using analytics tools designed specifically to identify data quality issues.

Kyle Schneweis*:* Getting at data quality issues requires data governance. It is hard to get data governance in place as it is the least fun to do, and likely, the most important part of a data program.

Question: How to you deal with fair share issues?

Russell McMurry: We use data from public meetings to present projects in Georgia as it is important to know what problem is to be solved. Sometimes we need to revamp the problem statement. For example, with safety crash data, you might need to modify a project to reduce

crashes and you can use a YouTube video to make sure the public can consume the information about the modification and why safety is a key component for the needed changes.

Jacob Tzegaegbe: The public is often not versed in transportation and you might find that people interpret data differently.

Yvonne Carney: Water services often have too many pages of pure data, with no interpretations. Data visualizaion helps people understand what the data means, using special tools.

Question: What can data convey?

Jody Bare: We need better data to deal with measuring performance. We are taking a different approach at the Regional Transportation Commission (RTC) now because we have so much data, but little understanding of it. You really need to know all about the data you are going to use for performance measurement, as well as having data governance in place and a plan for data sustainability.

Jacob Tzegaegbe*:* Here in Atlanta, we want to know the impact of past investments. For example, we struggle to tell the public about the impacts of spending $5M on signals. What did it provide? We have made robust multimodal investments to deal with new forms of transportation including Transportation Network Companies (TNC) and scooters. We need a strategy for scooters.

Yvonne Carney: Data-driven approaches require putting information where it is available so customers can take action. Dashboards provide graphical information so stakeholders get the benefits of having the information available.

Russell McMurry: We want to have forward leaning predictions for roads and bridges, to assist with assset management. We realize that prediction is hard and DOTs have pavement and bridge designs and methods that are in the process of changing. We need to learn how to protect all of our investments.

Question: New information is going to be needed for connected vehicles (CVs). Will they be a data source, or have data partnerships that will be useful?

Jody Bare: It is important to work with universities to learn how best to use these emerging data sources. For example, predictive traffic research can be explored through university research partnerships.

Kyle Schneweis: We want to bring data to other stakeholders for improvement. We are finding that commerical data sources (e.g., Waze, Google) are not always accurate. For example, for corridors with ongoing construction projects, we know today, people rely on their smartphones to give them only good information for their travel decisions. When the information is incorrect, drivers suffer the consequences.

Question: What are the performance mangement changes ahead?

Kyle Schneweis: Challenges should be focused on being flexible, and not being caught up in the data for data's sake. The national performance measures are based on what Congress wanted, rather than to meet local planning needs. The American Association of State Highway Transportation Officials (AASHTO) is trying to assist planners with performance measures, but their tools are not moving fast enough for the necessary reports for pavement, safety, or trucks. We need more flexibility in our data programs and analyses.

Jody Bare*:* It is an evolution as we learn more about the data.

Yvonne Carney: In order to successfully use performance measurement information, we need to be able to use new forms of data. Young people coming out of school have the ability to use new skill sets to answer questions with new forms of data and new methods of analysis.

Question: Maricopa is using machine learning, what is the future of performance management activities with these new approaches?

Kyle Schneweis: There are many new ways of using data. For example, aerial photos can be used in information technology (IT) integrations. At the same time, partnerships could have legal implications (e.g., ownership, sharing agreements).

Jody Bare: Unfortunately, we can be data rich and information poor. We have large amounts of data, but we need use cases to make it useful.

Yvonne Carney: The water industry is using artifical intelligence (AI) for billing customers. We use algorithms to assist in planning for maintenance opportunities.

Russell McMurry: AI has issues with privacy. At the same time, cities have opportunities as regulators, for example, with scooters. They can negotiate for the data to provide mobility origins and destinations (O/D) information for planning purposes.

Chapter 2

Multimodal Planning

SESSION 1A: STATE AND MPO TRANSPORTATION PLANS—HOW AGENCIES ARE USING DATA TO SHARE INVESTMENT DECISIONS

John Orr, *Atlanta Regional Commission, presiding*
Bryan Pounds, *Massachusetts Department of Transportation, recorder*
Holly Ostdick, *Illinois Department of Transportation*
Michael Vanderhoof, *Illinois Department of Transportation*
Eric Tang, *VHB*
Matt Haubrich, *Iowa Department of Transportation*
Monique de los Rios-Urban, *Mariposa Association of Governments*

IDOT ANALYZING FREIGHT FLOWS AND TRENDS TO IMPROVE FREIGHT INVESTMENTS

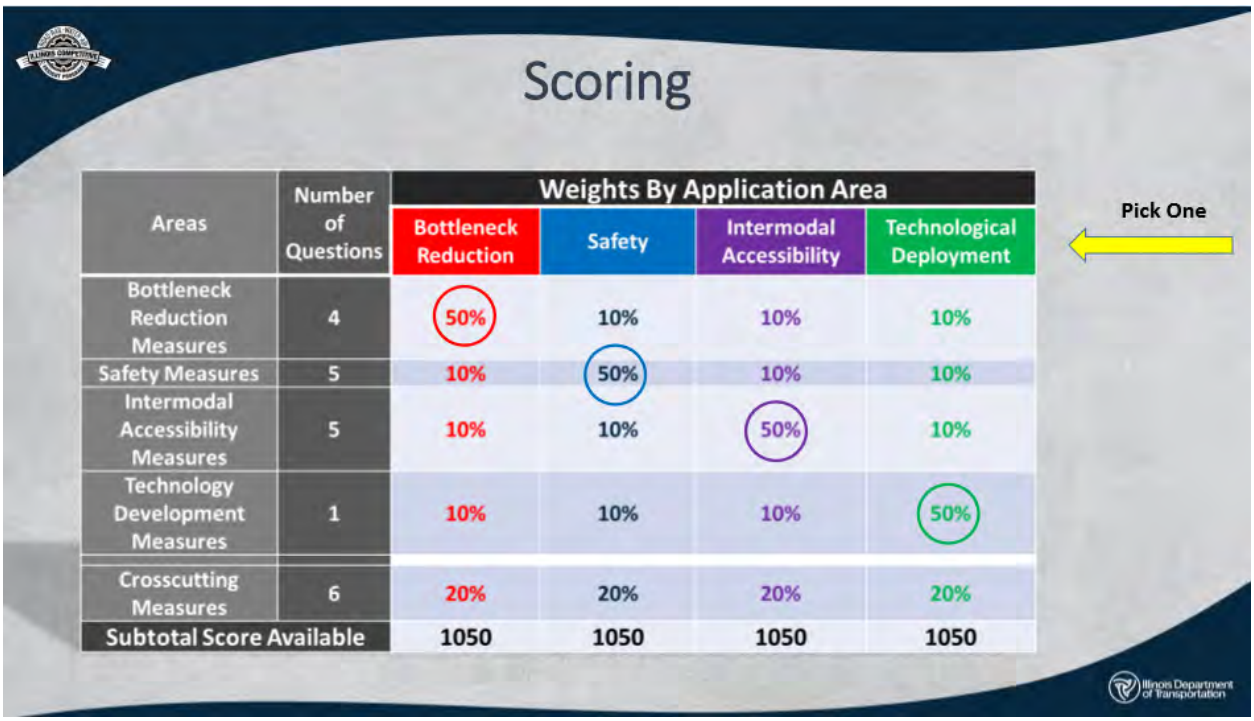
Holly Ostdick and Michael Vanderhoof

Background

The efficient movement of goods and services is central to making Illinois the transportation hub of North America. The Illinois Department of Transportation (IDOT) is responsible for the mobility of freight in Illinois. Under the federal freight planning requirements, IDOT needed to develop a State Freight Plan (SFP) to analyze freight flows, identify trends, and make recommendations to improve the mobility of freight, given fiscal constraints.

Methods and Measures

IDOT developed their Freight Investment Plan (FIP), as a component of their SFP, to identify how to allocate freight formula funds for its National Highway Freight Program (NHFP). IDOT used a competitive grant program that provided the opportunity for IDOT, and other stakeholders, to submit projects for ranking and selection based on a defined set of criteria. The Illinois Competitive Freight Program (ICFP) supports objectivity, equity, and transparency in project selection, reinforces the use of the freight performance goals found in the SFP, leverages funds through local or private participation, and provides the opportunity for the Illinois State Freight Advisory Council (ISFAC) to provide input into the development and delivery of the program. The program focused on reducing bottlenecks, improving freight related safety, improving intermodal accessibility to and from freight corridors, and encouraging technology deployments. These factors are weights for scoring. Figure 1 illustrates the matrix developed to assist in the scoring for the FIP.



Areas	Number of Questions	Weights By Application Area			
		Bottleneck Reduction	Safety	Intermodal Accessibility	Technological Deployment
Bottleneck Reduction Measures	4	50%	10%	10%	10%
Safety Measures	5	10%	50%	10%	10%
Intermodal Accessibility Measures	5	10%	10%	50%	10%
Technology Development Measures	1	10%	10%	10%	50%
Crosscutting Measures	6	20%	20%	20%	20%
Subtotal Score Available		1050	1050	1050	1050

FIGURE 1 Scoring strategy with four application areas with weights.

Contributions

The program received 46 applications from a mix of local and state agencies for approximately $600 million. Of those, 60% of the projects related to freight activities. IDOT awarded funds for 23 projects, including 17 local agency projects. Staff are implementing the program management provisions to keep the program on schedule. The transition from a funding based freight system to a truly competitive program was challenging.

Audience Dialogue

Question: What did the DOT do to make up for the loss of funds for investment for Interstate roads?

Response: IDOT had to make tradeoffs rather than considering “making up” funds. Since then, there has been new transportation legislation within the state to fund more projects.

GUIDE TOWARDS ZERO DEATHS—ANALYZE DATA AND SELECT STRATEGIES TO ADDRESS SAFETY ISSUES

Eric Tang

Background

Reducing transportation-related fatalities and serious injuries across the transportation system is one of the United States Department of Transportation's (USDOT) strategic goals. As identified in the USDOT Strategic Plan for FY 2018-2022, USDOT seeks to work effectively with state, local, tribal, and private partners, to improve transportation safety, address human behaviors to reduce safety risks, improve safety data analysis to guide decisions, continue to employ safety countermeasures, ensure that automation brings significant safety benefits, and pursue performance-based rather than prescriptive regulations.

Methods and Measures

The Federal Highway Administration (FHWA) Office of Safety published *Transportation Safety Planning and the Zero Deaths Vision: A Guide for Metropolitan Planning Organizations and Local Communities*, to help Metropolitan Planning Organizations (MPOs) and local communities understand and use the safety planning process to work toward the zero deaths vision. The guide provides a systematic process to develop, implement, and evaluate a regional, or local, safety plan, and highlights noteworthy practices across the nation.

Contributions

The Vision Zero program assists in the identification of networks with high injury to help prioritize investments (particularly if there are conflicts of modes). For example, in Richmond, VA, a health map assisted in the assignment of scores for each health tract, revealing that 16% of all road mileage accounts for 58% of all fatal and serious injury crashes. In San Francisco, CA, the California Department of Transportation (Caltrans) developed a robust collaboration between health departments and linked hospital records to augment data sets (see Figure 2). The City of San Diego, CA, developed a systematic safety analysis grid for their Vision Zero plan, using a strategy to identify issues and specific countermeasures. Hillsborough County, FL, provides a public facing component of Vision Zero, while the Alamo Area MPO in San Antonio, TX, developed a set of data visualizations of fatal and serious injury crashes, using a data portal. New York, NY, has the oldest Vision Zero program and produces an annual report card. Finally, the Macon Bibb Vision Zero Action Plan in Macon Bibb, GA, used a crowd-sourcing effort to inform crash cluster data. The Guide is available at https://safety.fhwa.dot.gov/tsp/fhwasa18024/ref.cfm.

It is encouraging that an increasing number of communities across the country share in and are working towards the same strategic goal to meet the zero deaths vision by developing and implementing data-driven safety plans that prioritize safety. The benefits of safety planning also contribute to the creation of a culture of safety, strengthened through the collaborations among stakeholders. Promoting a data-driven decision-making process is key to prioritizing funding for safety.

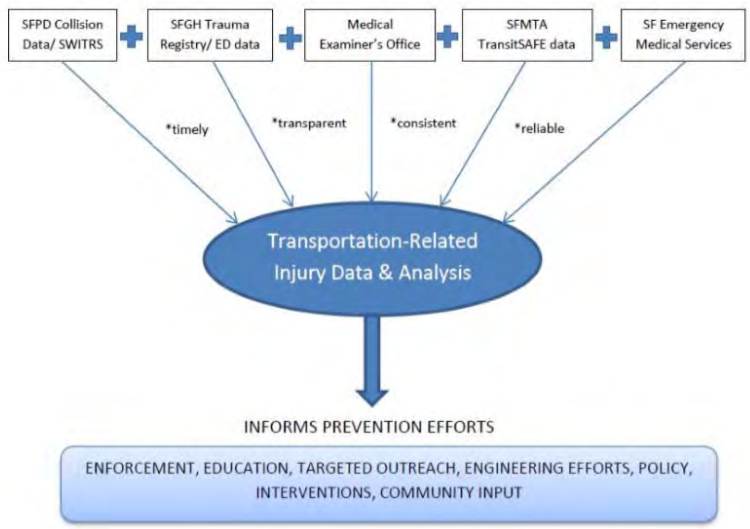


FIGURE 2 Illustration of process used to identify prevention efforts in San Francisco, CA.

PLANNING FOR AN UNCERTAIN FUTURE

Matt Haubrich

Background

The interstate system in Iowa has ten routes, with 3,300 mainline lane miles, 270 miles of ramps, and 700 bridges. In Iowa, 8% of the DOT lane miles carry 25% of the traffic, and 56% of that traffic is composed of trucks. While the road conditions are generally sufficient, there is concern regarding maintainence over the long run. Previous efforts to identify funding for transportation projects were impacted by the elimination of a tolling option.

Methods and Measures

Iowa DOT used a Planning Environmental Linkage (PEL) model to evaluate future scenarios under significant levels of uncertainty, including the impact of connected and automated vehicle (CAV) adoption rates, traffic growth, revenue construction costs, and the impacts of Transportation System Management and Operations (TSMO) strategies. The way forward required a "Plan for Every Section" with a strategy for determining return-on-investment (ROI) for various decisions. The *Iowa Interstate Investment Plan for 2040* was developed to provide a fiscally constrained plan to address all interstate system needs through 2040. Planning over longer periods of time requires an approach to deal with aspects of an uncertain future. The strategy developed for this research used a prioritization tool using the lens of transportation asset management (TAM).

The first step in the process was to plan a charette workshop (an intensive, multi-disciplinary event with the aim of developing a design or vision for a project or planning activity). In the workshop setting, participants were introduced to problems and an orientation

towards problem solving and biases. Seventy participants attended the workshop and spent two days of intense problem solving addressing planning, pavement design, structures, and safety. Participants were divided into eight multi-disciplinary tables and assigned segments of the system to analyze and provide recommendations. Data visualizations provided analysis of various aspects of the transportation system using Power BI, a business analytics service by Microsoft. The workshop recommendations emphasized stewardship of the system (e.g., $80 million for preservation treatments for pavement), widening options (e.g., specific segment expansion), limiting capacity expansions, and deployment of technology solutions and other management strategies. After the workshop event, concepts were quality checked, cost estimates were refined, and additional reductions were made in the scope of work for projects. Some projects were delayed until adequate funding would be available. The next step required staff to develop a single “front door” for all new projects, using consistent information and a uniform format. The approach for asset management (AM) efforts used a data-backed basis for alignment.

Contributions

One of the accomplishments of this effort was the ability for various investments to be displayed using consistent data and weighting factors (see Figure 3). The Scoping and Prioritization Tool provided a “one-stop-shop” for creating alignment and trade-off decisions.

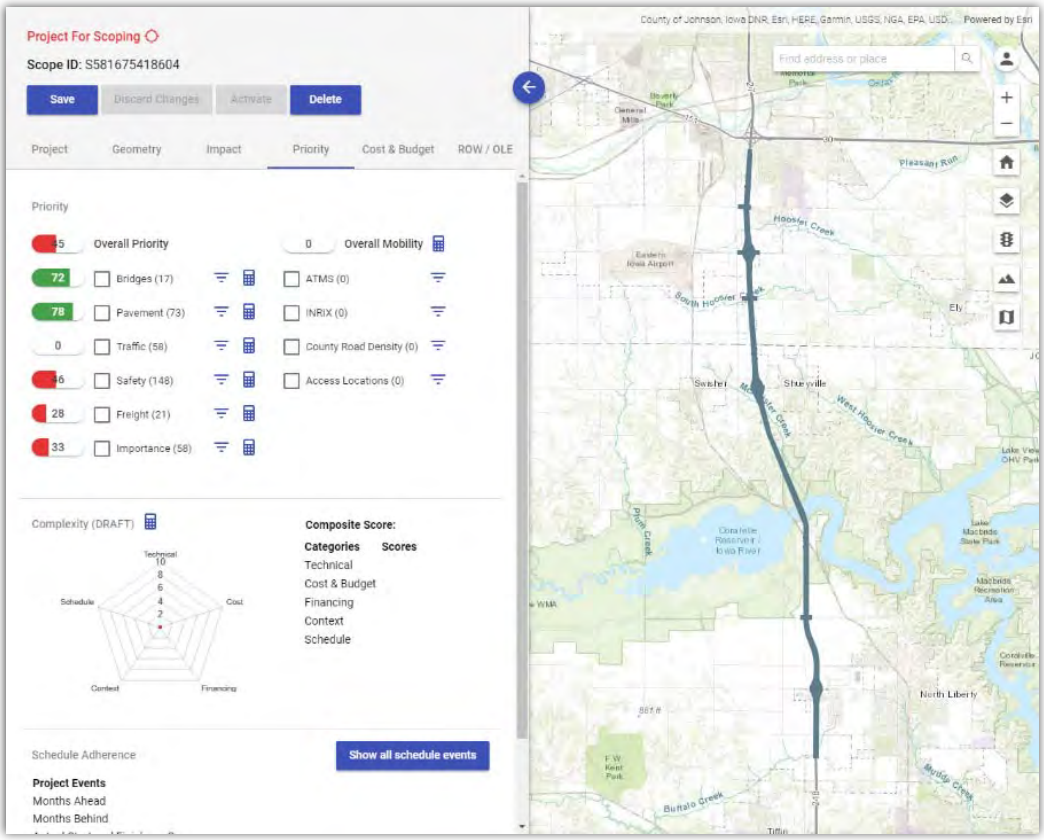


FIGURE 3 Interface for the Scoping and Prioritization Tool.

Audience Dialogue

Question: Were identified needs greater than funding levels made public?

Response: Yes, staff shared the results with the invited stakeholders, including the results of charrette as it was wrapping up. Everyone made a great effort to stick to a funding target. Having a flat revenue amount made it difficult to meet the full set of needs.

WHERE DO WE GO FROM HERE? PREPARING A PLATFORM FOR SUCCESS

Monique de los Rios-Urban

Background

Mariposa Association of Governments (MAG) has a population of 4.1 million (as of 2017), growing approximately 35% since 2000, and 2% annually. The county covers 10,600 square miles, with a total employment (as of 2017) of 1.9 million. The existing freeway system has 850 centerline miles, the principal arterials have 4,000 centerline miles, and the transit service has 59 local buses, with 59 million annual riders. In 2004, voters passed local Proposition 400, extending a sales tax for transportation funding, but requiring MAG to produce a performance-based Regional Transportation Plan (RTP). Beginning in 2010, Arizona State Law required performance audits of the RTP every five years, evaluating the effectiveness of the RTP and the projects listed in the RTP.

Methods and Measures

The 2040 RTP is based on four goals: system preservation and safety; access and mobility; sustaining the ennvironment; and accountability and planning. To assist in the required analysis, MAG uses the National Performance Management Research Dataset (NPMRDS) and other large probed-based, third-party datasets. The elements pertaining to transportation systems include establishing a framework for performance-based planning, key performance measures for different modes, analysis on system, corridor, and segment performance, and reports on performance progress and targets.

Contributions

To meet the requirements of the RTP, MAG developed a data analysis tool, including visualizations of spatial and temporal context of project performance, travel time conditions, and a set of metrics displayed on a report card (see Figure 4). The next step is to use these key features to make it possible to observe, document, analyze, measure, and report various aspects of the transportation system. A programming evaluation tool is being developed to provide both quantitive and qualiative measures to determine funding project eligibility. Additional information on this approach is available at performance.azmag.gov and projectcards.azmag.gov.

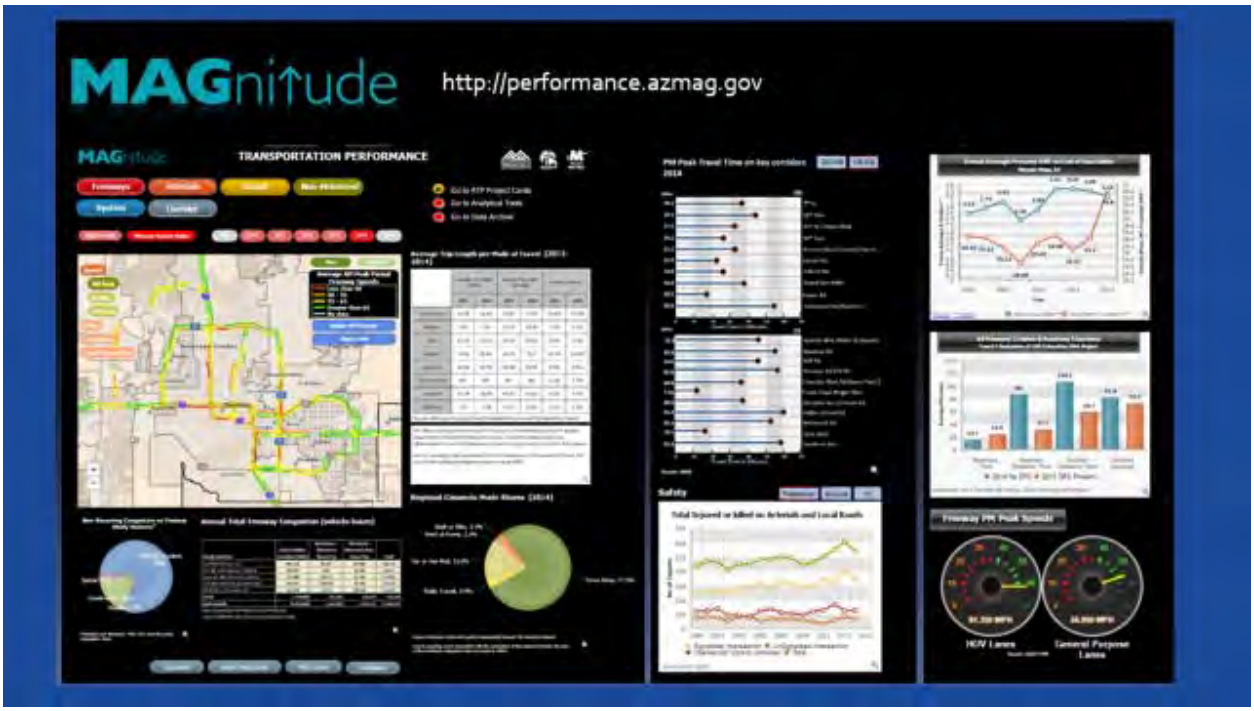


FIGURE 4 Dashboard interface for measuring and monitoring performance.

Audience Dialogue

Questions: Is real-time data available to the public yet?

Response: Not yet, as the MPO does not control the DOT-owned dataset.

Take Aways

- Throughout the development and implementation of the Illinois DOT's FIP, local agency collaboration, while challenging to navigate, proved key to the success of the process. Illinois DOT was pleased with the outcome and process, and looks forward to refining the scoring mechanisms moving forward.
- The Office of Safety at FHWA brought together best practices for Vision Zero plans. DOTs and local entities can use the multitude of these examples to implement these Strategic Highway Safety Plans (SHSPs) and Vision Zero plans.
- Iowa's DOT is leveraging existing tools (e.g. Power BI) and workshops with subject matter experts to influence TAM investments, focusing on stewardship versus capacity. For those projects moving forward, staff plan to develop ways to monitor progress (e.g., dashboards).
- Mariposa Association of Governments (MAG) reviewed best practices across the country to leverage data accessibility for both internal agency staff and the public. Transportation administrators can use these examples to implement what works for individual entities. Once implemented, staff track progress, measure, and report the impacts of the selected projects to refine future planning efforts. Data visualization and tools, in a common

format, make it possible for all parties to use an open and transparent transportation planning and programming decision-making process.

SESSION 2A: USING BUSINESS INTELLIGENCE TOOLS TO IMPROVE DECISION-MAKING

Yvonne Carney, *Washington Suburban Sanitary Commission, presiding*
Elissa McDade, *Washington Metropolitan Area Transit Authority, recorder*
Chowdhury Siddiqui, *South Carolina Department of Transportation*
Theodore Bobowsky, *Port Authority of New York and New Jersey*
Richard Boadi, *Wood Environment & Infrastructure Solutions, Inc.*

MAINTAINING AN ANALYTICAL FRAMEWORK FOR DATABASE MANAGEMENT OF PERFORMANCE DATA AT SCDOT

Chowdhury Siddiqui

Background

South Carolina Department of Transportation (SCDOT) has been in the process of developing an analytical framework for managing different sources of data to calculate performance on the interstate and non-interstate system. The project is a collaboration with the Office of Planning and the IT-wing within the agency. The challenge is to bring together internal and external data sources in an automated process with the capability of delivering the required reporting.

Methods and Measures

To meet their needs, SCDOT developed a framework as a standalone web-based software application, systematically retrieving different internal and external data sources and processing them through a relational database management system. The development team employed Vb.Net on a Visual Studio platform for the back-end, with a JavaScript front-end and SQL and R scripts. Users access the data from an internet website by entering their credentials. The dashboard interface allow users to choose a variety of options for analysis.

Contributions

The data analysis and viualizations provide findings on yearly variation of average weekday peak-period delay in hours on the interstate system. Figure 5 displays the percent of I-126 with speeds above 45 miles per hour. A number of challenges remain including how best to interface with users, maintaining inter-office coordination, providing documentation, meeting changing needs, dealing with changes in the dataset, and data quality. In addition, issues remain with required staff skills and whether to make the analysis “canned” or flexible. Staff are meeting these and other challenges by developing a better understanding of the data, cultivating an educated interaction with IT, and being patient with the trajectory of development.

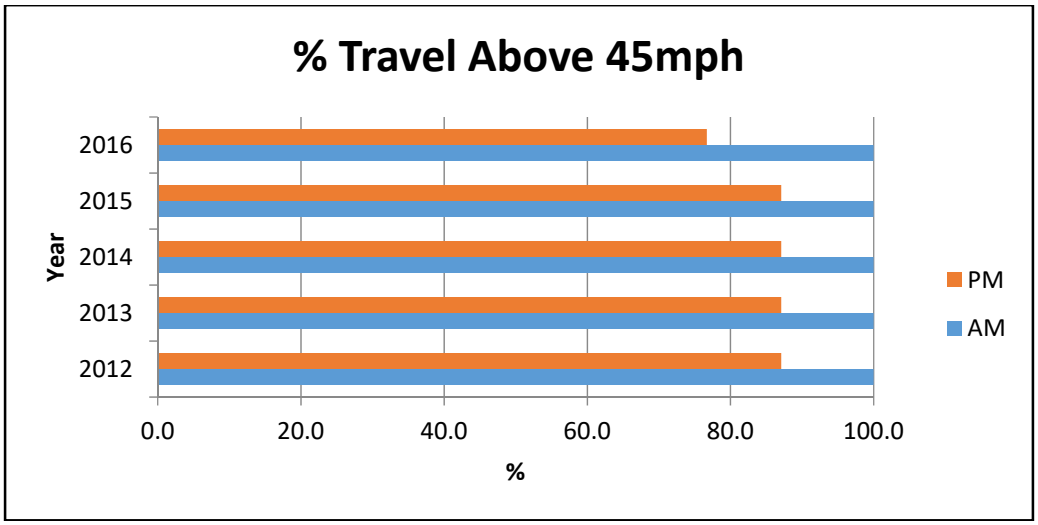


FIGURE 5 Percent of Travel above 45 miles per hour on I-126.

PORT AUTHORITY ENABLES DATA-DRIVEN DECISION MAKING USING AN INTEGRATED ANALYTICS PLATFORM

Theodore Bobowsky

Background

The Port Authority of New York and New Jersey (PANYNJ) builds, operates, and maintains many of the most important infrastructure assets in the country. The agency's network of aviation, ground, rail, and seaport facilities is among the busiest in the country and generates more than $80 billion in annual economic activity. These facilities include airport systems, ports, the PATH rail system, six tunnels and bridges between New York and New Jersey, the Port Authority Bus Terminal in Manhattan, and the World Trade Center. The Traffic Engineering group serves a myriad of internal departments and external stakeholders. Its broad portfolio of work includes managing maintenance work, providing data analysis, delivering traffic safety insights, managing traffic signals and analyzing key regional planning metrics. Data is critical throughout the organization, particularly the construction programs.

Methods and Measures

The Port Authority operations can be said to be at the intersection of a multimodal transportation system and the data associated with the operations and analysis (e.g., the Crash Data Management System, the Traffic Data Management System, the Traffic Analytics Platform, the Maximo Enterprise Asset Management System). The datasets inform analysis and modeling, in addition to operations (e.g., lane closures and hours of work). Field and office staff implement a number of strategies (e.g., signal timing) and make recommendations regarding the overall system. Historically, the datasets have been analyzed on an individual basis. Now the challenge is to integrate the data to unlock new and valuable insights, requiring a roadmap to support a comprehensive strategy. The vision of the desired integration is to enable proactive data-driven

decisions to assist in the deliverance of a safe and efficient set of operations and world-class customer service.

The development team identified analytical needs, followed by a list of projects and initiatives that would facilitate accomplishing these needs. The needs were mapped to the relative level of effort in terms of time and cost, compared to the expected benefits, using high- medium- and low-priorities. Each initiative and associated milestones were included in a roadmap to make it possible to track and assess progress on a quarterly basis.

Contributions

The dashboard system allows users to drill down into individual records (e.g., crash records) using Power BI. The records are automatically displayed making it possible for staff to spend time analyzing the data rather than entering, or manually loading it. The new approach creates displays that give insights into crash behavior, trends, and contributing circumstances. For example, Figure 6 displays the safety analytics processes, where the previous work flow resulted in quarterly meetings to review crash trends Now staff are able to conduct focused outreach on specific identified issues in a proactive manner.

The Traffic Safety Analytics (TSA) displays crash data by severity. For example, the George Washington Bridge data is divided between the toll plaza approach and the departure, to respond to the differences in the type of decisions that need to be made. Both have high crash rates and the tool functionality allows users to select data by year, holidays, specific areas, and facilities. The information can be summarized by number of crashes, crash severity, types of crashes, and contributing circumstances. The quarterly crashes tab displays histograms of daily crashes, in addition to a quarter-over-quarter bar graphs. Another feature is a related work orders tab to query "*what are we doing to address these issues.*" Users are able to geospatially link crash locations with maintenance work orders. Filters apply to specific facilities and areas of interest. Work orders are available for display, along with a status display. The relational database management system (RDMS) analytics displays weekly data for work orders created, work orders approved, total assets in RDMS, RDMS asset data entry backlog, work orders installed by sign shop, asset records added or updates in RDMS, RDMS-related ticket backlog, work orders awaiting installation, and RDMS-related Sharepoint tickets closed. The tool provides improvements for safety.

Challenges remain, in addition to new actions and strategies, to accomplish the mission of the Port Authority. For example, new features should include trending charts, action alerts, and the ability to integrate spatial analysis into the platform (e.g., geographic information systems (GIS) mapping strategies). Using dashboards creates a distinct culture and environment of accountabilty.

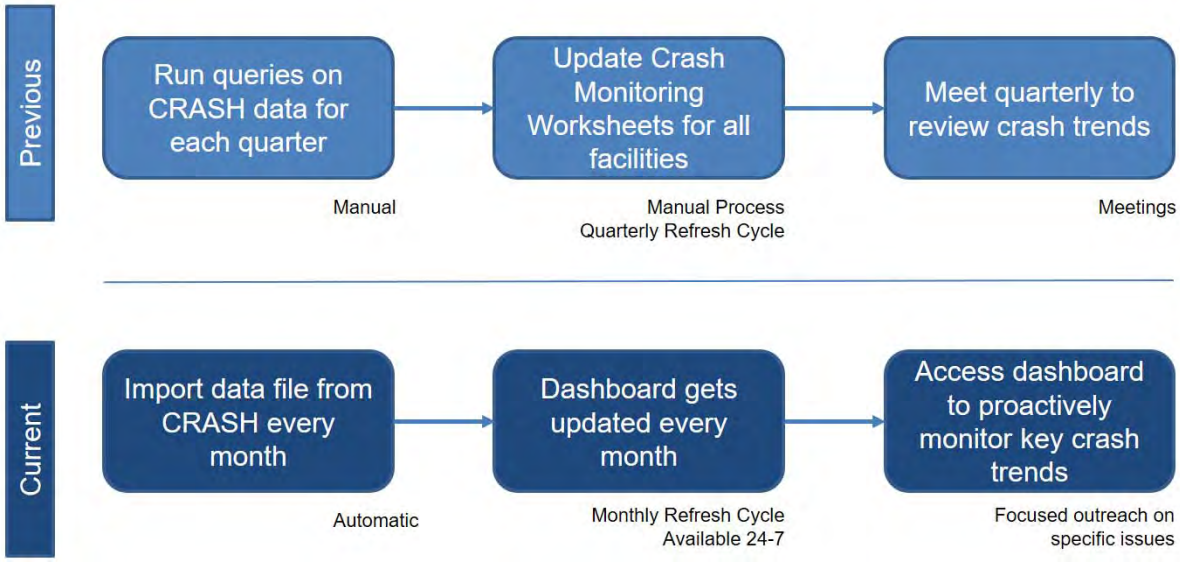


FIGURE 6 Traffic Safety Analytics work flow comparison.

DEVELOPING RECEPTIVE ENTERPRISE MANAGEMENT SYSTEMS IN AN ERA OF PERFORMANCE-BASED MANAGEMENT: A CASE STUDY

Richard Boadi

Background

Data is a critical asset that practitioners have not fully managed in a systematic and strategic manner. Though not thought of as a tangible asset, data remains the backbone of informed decisions recommended for resource planning and investment budgeting. The need for suitable, quality, consistent, and interoperable data for transportation performance management cannot be underestimated. It is essential for stakeholders to consider data as an asset group and apply formal and structured principles in identifying and gathering relevant and quality data that can address the multilevel business needs of transportation agencies. This data governance process begins with effective practice maturity assessment and gap identification. There are several data maturity model tools available across industries to facilitate the implementation of data governance. In 2017 and 2018, a group of consultants, in collaboration with the American Association of State Highway Transportation Officials (AASHTO), assisted by the Federal Highway Administration (FHWA), introduced twelve state DOTs and one MPO, to a data maturity model. They demonstrated how the application of a data maturity model improves data quality through improved data governance.

The agencies involved pulled asset data from different sources to develop an enterprise framework. In the process, they had to deal with fragmented systems, lack of data standards, issues with data redundancy and data inconsistency, inefficient processing, and outdated or unsupported software (e.g., regulatory compliance, security vulnerabilities, decreased

productivity, and increasing costs). The passage of Moving Ahead for Progress in the 21st Century (MAP-21) formally requires state DOTs to maintain performance data.

Methods and Measures:

The project used workshops to understand the various degrees of maturity in data assessment and governance. Key steps included exploring options to develop effective data governance to support agency data management. One solution to meeting the needs of an agency is to establish a receptive Enterprise Asset Management System (EAMS) with the following criteria.

- The use of large-scale application software package(s)
- Supportive business processes
- The ability to facilitate seamless information flow
- Supportive reporting
- The ability to enable robust data analytics
- The ability to be scalable
- Inclusion of a number of primary transportation elements
    - Highway maintenance management system
    - Pavement management
    - Bridge management
    - Road inventory management system
    - Facilities
    - Traffic signal inventory
    - Right-of-way management

Implementation of an EAMS requires a systematic process that includes the review of background materials, interviews, vendor demonstrations, recommendations, system capabilities requirements, and finally, the development of a Request for Proposals (RFP). In addition, stakeholders in the decision need to be on-board, both from a cultural point of view and with respect to personnel aspects. Attention to business processes and defining standards for access are key requirements. The technologies must fit the environment where it is applied.

Contributions

A key output from the workshops, and the introduction of best practices available to support data management, was a critical set of recommendations to enable stakeholders to benefit most from data governance initiatives. These recommendations are below:

- Lesson 1 – Establish strategic direction. It is problematic when agencies develop their practices from the bottom up with no agency-wide drive, with no communications from all interested parties. There is a need for strategic direction from an enterprise architecture to acknowledge that policy drives change.
- Lesson 2 – Establish multilayer governance structure. With policies and procedures, you need people to implement them. You need stakeholders and a champion that can get necessary resources and drive decisions.

- Lesson 3 – Do not leave out data governance. You can invest in all of the latest tools, but if your data is not good, only garbage results.
- Lesson 4 – Understand what is available. Invest time in learning from vendor demos, including going shopping to find what fits your need and interest. Nothing is going to be perfect, there will be a give and take, but go in with an open mind.
- Lesson 5 – Learn from peer organizations. Learn what they did right through a peer exchange with state DOTs that have used some of the systems to avoid mistakes.
- Lesson 6 – Know what you want. Determine your current state, hen plan for where you want to go. Use this information to measure respondents trying to meet your needs.
- Lesson 7 – Proceed gradually. Think about all of your systems; avoid problems by phasing-in the process.
- Lesson 8 – Manage the change process properly using a change management strategy. Most people would rather stick with what they know than venture into change. Look to technical support to help you integrate your system. Have your users own the new system so you do not have to continue to have help on site.

In addition to the eight identified lessons, agencies need to foster a responsive, unified governance that involves key stakeholders early in the process. With regards to business processes, avoid defaulting to system familiarity over efficiency. Finally, considerations for technology include avoiding over-purchasing capabilities for some systems. It is better to focus on scalability and manageability by adopting a phase-in implementation approach.

Audience Dialogue

Question: How much effort does it take to prepare the dashboards to this level and keep them going?

Response: The effort is dependent on datasets and how easily transferrable they are to Power BI. Right now, we are using data dumps from Excel. In the future, we are thinking of using the Azure cloud solution. In theory, it is very simple to go in and change displayed data. It is best to integrate manageable tools into your existing staff workload.

Question: Are you posting in the Cloud or Power BI *desktop?*

Response: We are using our agency-hosted network, anywhere that someone who has a device with WiFi can see it. Our end vision is in a true Cloud solution.

Question: Because the Port Authority system is limited to bridge, tunnel, and connecting pieces, for those assets you are not responsible for, how do you link that data?

Response: This is a challenging issue and a lot depends on the data set. For example, NY and NJ share the crash data. Our strategy moving forward, at key decision points, is to determine the needs of our agency and design our approach to incorporating other data sources so that these data will integrate with our shared databases.

Take Aways

There are three critical components to using BI to improve decision making. The first deals with people. Be sure to involve stakeholders early in the process. If you have the right governance process in place, people will fall in line. The second deals with business processes. Avoid defaulting to system familiarity over efficiency, and prepare to adopt new and emerging technology. The third deals with those technologies. Avoid over-purchasing capabilities for some systems by defining required capabilities in advance, and focusing on scalability and manageability by adopting a phase-in implementation approach (remember—do not overwhelm yourself).

SESSION 3A: ALIGNING GOALS OF STATE DOT PLANS FOR IMPLEMENTATION SUCCESS

Jesse Jones, *Arkansas Department of Transportation, presiding*
John Kaliski, *Cambridge Systematics, recorder*
Larry Shifflet, *Pennsylvania Department of Transportation*
Philip Schnffner, *Minnesota Department of Transportation*
Jeremy Jewkes, *Washington State Department of Transportation*

PERFORMANCE-BASED PLANNING AND PROGRAMMING—CONNECTING THE DOTS

Larry Shifflet

Background

The Pennsylania Department of Transportation (PennDOT) is responsible for 40,000 miles of road, 25,400 bridges, $2.4 billion annual awarded construction contracts, 11,375 employees and 7,200 maintenance employees, 53 transit systems, 64 operating railroads, 10.3 million licensed drivers, 11.8 million registered vehicles, three ports, 128 public use airports, 102 billion annual vehicle miles traveled, and 2,440 miles of BicyclePA routes. PennDOT's *Transportation Asset Management Plan (TAMP)* provides financial guidance for a 12-year period, with general and procedural guidance for the transportation program. PennDOT took on the challenge of aligning and providing guidance across their plans to support performance assessment of their assets, including the Transportation Performance Management (TPM) targets.

Methods and Measures

The TPM program was developed to include written provisions of PennDOT's Performance-Based Planning and Programming (PBPP), performance management targets, and their TAMP. The need to develop a more streamlined and cooperative approach led to the decision to integrate TPM requirements into planning documents. The challenge was to implement federal requirements in the context of PennDOT's planning approach. Federal metrics were tied to PennDOT's funding formula, supporting programs, and processes.

Contributions

On July 31, 2018, PennDOT produced Pennsylvania's *2021 Transportation Program General and Procedural Guidance* document, reflecting a performance-based planning approach, streamlining efforts with a fully-connected approach. Multiple plans and documents relied on common data elements. The experience demonstrated an opportunity to connect the dots, using the same data and targets, and providing for cooperative development with TPM integrated across all the documents. The approach outlines a clear process and documents agreements. It also illustrates the importance of internal coordination (e.g., signoff by both planning and highway operations). PennDOT promoted strong communication with partners including MPOs and Regional Transportation Planning Organizations (RTPOs) at each step of the process, recognizing the importance of coordinating with FHWA division office.

Challenges remain in planning the necessary coordination with statewide and MPO Long Range Transportation Plans (LRTPs) in the development of mobility targets. PennDOT also decided to shift their TAMP from a worst-first approach to a lowest-life-cycle approach. Decision makers are taking advantage of the opportunity to realign funding formulas to support targets, ensuring consistency between funding formula and performance-based plans. A transition period allows for the first two years to remain unchanged, and then the new approach will be implemented.

Audience Dialogue

Question: Given the transition in funding formula will take two years, how do you convince commission or legislature to make the change?

Response: Our legislature is supportive of our current process because they recognize the degree of coordination with MPOs and RTPOs.

Question: Can you explain the degree of stakeholder engagement and education on formula changes?

Response: We are using an extension of what we already had begun for target setting. We hold monthly calls with MPOs and have statewide meeting with MPOs every October for three days.

TOWARDS A COMMON VISION: ALIGNING MnDOT'S FAMILY OF PLANS

Philip Schaffner

Background

Minnesota Department of Transportation (MnDOT) over time has developed a large family of plans. Examples include the *Minnesota GO 50-year Vision Plan*, the Statewide Multimodal Transportation Plan (SMTP), modal and system plans (transit, pedestrian, bicycle, highway, freight, aviation, rail, ports and waterways), plus a number of special purpose plans (e.g., Transportation Asset Management Plan (TAMP), Intelligent Transportation Systems (ITS), the

Strategic Highway Safety Plan [SHSP]). MnDOT took on the challenge of aligning all of their various plans.

Methods and Measures

To accomplish the major task of aligning all of its plans, MnDOT is using an iterative process that is flexible and nimble, providing consistency overall. For example, in 2012, the SMTP set broad direction for bicycles, then in 2013, the Minnesota State Highway Investment Plan (MnSHIP) allocated a percent of funds for bicycle projects for the first time, but had no clear strategy or performance requirements. In 2016, the State SMTP added new performance measures and strategies, and updated the MnSHIP, based on the state bicycle plan. Finally, in 2019, district bicycle plans contained detailed routing and needs estimates for next MnSHIP, and produced a new *Bicycle Facility Design Manual*. A similar trajectory has occurred for pedestrian planning.

Contributions

With a strategy of consistency, documents will have a common brand and voice to reinforce the purpose and provide for internal guidance for plan development and review. This approach assists in plan consistency, performance measures, and internal review processes. Another key element is the establishment of a planning management group to review and recommend to leadership approval of all statewide plans (e.g., scoping, public engagement plan, new performance measures, draft plan for public comment, final plan). Launching a website helps to organize all available plans and facilitates the tracking progress (see https://performance.minnesotago.org/).

Challenges remain beyond the internal alignment of plans within and across the state. The array of plans still needs to be aligned and coordinated with federally and state required plans. Many of the plans have different update cycles, with different offices and teams involved in the planning process, including in-house staff and consulting firms. There are a variety of topics to be addressed by legislative bodies with their own requirements and stakeholders. While MnDOT has been active with performance-based planning since 2003, some areas have matured more quickly than others. In addition, MnDOT has an internal culture of consensus and decentralized decision making.

Audience Dialogue

Question: With so many plans, how do you prevent plan fatigue, both inside and outside the department?

Response: This is an important concern. We try to leverage previous work so that not everything is from scratch every time. We also try to identify a small number of key emphasis for areas in each plan update. We also recommend establishing a predictable schedule so that people know when they are on or off a planning process.

Question: When you are developing policies, how do you avoid inconsistency among policies and set clear priorities?

Response: We agree with this concern. Having a 20-year highway investment plan that is fiscally constrained as part of the mix helps provide a reality check for the highway element.

Question: What is the degree of coordination with modes, particularly related to implementation?

Response: It depends on the mode and the level of investment the state makes in each mode. We are trying to get better at tracking progress, including what our partners are doing.

Question: What is your advice to someone starting this process?

Response: Do not try to do everything at once, but at the same time, make a commitment to advance the process over time.

HOW DO WE PLAN TO CREATE A STATEWIDE PERFORMANCE-BASED INTEGRATED MULTIAGENCY MULTIMODAL TRANSPORTATION STRATEGY FOR WASHINGTON STATE IN THREE EASY STEPS

Jeremy Jewkes

Background

Washington State Department of Transportation (WSDOT) oversees a connected system that serves many modes and users. For example, there are 18,712 lane miles of highway, 307 HOV lane miles, 3,322 state-owned bridges, 23 ferries serving 24.6 million passengers per year, 32 transit systems, 16 WSDOT-operated airports, 125 miles of dedicated bike lanes and 400 miles of sidewalk within/adjacent to WSDOT right-of-way (most pedestrian and bicycle facilities are operated by local governments), 333 miles of Amtrak Cascades service with 800,000 annual passengers, and 298 miles of WSDOT-owned shortline freight railroad. The state is divided into six transportation regions, and has RTPOs and MPOs located across the state.

Washington is one of the most trade-centric states in the United States, with gross business income for freight-dependent industries of approximately $595 billion (as of 2017). In addition, one in three Washington-state jobs is directly or indirectly related to international trade. At the same time, the geographic features of the state create unique and restrictive transportation corridors, impacting commute patterns and transportation services. The challenge facing WSDOT is how best to coordinate across multiple plans to create an overarching statewide transportation strategy.

Methods and Measures

The vision for the way forward focuses on aligning investments with values to develop an integrated multimodal investment strategy, creating a 20-year plan over the next 5 years, tied to statutory guidance. This approach will ensure legislative policy goals are able to shape investment decisions, using a transparent performance framework to align with regional and

local partners' plans, and at the same time, improve project quality and use limited funds in the most effective manner. The three easy steps to begin the process include asking who is willing to go on the journey, establishing the ground rules for traveling together, and to go on the journey.

Contributions

The outcome of this approach is a 20-year plan where priorities with a long-term vision for a state transportation system that best serves people, goods, and services. In addition, MPOs and RTPOs partners will benefit from having greater consistency between state and regional plans; shared priorities for future investments; a clear, consistent, repeatable set of processes for state inputs into regional plans; and the ability to share data and plans for state facilities with local significance. Other partners in this effort include federal agencies, tribal governments, other state agencies, and members from various communities (e.g., business, labor, freight, development, environmental and other interest groups including accessibility, alternative modes).

The process is faced with the rapid pace of change and the need to adapt the process going forward. The challenge will be to identify the best strategies for aligning funding to address the most important issues and meet the greatest needs. In terms of societal costs, safety impacts may be the greatest, yet they received the least funds in previous programs. Leveraging strong collaborations with partners, especially MPOs and RTPOs, is a promising strategy for the alignment and priority identification.

Audience Dialogue

Question: What are your assumptions about future funding, given the decline in the value of the gas tax and discussions of alternative ways of funding transportation? Should this go into a long-range plan?

Response: Washington State Transportation Commission (WSTC) is involved in this discussion and staff are coordinating with them on what to assume in the plan.

Question: How is the concept of practical solutions integrated into this process?

Response: It is one of three priorities in our current agency strategic plan, along with inclusion and workforce development. We try to focus on making the right decision at right place at right time. As a result, integrating practical solutions fits into our process.

Take Aways

A review of examples and approaches illustrates the fact that there is no single approach to aligning goals of state DOT plans. There are common threads that are important including collaboration, communication, data sharing, and the establishment of a clear process.

SESSION 4A: TOOLS TO AID IN THE MONITORING OF MULTIMODEL PERFORMANCE MEASURES

John Kaliski, *Cambridge Systematic, presiding*
John Orr, *Atlanta Regional Commission, recorder*
Stanley Young, *National Renewable Energy Lab*
Marketa Vavrova, *University of Texas El Paso*
Sonia Perez, *El Paso Metropolitan Planning Organization*
Monica Zhong, *Florida Department of Transportation*
Praveen Pasumarthy, *Cambridge Systematics*
Chandra Bondzie, *Federal Highway Administration*
Patricia Hendren, *I-95 Corridor Coalition*

U.S. DEPARTMENT OF ENERGY: MOBILITY ENERGY PRODUCTIVITY MEASURE—STANDARD FOR SMART CITY MOBILITY

Stanley Young

Background

The U.S. population continues to grow and age, with population densities increasing (e.g.,75% of residents living in urban mega regions). At the same time, technologies and fuel choices are expanding, with transportation costs second only to housing expenses for households. Maintaining mobility for these household members requires a new approach to quantifying mobility. Existing performance metrics only measure utilization or efficiency of the road network (e.g., vehicle miles traveled, volume to capacity ratios). A viable metric needs to quantify accessibility by all modes, relative to travel times, affordbility, and energy consumed. The productivity of a network would be defined by the mobility benefits divided by costs.

Mobility is the quality of a network or system to connect people to goods, services and employment that define a high quality of life. The metric to measure mobility needs to be based on established research, yet be supportable using available data and comparable across locations and planning strategies. For example, the methodology needs to make it possible to compare two locations within a city (downtown versus suburbs) and different modal solutions (roadway extension versus transit expansion). It needs to be mode-neutral and include travel time, energy, and monetary costs of travel. It needs to be sensitive to new technologies (e.g., electric vehicle penetration) and be spatially scalable (e.g., applied to a residence, a district, a city, an employer).

Methods and Measures

The Department of Energy (DOE) is developing an Energy Efficient Mobility System (EEMS) that will identify and support technologies and innovations to encourage maximium mobility with minimum energy. The EEMS research program generated a response to the need to measure mobility with the development of the Mobility Energy Productivity (MEP) metric. It is a new paradigm for evaluating mobility options within an urban area. This metric is, at its heart, an accessibility measure, appropriately weighted with respect travel time, cost, and energy of modes that provide access to opportunities in any given location. The MEP metric is capable of

reflecting the impacts of new mobility technologies (transportation network companies, electric scooters), business models (car shares and bike shares), infrastructure investments (road capacity enhancements or major transit) and land use practices (such as transit-oriented development) on sustainable urban mobility.

The MEP metric concept recognizes the many "siloed" metrics (e.g., walk score, bike score, transit score, available travel time index). It uses a data spectrum including travel time isochrones, land use data, energy efficiency measure, travel demand data (e.g., the National Household Travel Survey (NHTS)), and cost measures. Figure 7 displays how layers in the data spectrum create the MEP metric. The process can quantify the number of opportunities reachable within a certain travel time threshold by different modes. The process allocates the values across all activities by frequency of trip purpose, weighted by the time, energy, and cost efficiencies by modes.

Contributions

The MEP metric is versatile, computed from readily available data sources or derived from outputs of regional travel demand models. It is customizable, using different weighting parameters at the local level, and then aggregated by population. It can also be disaggregated by geography, mode, trip type and population sub-group. The process uses end times associated with parking, curb access, cost, and reliability and frequency of service to obtain an appropriate and accurate perspective when computing the metric. The DOE plans to use the MEP as a central lens to evaluate a variety of mode alternatives, including future modes (e.g., CAVs).

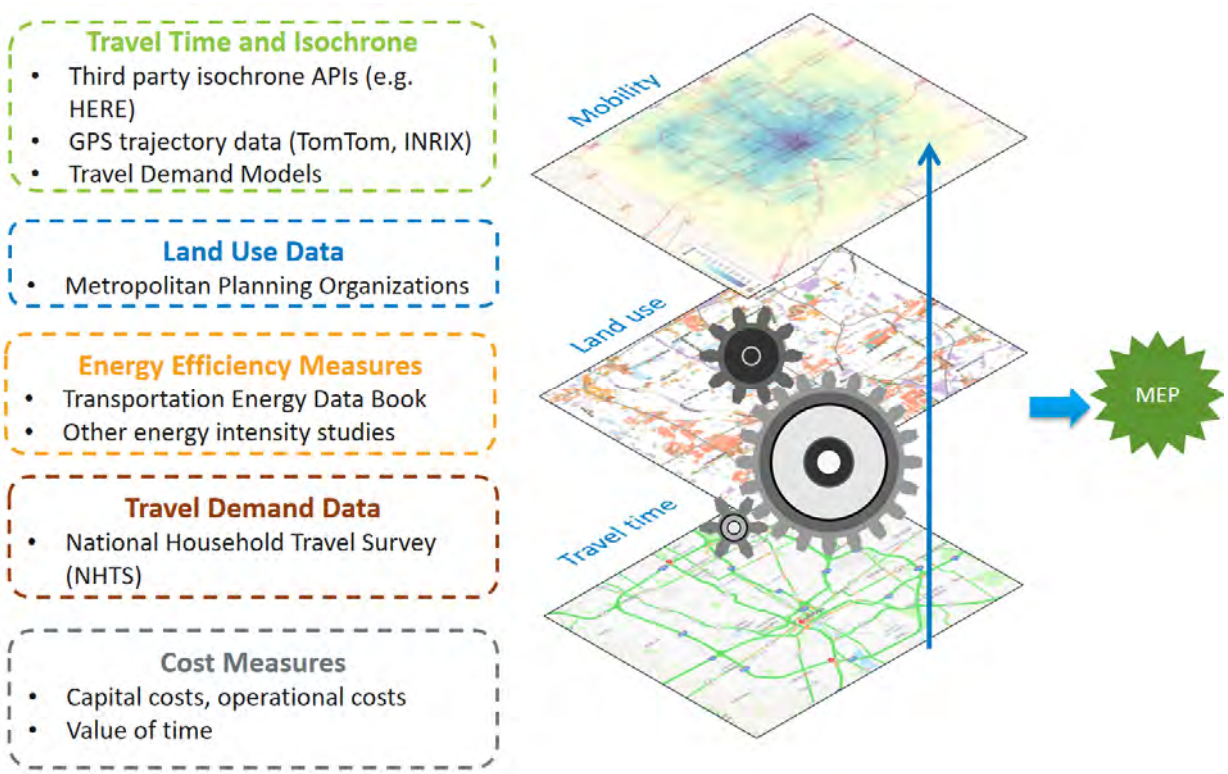


FIGURE 7 Data spectrum driving the metric.

EL PASO MPO's MULTIMODAL WEB TOOL

Marketa Vavrova and Sonia Perez

Background

Performance-based planning is a major topic in the last two transportation bills. *The Moving Ahead for Progress in the 21st Century Act (MAP-21)* and the *Fixing America's Surface Transportation Act (FAST) Act* put an emphasis on transportation performance management. MPOs are required to strategically establish targets and monitor asset condition, safety, and system performance as a part of an ongoing process. El Paso MPO (EPMPO) is uniquely located between two states, Texas and New Mexico, and is impacted by the travel behavior of two countries, the U.S. and Mexico. El Paso, TX has a population of 830,000, while Ciudad Juarez, Mexico has a population of 1.3 million. The annual northbound crossings include 13,073,997 passenger cars and 7,222,224 pedestrians. According to the 2017 American Community Survey, El Paso's predominant mode is auto (90.8%). With respect to air quality, CO is in maintenance, while O_3 is in marginal nonattainment and PM_{10} is in nonattainment. Texas Department of Transportation (TxDOT) has set their goal of zero traffic fatalities by 2050; El Paso experienced 91 fatalities in 2018, 41% of which were pedestrians.

EPMPO strives to address the performance measures orientation of MAP-21, and now the FAST Act, including establishing a performance-driven planning and programming approach, with metropolitan planning factors (e.g., economic vitality, safety, security, accessibility, mobility), and the national performance measures (e.g., safety, pavement condition, bridge condition, traffic congestion, system performance, freight movement, on-road mobile source emissions). As an MPO, their primary goals are to track transportation performance over time, support identification of gaps in infrastructure across transportation modes, inform planning and programming decisions, and to be a resource for local planning partners and public.

Methods and Measures

To address the performance measurement requirements, in 2018, ELMPO collaborated with the University of Texas at El Paso to develop a multimodal web tool. The plan is to launch the web tool in January 2020, to aid the MPO in monitoring performance across five modes of transportation: driving, freight, transit, walking, and bicycling. National and local data area inputs for this tool aim to track transportation performance over time, support identification of gaps in infrastructure across modes, provide performance-based information for planning and programming decisions, and ultimately serve as a resource for local planning partners and the public. The multimodal tool covers the City of El Paso, El Paso County TX, Otero, and Dona Ana, NM.

The multimodal tool builds on previous efforts including a review of multimodal performances measures, conducted in 2016–2017, and a pilot web application for one corridor (2017-2018). The research team includes undergraduates, graduate students in civil engineering and computer science, guided by staff researchers, with MPO staff overseeing the progress and providing feedback.

The research to identify the performance metrics in the web tool began with a review of the relevant literature, including the *El Paso MPO 2045 Metropolitan Transportation Plan – Destino 2045* prepared by Alliance Transportation Group, Inc., in 2018. Further, the research

identified 40 performance measures from the MPO's existing plans, and 21 from the national performance measures program. Figure 8 illustrates the types of processing required of some of the data elements.

Contributions

The Multimodal Web Tool has 26 designed metrics. The metrics include four for safety, 12 for quality of life (10 for accessibility measures and two for infrastructure condition), three for the protection of the environment, three to reduce congestion (measures of reliability), and four for mode share for multimodal analysis (e.g., driving, freight, transit, walking, and biking). The tool needs to be useful for small- and medium-sized urban areas. National data to be used include travel time from the NPMRDS, commute-to-work, population and jobs from the U.S. Census, and pavement condition from Highway Performance Management System (HPMS). State data include crashes (fatalities and serious injuries) from the TxDOT and the New Mexico Department of Transportation (NMDOT) crash database. Emissions data (e.g., ozone, carbon monoxide, particulate matter) are from New Mexico Environment Department and Texas Commission on Environmental Quality, and active transportation (e.g., walking and biking trips) are from Strava Metro via TxDOT. Intelligent Transportation Systems (e.g., traffic detectors, closed-circuit television (CCTV), and dynamic message signs (DMS)) are from TxDOT District, and bridges and culvert conditions are from TxDOT and NMDOT. Local data include ridership and bus stop locations from transit providers; presence of sidewalks and bikeways, northbound crossings and wait times from municipalities; planned and existing trails from health foundations and municipalities; and projects enhancing safety from the Congestion Management Process (CMP) network from the MPOs. All the data series need to be part of a program that provides regular updates rather than a single point in time.

In the short-term, plans continue towards the website launch in January 2020 and the successful incorporation of the web tool into the planning and programming process. A training program for MPO board members and planning partners will provide education for using the

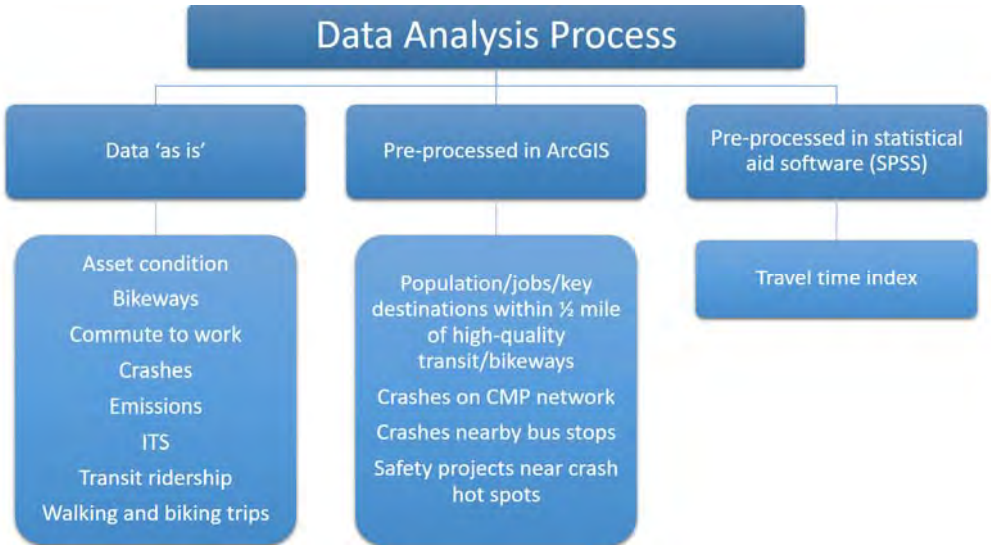


FIGURE 8 Data Analysis Process illustrating processing requirements.

tool. At the same time, staff will gather feedback and opportunities for improvements. In the longer-term, performance measures will require revisions, and additional tailoring to suit planning and programming needs and seeking opportunities to add newly available data in predetermined time intervals. The research team found that it is best to work with what is available, encouraging interagency relationships, identifying opportunities for improvements, and determining the level of attainable complexity in trying to navigate the challenges in meeting mode share, air quality and safety goals. Perhaps the most challenging aspect will be to "sell" the approach to the region (i.e., member agencies), and whether there is any risk that the data might be used against the planning purpose that being established.

EVOLUTION OF THE FDOT MULTIMODAL MOBILITY MEASURE PROGRAM

Monica Zhong and Praveen Pasumarthy

Background

Florida Department of Transporattion (FDOT) has a long history of measuring performance, beginning in 1998. One of the first products was the *Highway Data Source Book* (2000–2012). This was followed by a multimodal report for 2013–2016. In 2019, the source book was transformed into a digital resource.

Methods and Measures

In 2019, the various performance measures across the modes were reorganized into a new classification schema (see Figure 9). For example, pedestrian and bicycle measures included: bicycle level of traffic stress; pedestrian faciltiy coverage; percent bicycle facility coverage; and percent population within one mile of a bicycle facility.

Contributions

FDOT established four dimensions of mobility: quantity; quality; accessbility; and utilization. Each mode reports these dimensions. There is an emphasis on travel time reliability. The data makes it possible to tell stories by combining different factors and comparing them to national trends, for example, the relationship between vehicle miles traveled (VMT) and fatalities. The analysis indicates that, for Florida and nationally, fatalities are decreasing while VMT is increasing. In Florida, the relationship between VMT and the economy compares GDP, VMT and the number of visitors, and shows greater impacts than nationally. Future research will examine different regions of Florida using the same factors. Another analysis utilizes transportation network companies (TNCs) data (which is very sparse) and divides by county populations to examine percentage changes. The technology uses Tableau to display trends.

FDOT focuses squarely on serving customers, including developing better relationships with MPOs and Statewide Mobility Team (SMT), and involvement with national pooled funds studies. FDOT uses visualizations to provide measures on six different topics, including travel time reliability for the 27 MPOs. The uses of the data include input to the Florida Transportation Plan, the Strategic Intermodal System Strategic Investment Tool (SIS SIT Tool), the Traffic Systems Management and Operations (TSMO) plan, Freight Mobility and Trade Plan, inputs to MPO LRTPs, and before-and-after studies.

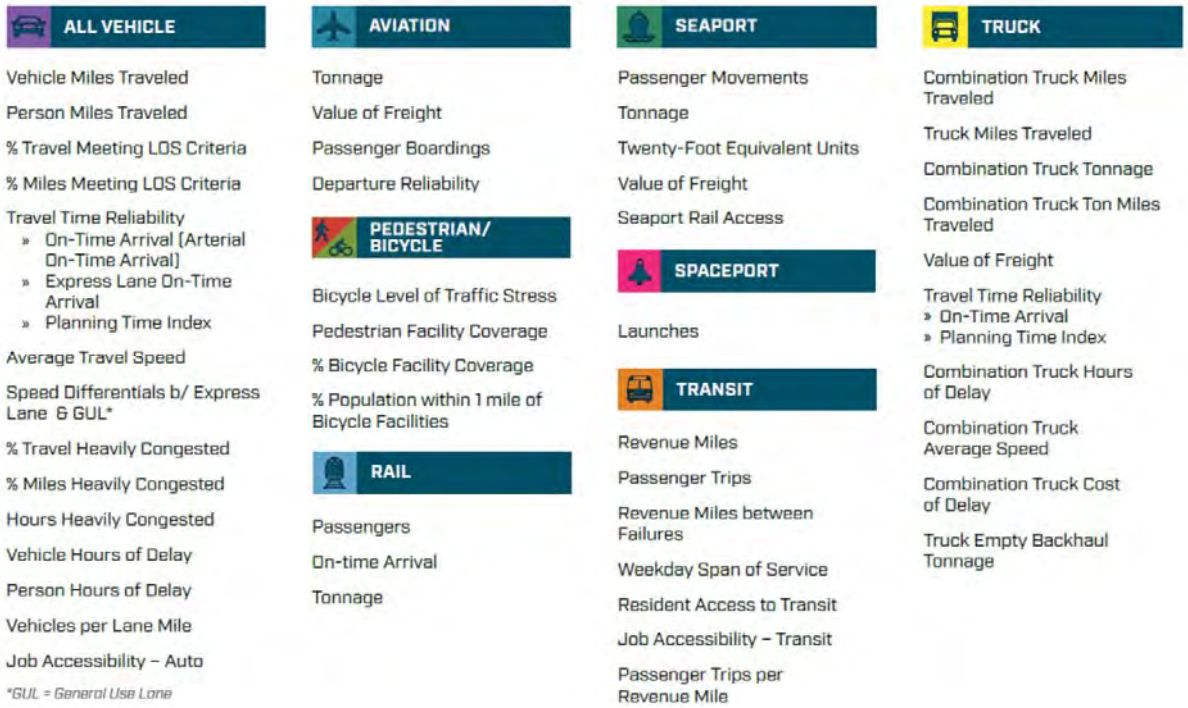


FIGURE 9 List of FDOT multimodal mobility measures.

A NEW MULTIMODAL TOOL TO BETTER UNDERSTAND SUPPLY CHAIN PERFORMANCES

Chandra Bondzie and Patricia Hendren

Background

The need for using a supply chain approach is tied to the way freight users do business. An analysis of the supply chain needs to depict the performance of the freight system from end-to-end. Supply chain performance is key to economic competitiveness. Supply chain performance relies on both the public sector and the private sector. The public sector contributes the networks and policies that impact the total outcome, and contributions occur at many stages from many jurisdictions. Supply chain performance is a cooperative venture between sectors and among agencies. The I-95 corridor definition is a multimodal, multi-jurisdictional, and multi-disciplinary group consisting of 16 states, plus the District of Columbia. It is a partnership of entities working together to create a seamless and efficient transportation system.

Methods and Measures

The Freight Fluidity project is designed to measure performance of supply chains across multi-state jurisdictions. The objective is to demonstrate and improve the measurement of freight transportation performance using a supply chain perspective. This perspective requires an end-to-end conception of performance and measurement, across modes and across jurisdictions. The stakeholders include the I-95 Corridor Coalition, the Coalition's Intermodal Committee, Federal

Highway Administration (FHWA) Office of Freight Management, and the U.S. Department of Commerce Advisory Committee on Supply Chain Competitiveness. (For additional details see https://i95coalition.org/wp-content/uploads/2016/03/FR1_I95CC_Freight_Performance_Measurement_White_Paper_Final-20160406.pdf?dd650d).

The first phase demonstrated that it is possible to measure supply chain performance across modes and jurisdictions using travel time, travel time relibliability and cost. The concept can be scaled for national, multi-state and metropolitan uses. The research identified pain points with respect to the transfer process and conditions, and recognized how "local" issues have larger consequences. In addition, there are gaps in data and the analytical methodology to refine. The research team collected data from 30 U.S. companies, the National Performance Management Research Dataset (NPMRDS), Chainalytics, TransCore, STB Waybill, Federal Railroad Administration (FRA), and the U.S. Army Corps of Engineers.

Contributions

Following the success of the original research, a new USDOT-owned database is being developed with visualization and mapping tools to record and report the three types of performance metrics across multiple modes. The tool is capable of segregating the data by industry type and supply chain function, linking transportation performance to the value, or cost effects on key U.S. industry sectors. The tool is populated initially with four quarters of data for 30 U.S. industries, with the ability to expand with additional time periods and additional industries. The metric for cost is measured in dollars and includes the typical prices paid by shippers for trucking and intermodal rail, and typical railroad revenues for carload rail. Travel time is measured as an average. Specifically, it includes water times from geofences analysis provided by the U.S. Army Corps of Engineers using Automatic Identification System (AIS) data, rail times as reported by shippers, and truck travel times based on the NPMRDS speeds by time-of-day and least-time path assignments. Reliability is measured using buffer time or planning time indices as a ratio including .99/.50 travel time for trucks, .95/.50 travel time for rail, and .75/.50 or .50/.25 (whichever is best) for water.

The approach for acquiring data from individual companies focuses on identifying key supply chains (e.g., parts inbound, finished products outbound, parts for repair and maintenance). For each chain, the following questions are asked:

- *Is it a single end-to-end move, or are there different links (e.g. individual trips) in the chain?*
- *What is the specific role of each link (inbound raw materials, outbound goods to warehouses, delivery to customers)?*
- *What is the commodity or commodities being moved?*
- *What is the mode or modes you are using for each link?*
- *What are origins and destinations for each link (city-state pairs for each trip)?*

A key lesson learned is to never ask about business sensitive information (e.g., volumes, customer names, carrier names, performance). Acquiring information from vendors requires a different approach and varies by vendor and business purpose. At this time, Tableau is being used as the visualization platform.

The toolkit monitors key performance indicators (KPIs) comparable to how freight system users monitor themselves. The analysis keeps public agencies abreast of developments affecting industry and anticipates concerns of Freight Advisory Committees (FACs) and other users. It also monitors KPIs that affect industrial competitiveness, supporting economic development, and timely response to freight transportation issues. It provides performance trends by industry sector and operational and investment actions. The Freight Fluidity tool complements and combines with other tools for public agency analyses by filling the gap between supply chain logistics and connected links. The national platform supplies foundational information for state and local agencies to build upon.

Going forward, the next steps are to collect and document feedback from New York Metro and Chicago state and regional technical user meetings. The researchers will finalize and complete the tool functionality and content, and provide how-to documents. FHWA Office of Freight Management and Operations (HOFM) plans to make Freight Fluidity Quarterly Monitoring Data Tool available as resource, and as a complement to other FHWA data tools for freight and system performance analysis. Challenges going forward include data quality issues and developing a better understanding of the geographies between the data. Throughout this project, the I-95 Corridor Coalition serves as a proven convener to bring parties together to examine data and provide outputs from a neutral forum.

Audience Dialogue

Question: Have you had any dealings with risk and liability in asset conditions reporting?

FDOT: We are beginning to address this measure in terms of how it affects mobility. Most regional offices are taking it down to specific routes and segments.

FHWA*:* We have noted this as a problem, especially if inappropriate representations and routing occur. FHWA is updating their approach, but we realize that, for example, local data from the states is actually better than HPMS for some uses.

Take Aways

- U.S. Department of Energy's MEP focuses on energy, making it different from accessibility. In addition, MEP is quality-of-life centric, whereas accessibility is a bit more job-centric. There is a difference between private vehicle and TNC performance, as TNC driving does not account for time to park, which takes about 15–30 minutes.
- El Paso MPO found it was best to work with what is available. Interagency relationships are important, as is the ability to identify opportunities for improvement. It is also important to focus on attainable complexity, not over-complicating necessary tasks. There is some resistance in data sharing with member agencies, so be explicit on needed data and purpose.
- Florida DOT cites coordination as a very important at all development steps in identifying data sets and reports, including striving to gather feedback from stakeholders.
- The Freight Fluidity research team recommend reserving funds for data quality issues as quality assurance/quality control (QA/QC) are very important, especially for local agencies that have better access to the datasets and are on the ground.

SESSION 5A: GUIDING THE PROCESS FOR EVALUATING NEEDS AND INVESTMENTS FOR DOTs AND MPOs

Paul Hershkowitz, *ICF, presiding*
Jerri Bohard, *Oregon Department of Transportation, recorder*
Chris Upchurch, *Wichita Area Metropolitan Planning Organization*
Kyle Schroekenthaler, *Economic Development Research Group*
Alex Trauger, *MetroPlan Orlando*
Nick Gill, *Mid-Ohio Regional Planning Commission*

NCHRP 19-14: SHARING INTELLIGENCE ABOUT SYSTEM PERFORMANCE TO "RIGHT SIZE" TRANSPORTATION INVESTMENTS

Kyle Schroekenthaler

Background

Agencies are all facing the challenges of a changing environment and need to be able to prioritize and program the right projects. Much of the transportation system was built 50, 60, even 70 years ago, and since that time, urban patterns have changed. There is currently a movement towards using new types of performance measures and new objectives to achieve transportation goals on those original networks. In addition, even in the best performance-based processes, there is always some risk of using the wrong metrics. Transportation agencies need practical and implementable methods to identify opportunities for "right-sizing" and thereby unlocking economic value and improving efficiency of the existing infrastructure. Right-sizing is fundamentally about revisiting decisions about the size, extent, function, and composition of infrastructure. It focuses on using the right quantitative and qualitative data to match projects to desired economic and quality of life value outcomes. Specifically, it can be implemented agency-wide, or just to specific program or projects to avoid over- or under-building. It matches investment to markets served, contributing to economically sustainable investments. Finally, it creates greater life cycle value for society.

Methods and Measures

NCHRP 19-14: Sharing Intelligence About System Performance to "Right Size" Transportation Investments focuses on the potential for investments to avoid over-building infrastructure. Solutions require qualitiative, as well as quantitative data, to assist in investment decisions with a right-sizing orientation. A strategy for reaching alignment among infrastructure owners of long-term maintenance of infrastructure includes the decision regarding who will pay for it, while surrounded by changes. For example, decision makers have the opportunity to think differently about safety, even if the roadway designations are the same, but the impacts on communities are different.

The transportation ecosystem is changing, including the difference between project selection and project prioritization. For example, aging infrastructure, changing funding mechanisms, new technologies, and changes in behavior, have led to the need for new methods and ways of solving transportation issues. One of the major risks is not measuring the right

things, making it important to take opportunities to improve processes and give agencies practical and implementation methods for identify those opportunities. There are agencies starting with a massive, overwhelming backlog of projects requiring re-evaluation for current and future appropriateness and need. Now, new tools and data, using different processes, allow us to conduct these re-evaluations to ensure the right quantitative and qualitative data match projects. The goal is to have the desired quality and economic outcomes identified in the planning process, and achieved through the programming process. One example of the kind of large-scale project that might fit into a right-sizing program focuses on urban highway repurposing projects across the country. For example, Rochester, New York converted an underused freeway back into a boulevard arterial, opening up land, and driving economic redevelopment in the region.

Effective right-sizing relies upon intelligence (e.g., an understanding of changing conditions and needs that precipitate the need to right-size and the objectives of right-sizing), authority (e.g., the ability to take the necessary actions in support of right-sizing), and resources, including ownership of relevant assets and services. In addition, right-sizing requires adequate funding and staff to achieve objectives. The roadmap to implement right-sizing begins with identifying misalignment between the infrastructure provided (or planned) and a holistic understanding of the value generated. Next, forming appropriate partnerships and incentives facilitate the identification and engagement of key partners and their particular starting objectives, resources and interests. Conventional planning practice identify alternatives, including new options. Finally, monitoring is required to continue to track outcomes while realizing objectives.

The report focuses on how to identify mismatches and miscommunications associated with the need for changes due to external conditions or internal changes, and to start thinking about new solutions. For example, Maryland DOT is considering giving new safety guidance for context sensitive design because, on the state system, it uses the same functional class everywhere. At the same time, the types of needs of different communities are different in terms of who is traveling on the network. It is very important that different stakeholders collaborate (e.g., public dialogue, infrastructure owner, funding sources available for change, legislative issues). In some cases, this will require the collection of new data, or the location of necessary data from data-sharing partners, making it possible to build a broader coalition to look for ways to leverage identified changes and move the vision forward. Right-sizing opportunities also exist in rural environments where resources face a number of constraints and many roads serve pass-through traffic in between communities and primary economic sectors, (e.g., agriculture, natural resources).

There are two major categories of risk. The first risk is from emerging technologies and how they will affect infrastructure usage and capacity in the future. The second is the economic risk tied to the uncertainly about preferences, economic growth, and settlement patterns, with both upside and downside risks. In both cases, communities risk over- or under-investing because of the expectations that vehicles will operate on their own, requiring investment in IT infrastructure to deal with data for vehicle issues, rather than physical roadside ITS; at the same time, increasing physical capacity for traffic in 2030, or 2040, only to find that IT advances (e.g., closing following distances) provides adequate capacity expansion on its own.

Contributions

The guidebook focuses on scale and complexity as two key components that differ depending on location, the vision of the community, and differences associated with the environment (e.g., urban, suburban, rural). In addition, scale and complexity differs between users and partners regarding infrastructure needs. It also provides targeted methods and tools to support integration of right-sizing decisions into agency business processes. These tools and methods can be used to identify and diagnose right-sizing situations, evaluate right-sizing scenarios, and make a plausible "business case" for a right-sizing decision, or policy. In most cases, the methods can be applied using available data and technologies, built with the existing state-of-practice. The examples offer flexibility and open-endedness, and can be tailored to the needs of right-sizing situations or agency capabilities. The guidebook also discusses the issue of uncertainty associated with benefit-cost analysis (BCA), or multi-criteria scores within economic or technology risks.

Making decisions on an appropriate trip length by mode is an example included in the guidebook. An agency can seek to know where and when new assets (e.g., transit, bicycle-pedestrian facilities, and different classes of local streets) can be productive or unproductive. To do this, transportation planners need to look beyond aggregate volumes to understand how different trip-making patterns may point to a reconfiguration of the balance between modes. One approach to trip length analysis is to rely on a travel demand model, based on traditional travel surveys. Another approach is to use probe data (e.g., Streetlight data) to understand who is using a particular facility, volumes of traffic, and trip-making patterns. This information would be valuable for considerations of a different modal mix on a facility, or operational improvements that might help. This is especially relevant for older arterials, originally urban-to-suburb commuting facilities, and over time have added mixed use along the corridor (e.g., restaurants, shopping trips, new office uses). At the same time, suburban bedroom communities have moved farther away, creating a completely different kind of trip pattern. Now, many trips in the corridor are quite short, with cars adding to congestion when they are just trying to go across the street on their way home. There are opportunities to consider which types of trips are walkable, and where making sidewalk improvements or cross walk improvements could move people (e.g., replacing an auto trip from an office to cross the street for lunch). Short trips (e.g., less than five miles) could be taken using e-bikes, as one illustration of the transition to a smaller mode. At the same time, trips greater than 10 miles may need to prioritize speed on facilities.

Figure 10 illustrates how the sketch level planning toolkit expands the ability to understand trip length analysis with respect to understanding different trip patterns, and how the use of a particular segment might look different from what was intended when the facility was first built. A better understanding of these differences from an original intent helps planners think differently about potential solutions going forward. It is also possible to look differently at return-on-investment (ROI) depends on future ownership of a facility. This guidance on why and how to right-size and the importance of coordination requires transparency across and between stakeholders. For the best results, agencies should start small (e.g., identify only a few programs, asset classes or businesses processes) and then gradually expand with awareness and visibility of benefits of right-sizing, recognizing that it is better to err on the side of keeping the program narrowly defined.

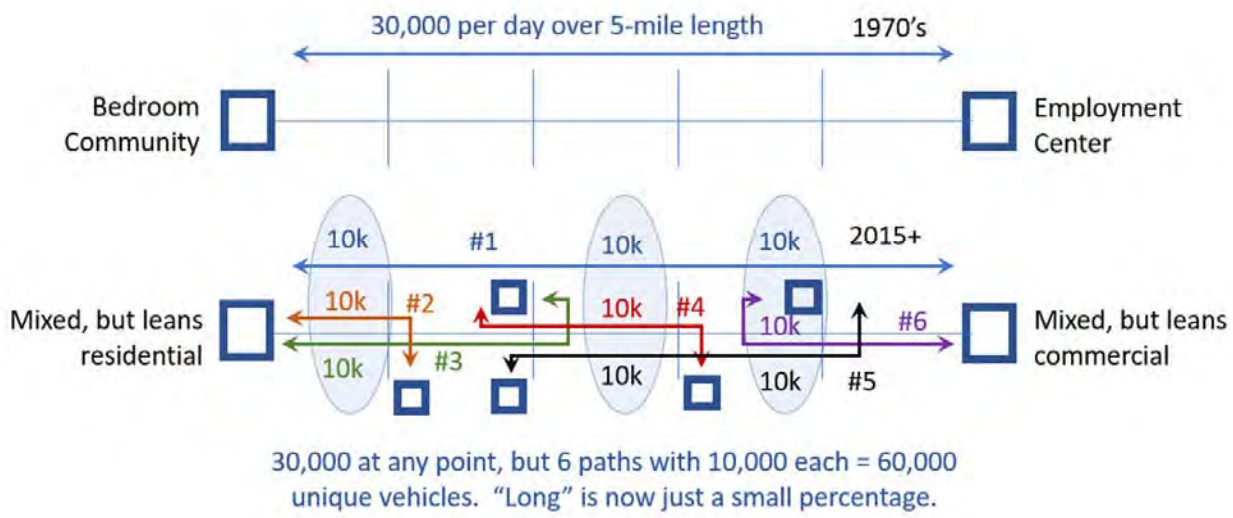


FIGURE 10 Trip length analysis using the sketch level planning toolkit.

METROPLAN ORLANDO—ALIGNING OBJECTIVES AND INVESTMENTS USING DATA AND PERFORMANCE-BASED PROCESSES

Alex Trauger

Background

Performance-based and data-driven decision-making has been at the heart of private industry investment and optimization for decades as a means of achieving efficiency and ultimately increasing profit margins. However, what if it was not about the proverbial "bottom line?" What if the bottom line was providing a safe, reliable, and balanced transportation system for all users? This would change the approach from transactional to transformational, broadening decision-making participants from financial shareholders to a diverse set of public stakeholders. MetroPlan Orlando (MPO) is actively implementing performance and data-driven analyses into the short-term and long-range identification, prioritization, and programming of regional investments. The MPO encompasses Orange, Orlando, and Cayenne urbanized areas, including 27 jurisdictions, governed by 21 elected officials. The region continues to grow. Nearly one thousand new residences arrive each week, with expanding tax rolls, and the region hosts 75 million visitors, including convention and business travelers. To understand these changes requires new sources of data (e.g., Big Data) to elevate the planning process and improve decision-making. These data come with new costs, both financial and technical as it takes time, labor, and talent to convert the data to information. Issues include transparency, as the data sources come with license agreements, restricting public agency data sharing opportunities, and uncertainty as these data sources are "shiny and new" but may not be appropriate for making investment decisions.

Traditionally, the prioritization process, relied upon three criteria: a volume-to-capacity (V/C) ratio greater than 1 (if you are growing, C is extended to a 30 plus horizon year), if the project is identified in a local government comprehensive plan (most are), and whether the project is in the cost feasible long-range plan. A "yes" answer to these three questions qualified

the project, and then it was “horse traded” in a Delphi process where the power of the person advocating for that project could be more persuasive than the merits of the project. With the introduction of federal performance measure guidelines, a technical advisory committee was convened, as well as citizen advisory groups, to form champions, to realign the prioritization process based on funding eligibility and performance measure applicability. In addition to the four performance measures required by FHWA, staff decided to include five additional performance measures that focus on local needs, evacuation, environmental mitigation, and supporting our transportation equity.

Methods and Measures

The MPO is using multiple forms of cellular, location-based, and GPS data to validate traditional planning tools, influence corridor and sub-area needs assessments, and guide the evaluation of multimodal projects. For short-term programming, the MPO is in the process of restructuring the project prioritization process to be consistent with community values and new federal performance requirements. Relating to long-range planning, the *2045 Metropolitan Transportation Plan* (MTP) will implement new and innovative system performance measures, which de-emphasize traditional road "congestion" in lieu of broader desirable transportation outcomes to support the future, not past investments.

To identify origins and destinations (O/D), planners can use the Census Transportation Planning Package (CTPP), travel diaries, or intercept surveys. Another approach is to use travel demand modeling trip generation that produces desire lines, and uses propensities based on gravity models. The concern is whether these methods are reliable for understanding how people travel today. As travel patterns change when the region grows and urbanizes, trip distances shorten, and the desire for a non-auto modes grows. Potential data sources with granularity and trip resolution features include Air Sage and Streetlight data for O/D analysis. These data sources are being used to inform corridor and sub-area studies, especially looking at cut-through traffic, and for similar modeling exercises (e.g., select link and select zone), to inform transit planning for express bus and park-and-ride location investment using Tableau. To overcome issues with raw data, the Tableau online widget allows local partners could conduct their own select zone analysis, activity centers, and areas within the region.

The role of visitors in the region and the FAST Act requirements to include tourism, as part of the metropolitan planning process, is requiring new data sources and techniques. Central Florida experiences almost 500,000 visitors a day. Staff are using AirSage to identify activity centers by time of day in resort areas and in well-defined tourism districts (e.g., Universal, Disney World and the International Drive area). In addition, the AirSage data revealed concentrations occurring in non-traditional tourism areas (e.g., ecological sights), some of our suburban neighborhoods and other urban communities), prompting discussions of eco-tourism in the mid-day period in natural parks. It also revealed the potential that Airbnbs are forming concentrations in suburban communities. The last traditional tourism O/D visitor intercept survey was conducted in 2000.

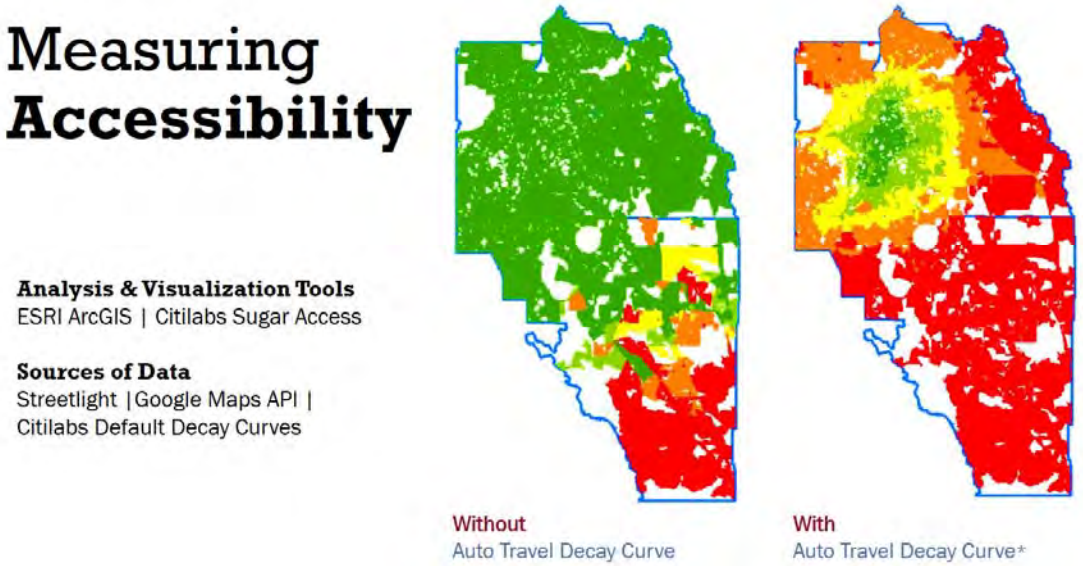


FIGURE 11 Illustration of analysis that includes Auto Travel Decay Curve.

To measure "access," the MPO is developing an accessibility model utilizing Citilabs Sugar Access, to identify opportunities and deficiencies by transportation mode and by socioeconomic status. While mobility is how far a traveler can travel in 30 minutes, accessibility measures how many places are reachable in that same 30 minutes. Accessibility has been a core goal of the Board of Directors for the past decade, measuring traditional proximity and distance using model distributions and delay curves. In 2018, staff received an FHWA connectivity grant to explore alternative transportation performance measures, especially relating to accessibility. Citilabs Sugar Access, an accessibility model, is more sensitive to trip distance and land use by type. The model provided more than the traditional service employment, industrial and commercial uses. The new data provided information on actual types of employers and services, making it possible to connect people to places (e.g., essential service, food, government, medical services). Streetlight data provides data that attempts to derive O/D patterns, trip distances and the development of some preliminary travel delay curves. The delay curves in Citilab Sugar Access were originally derived using data from Minnesota (based on University of Minnesota research), not from Florida. The concern is whether different topologies, different cultures, different temperatures, people's willingness to walk or bike for a work trip, would be unique to Florida's populations. The MPO used Google Maps' Application Programming Interface (API) to access details to refine and calibrate the points of interest (prior to Google's decision to apply a priced tier model). These high-resolution data on actual shopping locations will be used to produce the most relevant parameters for 2025 transportation plan updates, their long-range plan, their arterial planning process, their needs assessment, and next project prioritization and update.

Contributions

Staff plan to incorporate accessibility measures into the annual prioritization process, instead of using surrogate measures of proximity as a function of access. Figure 11 displays the analysis developed using Esri ArcGIS and Citilabs Sugar Access analysis and visualization tools, with Streetlight, Google Maps API, and Citilabs Default Decay Curves. Bicycle travel used a similar analysis. Another use of the tools and data prioritized performance, focused on safety (e.g., high crash corridors), travel time reliability (e.g., worst travel time corridors), bridge condition (e.g., poor bridge condition), and pavement condition (e.g., poor pavement condition) applied to National Highway System (NHS) to identify top ranked corridors.

Since the National Performance Management Research Dataset (NPMRDS) provided by FHWA only has data for the NHS, staff used Streetlight data for peak and off-peak travel time reliability for the rest of the network. Freight and other commuter corridors need additional attention, expediting staff's desires for a more data informed process with the goal of using the best data for the planning process (e.g., a subscription model, by project, à la carte purchasing). In addition, there are potential partnership opportunities with local universities.

USING PERFORMANCE MEASURES TO GUIDE METROPOLITAN TRANSPORTATION PLAN DEVELOPMENT AND PRIORITIZATION

Nick Gill

Background

The Mid-Ohio Regional Planning Commission (MORPC), in the central part of Ohio, is the planning agency responsible for bringing all the various transportation agencies, including the state DOT, together to vision, develop goals and objectives, and conduct other planning functions, but it is not responsible for the building or the implementation of prioritized projects. The region is growing, driving the state's overall growth. For example, last year, 43,000 people (roughly 840 per week) moved into the region. Population projections envision 3 million by 2050. The MPO includes two counties, and parts of three other counties. The area has a large emphasis on logistics activity, including the largest freight-focused airport in the country and three Amazon warehouses. Beginning in the mid-90s, the Intermodal Surface Transportation Efficiency Act (ISTEA) required a Congestion Management System (CMS) and a Congestion Management Plan (CMP) process. At that time, staff used qualitative data to evaluate projects for a MPO plan. In 2000, goals in the transportation plan were linked to project selection, demonstrating how projects contributed to the advancement of these goals. By 2010, at the end of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) legislation, there were indications in Congress that performance measures would most likely be included in the next transportation bill. The passage of Moving Ahead for Progress in the 21st Century (MAP-21) put performance measures in place, although previous plans already incorporated measures in the 2012 plan. With a number of workshops, public and MPO members expanded the original three local goals to six. The 2016 plan included 16 objectives and increased the number of quantitative measures.

Methods and Measures

With the passage of the Fixing America's Surface Transportation Act (FAST), in addition to just identifying measures and setting targets to meet federal requirements, MORPC (annually since 2013) publishes a Report Card—reporting on the progress made toward near- and long-term targets established for each of the objectives identified in the MTP. This approach provides a concise status update on achievement of regional goals, and a level of accountability and transparency for regional planning partners. The Report Card also summarizes the previous year's construction projects by type and mode, giving the public a clear picture of how the MTP funded and implemented projects. MORPC took that experience, and the guidance available to date, to adjust and refine the performance measures adopted for developing the next MTP planned for May of 2020. Performance measures will be used to guide the plan development and project prioritization. The 2020 MTP will have 21 objectives and 57 quantitative measures (23 for federal requirements). The goals are broad statements, while the objectives must be measurable metrics to track progress. Benchmarks are set with current data and then targets are set to guide communities toward their goals. Strategies are the actions taken to accomplish the targets, with projects as the core for these accomplishments.

The six goals in the transportation plan include economic opportunity, safety and welfare of the region, sustainable neighborhoods, fostering regional collaboration, reducing in energy consumption, using alternative fuel resources, and protecting of the natural environment. In addition to transportation planning, MORPC deals with housing, weatherization programs, and water quality planning. To assist local communities with planning, MORPC provides tools for others and information to help them in their decision-making process.

Staff examined each goal and its set of objectives. To address the economic opportunity goal, the transportation perspective focused on minimizing the amount of travel under congested conditions, and reliability through the reduction in variability. The metrics set were 20 minutes by car and 40 minutes by transit. During the update of the plan objectives, the new chief executive officer (CEO) for the transit authority expressed wanting to measure how many jobs were within 20 minutes on transit, and within 40 minutes. Specifically, the desire was not to have a different threshold just because it was transit, but to strive for equal measures across modes. Safety and welfare included transit useful life and making the system safer. Attention focused on serving concentrated employment areas, using innovative solutions for ITS throughout the region, reducing the vehicle miles traveled, reducing energy usage, and reducing emissions to achieve air quality standards.

Accomplishing the goals and objectives requires structuring strategies and choosing appropriate projects. For example, a solution for reducing crashes adds capacity with a project to widen a road. The annual crash list for the region provides the information on the highest-crash routes, and once identified, MORPC works with jurisdictions to identify sources for funding. There are different types of strategies to maintain the system and for management. The project evaluation process focuses on expansion—adding capacity to the roadway system, adding capacity to the transit system, adding more bike roads, and trails and sidewalks. These expansion needs require specific projects be evaluated for inclusion in the transportation plan. All available plans and analyses are examined (e.g., comprehensive plans, thoroughfare plans, CIPs, planning studies' results, crash analysis lists, travel demand forecasting, future state, local and state partners, and the public). An interactive web map on a public website provides a place where the public can annotate where they want projects, what the problem is at that location, and

recommendations for solutions. Mode-neutral comparisons pose difficulties as some funding opportunities are tied to certain types of projects. In addition, it is impossible to compare a freeway project to a bikeway project. The general policy is to find funds to be spent across all types of modes, based on the best projects for that facility type (e.g., best freeway type of project, best transit type of project, best bike or pedestrian type of project) and make sure those particular best projects are evaluated and get included in plan.

Contributions

Throughout the planning process, lessons learned included the importance of citing and documenting all of the data sources used to ensure the ability to replicate the process for plans. For example, when assembling the bike lane inventory, bike trails were not included in the original baseline information. When the analysis of the data resulted in a sudden, unexpected increase, in fact the change was attributed to the original oversight rather than new bike lane infrastructure. It is important to look at the relationship of all the pieces in developing the transportation plan and discussing goals and objectives to ensure projects are moving communities towards their goals, while some strategies are actionable work items (e.g., forming a committee to look at high crash location list, keeping the ITS architecture up-to-date).

MORPC does not use specific weights for each criteria or weights on goals. Some of the data come from models, some from GIS, and some from qualitative questions that are part of the criteria. The displayed score sheets use a histogram to compare projects. This is just one tool, balanced with long-range plan information (updated every four years). During the updating process, staff re-evaluated selected projects, and provided new information, if available, at the time of the update. Of the $19 billion, one-third maintains the current infrastructure and system, one-third maintains the current transit system through 2050, and the remainder is available for new projects. Recognizing that data is one tool in the decision-making process, MORPC has also built-in qualitative criteria to aid in evaluating extraordinary circumstances such as political will, public input, and stakeholder collaboration.

PICKING UP THE PIECES WHEN DATA AND POLITICS COLLIDE

Chris Upchurch

Background

In 2014, in preparation of the Metropolitan Transportation Plan (MTP), a stakeholder workshop was held where a list of projects, based on an approved project selection criteria, was presented and immediately rejected. The list had only a few road projects at the top. Previously, most of the available funds were allocated to roads and bridges, not transit or bike and pedestrian projects. While the stakeholders at the workshop had signed off on the criteria that was used, they had not signed off on such a fundamental change in how to spend the funds. The experience led to the development of a new project selection process with new project selection criteria. The committee developed a list of projects using subjective criteria, and staff were able to complete their contributions to the National Transportation Plan (NTP*)* by the federal deadline. Transportation professionals are often process-focused, while stakeholders are often outcome-

focused, particularly on end results. The process may be fair and accurate, but if it doesn't produce the outcomes that stakeholders expect, there will be an issue.

Methods and Measures

The new approach focused on the goal of the project selection process—trying to pick the best projects. The list of all possible projects, when rank ordered, will have the best at the top, and the worst at the bottom. While it is possible to use all the available funds to fund the projects in rank order, funding all the projects could mean funding the worst ones, which could impair the transportation system. A better principle is to fund the best projects and not fund the worst ones. Given this approach, a rank ordered list is not necessary (and saves a great deal of work). If, instead, the best projects are identified, along with the good projects, and then the projects that do not perform very well. It is not necessary to spend the time to sort the average projects. The decision applies to which are the best and which are the worst projects. The goals guide the decision as to which projects are good, or not good. Most communities have a number of goals, so a particular project may just help accomplish one of the goals, but not others. The Wichita Area Metropolitan Planning Organization (WAMPO) has eight goals and not many projects contribute to all eight.

The new approach began with a list of all the possible projects, covering a wide variety of categories (e.g., road, bridge, preservation, urban area, rural), making it very difficult to develop a single metric for such diverse projects. Each criteria has multiple metrics. For example, the economic development criteria applies when a transportation system contributes to the economic development of a region. For example, a project that serves a freight facility has a tiered set of criteria (e.g., 100 truckloads per day is excellent for the economy, at least 50 truckloads is good, and those with less than 50 are acceptable). In addition, there is more to economic development than just freight, requiring the inclusion of another factor such as access to jobs (e.g., serving an employment concentration with at least 750 jobs is good, at least 250 jobs is acceptable). Another factor is access to jobs via transit. This was very important to stakeholders, especially for employers having trouble filling jobs where potential employees did not have cars and transit service was inadequate. An access-to-jobs-via-transit metric is responsive to levels of service (e.g., serving employment concentrations of 750 or more is rated excellent) and projects would get more credit for serving employment with transit rather than only by auto.

Another factor is travel time reliability for just-in-time supply chains. For this metric, if a particular project is entirely devoted to travel time reliability (e.g., technology or operations projects), it is considered to be excellent. If 50% of the project budget is devoted, the rating is good, and if any features contribute to travel time reliability, it is acceptable. Other factors include access to schools, health care, walkability projects, place-making, land use and transportation projects that serve high density, mixed use types developments, historic downtowns, multimodal connectivity, expanding a bike-pedestrian network, expanding transit, and reduced headways.

Financial sustainability, maintenance, and preservation metrics include credit for reducing capacity where it is not warranted. Jurisdictions applying for a project under the new process were required to submit a six-page questionnaire with details regarding all the metrics associated with the eight selection criteria for the eight goals, putting a burden on the project sponsors. To assist applicants, particularly small ones, WAMPO hired a pair of consultants to assist member jurisdictions, including with the questionnaire.

Contributions

In practice, it has been a little more subjective than the general description would suggest because some of jurisdictions are very good at meeting selection criteria that are favorable to their project. To deal with this, a project selection committee composed of three engineers and three elected officials, review the proposed ratings for projects. This allows the planners to remain neutral in the final decision-making process. In addition, the rules for the selection committee say they can adjust the ratings upwards or downwards if they feel the rating based on the metrics alone does not represent how well a project contributes to a particular goal. The selection committee hears presentations from the project sponsors and picks projects. Jurisdictions provide a list of their priorities. These proposed projects receive public inputs as well. Combining all of the various inputs, the selection committee makes the decision on the project list. The committee can also pick any project, regardless of the rating. So even if a project has the lowest rating on the list, it can still be chosen. Though in practice, this option has mostly been theoretical. The way it tends to work is that the poorly performing projects get ruled out, the really great projects get funded, and then the committee uses more subjective factors to decide which of the average projects to fund. For example, they may pick a project with high scores on a criterion none of the other projects addresses. They can choose a project, although it has a low score, because it is a sponsor's top priority, or because it is from a jurisdiction that has not had a project funded, providing geographic equity. Moreover, they might choose a project because it is popular with the public, or it should get more funding. Again, the goal is to fund the best projects and not fund poorly performing projects, using a project list that is acceptable to the stakeholders.

In the final step, the transportation policy body takes the recommended list from the selection committee and approves it when they approve the MTP. At this stage, they have the power to change what is on the list. In practice, they have not done this: they have taken the recommended list from selection committee. By thinking about the goals differently, it enables planners to use different options in the project selection. The WAMPO approach has no complicated weighting system and it is possible to have not all of the criteria apply to all of the projects. Having a very complex weighting system without weight on any one factor tends to lead to "jack-of-all trades" projects. WAMPO will not have that problem with their methodology. There are many routes to a rating strategy to evaluate a wide degree of projects using various methods for each criterion. One of the ratings makes the best performing and the worst performing projects obvious. Other factors may really tip the balance on the average projects.

Audience Dialogue

Question: Why did you decide to cut off the criteria at 100 jobs?

Response: The evaluation of all the projects occurs after being sorted into categories, with cut-offs to accomplish goals, evolving over time, and guiding decision-making.

Question: What was the process behind having applicants fill in the blanks on forms?

Response: Differences in the size and density of project sponsors made a difference in project impact. We tried to be neutral, to think about implementing a community ratio approach where the same number of dollars invested in City of Phoenix would affect outcomes differently. This represents a subjective part of the rating system. Consultants help with the consistency of the fill in forms.

Question: Concerning right-sizing, what are your thoughts on using operations for short-term solutions (e.g., 5 to 10 years) instead of trying to right-size the infrastructure?

Response: Many people in the industry focus on how to address resource shortages. There are cases where there is no space to expand capacity, however, solutions have not been based on operations. Now with new data sources, it may be possible to look at our prioritization strategies (e.g., using an online tool) to sub-divide into technology, bike and pedestrian, and Complete Streets projects. Staff prioritize by category and by project type, to produce a good blend of multimodal projects. The key will be to find the necessary data to allow this type of analysis.

Take Aways

There is a vast range of approaches to prioritization. For example, some organizations are using Big Data to develop a complex methodology, while others (e.g., WAMPO) are using a more casual approach (e.g., identifying the best and worst projects). In addition, some agencies are using consultants to allow for a more level playing field.

SESSION 6A: IT IS ALL ABOUT TRANSIT

Kenneth Cervenka, *Federal Transit Administration, presiding*
Elise Barrella, *Wake Forest University, recorder*
David Miller, *Foursquare ITP*
Alice Grossman, *Eno Center for Transportation*
Simon Berrebi, *Georgia Institute of Technology*

PERFORMANCE MANAGEMENT: FROM PROGRAM INITIATION TO PLANNING AND OPERATIONS FOR MARYLAND TRANSIT ADMINISTRATION

David Miller

Background

In 2015, the Maryland Transit Administration (MTA) began a system redesign process called Baltimore Link, re-imagining that entire system with different classifications of service. These classifications include 12 high frequency colored routes and suburb-to-suburb connectors. Some new staff members wanted to build on that momentum, using the developed data-driven process. The process takes a more proactive approach to planning versus a typical reactive approach. For

example, typically, transit agencies receive complaints from the public, or requests from politicians and other stakeholders, to try to modify service plans. MTA wanted a program that drove service planning rather than just responding to issues. They developed a set of policies to go into that process. Their Program Goals are to:

- Create a unified approach to service planning and service changes, not responding ad hoc;
- Increase transparency of the service planning process, both internally and externally;
- Use data to make consistent, informed decisions about modifying bus service and bus stops;
- Provide staff with clear guidance based on industry best practices from National Association of City Transportation Officials (NACTO) and leading transit agencies; and
- Establish a work plan for the Office of Service Development.

Methods and Measures

MTA developed three guidance documents for bus service planning that could be public facing and foundational for the annual work plan for the Office of Service Development. The three guidance documents were *Bus Service Guidelines, Bus Stop Design Guide, and Bus Performance Monitoring Guide*. The Performance Monitoring Guidelines (PMG) include sources of data and the levels of analysis on that data, all the performance measures, how often they will be reported, who receives the reports, and how to actually use that data to analyze service, and actually change that service on a regular basis. The PMG document aligns with MTA's goals, and describes a process of how that program informs the planning process in implementing the service changes. It includes education for the public, the staff, the stakeholders, and the politicians, putting everyone on the same page in terms data sources, and how it is being analyzed, and incorporated into plans.

MTA has four goals centered on safety, efficiency, reliability and customer service, with targets for every measure, based on peers, best practices, and looking at data about how the routes were performing before a system redesign. A grading system grades every measure for every route, for inclusion in a reporting process. Details focus on data collection and processing, the time line for the data, and the creation of a dashboard to understand the performance of the routes in a number of different ways. Finally, integration of the performance monitoring system so key performance indicators (KPIs) is not just for the sake of KPIs, but accomplishes specific goals, with the ability to integrate what comes out of that performance monitoring system into the planning process on a regular basis. The process for the performance measurement was really to collect data by months, by picks (based on seniority at MTA, drivers select their assignments three times a year, so there are three picks), and by year. It also needed to be able to measure against, or by targets, on those three time periods. A dashboard would allow for instantaneous analysis, be able to look back at data at any time, be able to grade the routes, grade every measure for a route, and have an overall grade for the route with weighting, and then actually analyze the service based on those grades. In other words, it would be able to determine which routes need more in-depth review, conduct that review, and then develop service change proposals and a schedule to implement them. The performance measures reflect issues that are actually under the Office of Service Delivery's control when it comes to service development

and service delivery. There are also elements that can be analyzed and scored at the route level, and are used to develop evaluation criteria.

The analysis focused on a set of issues. For example, safety related to overcrowding is a function of how many buses are on the street. Efficiency is the distribution of resources relative to the demand and the need. Reliability uses the run times and the schedules. Missed trips are not included as they are a function of a bus breaking down, a driver not showing up, or a driver missing their assignment, and cannot be controlled. Finally, customer service is measured by how the customers feel about the service delivery. These factors resulted in a report card with detailed routes profiles, including the basics about the route, how long it is, where it goes, its ridership, and its span on different days of the week. Each individual measure has a grade and an overall grade is at the bottom of the card.

The process started with a monthly report, processing the data in Access and extracting it using Excel, with the measures in columns and all the routes going down the rows. Although it was a large volume of information, it did not provide much analysis, was unable to reveal trends, and was not useful for comparisons between service types. The data was pulled into SharePoint tables and linked to Tableau, to create dashboards. When MTA started using Swiftly for scheduling, suddenly staff had access to millions of records with schedule adherence for every single bus arrival. In the past, trying to access this type of information would have required downloading and processing massive amounts of Excel databases, every single day. R code was written to download the data from the Swiftly API. Staff purchased server space to accommodate validating and processing of all the data. After the cleaned data is loaded into SQL tables, Tableau pushes the tables into dashboards. A login function allows for the restriction of access. Four dashboards were developed in total: one for performance monitoring; one for staff to QA/QC the schedules for General Transit Feed Specifications (GTFS); one to look at data by bus stop levels, arrivals, ridership at bus stop level, and trips; and one to look at the origins and destinations to examine route level changes over the day. The dashboard allows the user to look at reliability, by route and time, and efficiency (e.g., cost per hour, cost per passenger, service type), along with numerous other combinations.

Contributions

Ongoing and future efforts include splitting the bus service into two documents. One explains the planning process to the public, and other is for internal purposes to explain the implementation process for anybody within the agency to know the details. Lessons learned from the experience of developing the automated system include:

- Develop a program tied to an agency’s goals;
- Form a process around aspects that can actually be controlled;
- Develop elements so everything is clear to everyone in the process, both internally and externally;
- To the degree possible, automate everything related to data collection and reporting so staff can spend the time on analyzing the routes, planning the routes, and making service changes to the routes, rather than being burdened by manual, or semi-automated tasks;
- Do not be afraid to ask how to make the system easier as the evolution makes each lesson learned an improvement;
- Continue to adjust the guidance and tools to respond to user feedback and needs;

- Use a three-step process for service change determination;
- Review report card grades to determine which routes most need intervention (see Figure 12);
- Conduct further analysis to identify the leading causes for under performance; and
- Design and implement service changes to determine which types of service changes apply to address the underlying causes identified.

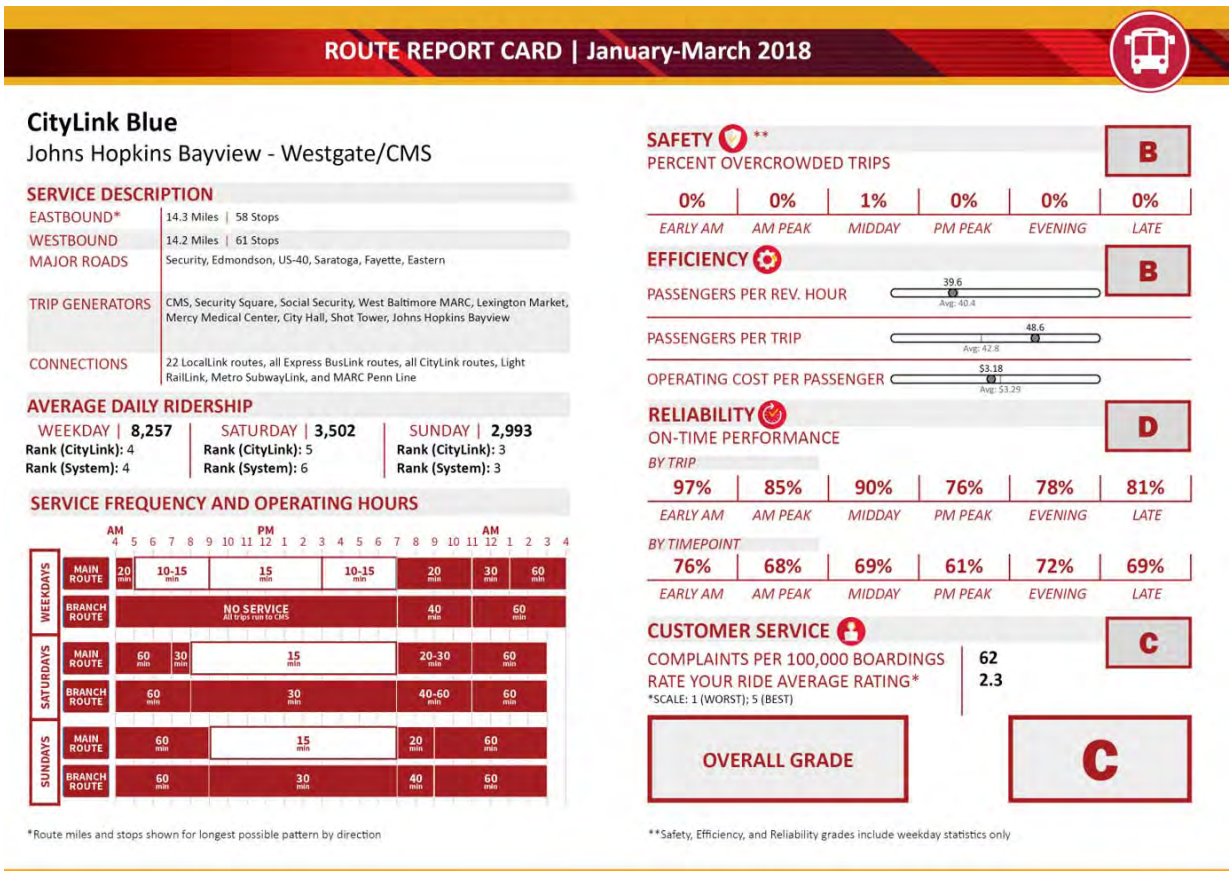


FIGURE 12 Route Report Card with example data to illustrate measures.

EVALUATION ALTERNATIVE MOBILITY PERFORMANCE MEASURES FOR THE TRAVELER'S EXPERIENCE

Alice Grossman

Background

Public transit agencies have developed and incorporated performance measurement into capital and operations planning for years. Current performance measures use a transit focus on indicators (e.g., unlinked passenger trips, farebox cost recovery, and on-time arrival) well suited for traditional service types and technology. However, as new transportation modes, providers, and technologies enter the market, existing measures may not be the most useful to evaluate performance and aid decision making. The Federal Transit Administration (FTA) has embarked

on an initiative to evaluate alternative mobility performance measures (MPMs) to reflect traveler experience in the twenty-first century. Expanding performance measurement beyond a system level understanding can account for multimodal trips, trip chaining, and new modes and technologies necessary to match funding and prioritization with local, regional, and national goals. As part of their MPM efforts, the FTA has assessed the data needs and feasibility associated with the proposed measures in the categories of time, budget, reliability, availability, and safety for both trip planning and travel. FTA is looking at the next generation of performance measures for public mobility. How do we measure services on a more personal level to be able to incorporate all of these modes and access and mobility from a performance measurement perspective instead of just system level for the bus, or a specific transit system?

This project has three parts, with the Eno Center for Transportation focused on the third part, building on the progress made by Transit Center in New York, and by APT. Transit Center conducted a literature review on how transit agencies measure performance, and how cities and others measure performance, what performance measures are not yet available, and could easily be incorporated into the analysis. Specifically, they examined the challenges and opportunities in the policy environment for operationalizing new performance measures, including private and public sector mobility data, and the options and support the policy process can provide in the context of performance management.

Methods and Measures

Researchers reviewed existing metrics used by many transit providers in terms of benefits and challenges to measure a traveler's experience. New measures of success identified include customer satisfaction, time effectiveness, and demand for Mobility on Demand (MOD), in an integrated, multimodal transportation system. In general, FTA-funded programs, and the National Transit Database (NTD), are the main sources for public transit data collection and performance measurement and focus on ridership numbers, passenger miles, and miles of infrastructure. These measures do not include individual level satisfaction, how people make choices, mode choices, mobility options, or acessibility; measuring satistfaction levels as assumed to affect ridership, how multimodal systems are working in the trip stages (pre-trip, trip and post-trip), and geography (e.g, individual travelers trip, city, region, the entire country). Future performance measurement systems need to include all of these elements and be useful at all levels of government and planning.

The next task (in Volume 2) assembled a table of 110 performance measures, each assessed for data feasibility, scored on a 0 to 1 scale from an FTA perspective for data from transit agencies that receive federal funds (e.g., NTD, part of the formulas, discretionary funds). Some data is available, but not currently being measured (e.g., vehicle or rider-based data). Outside data can be easy to access (e.g., Census) or difficult (e.g., Transportation Network Company [TNC] data, scooter data). Some cities facilitate the ability to access TNC data, but other issues arise (e.g., privacy, cybersecurity, the cost of collecting the data). Potential data include measuring app activity (e.g., choices of when and where app is triggered for Metropolitan Atlanta Rapid Transit Authority [MARTA] service). Internal data, currently used, future use, external data sources, and these other concerns, were scored with a feasbility score from 1 to 4, each of those four elements aggregated into a score.

Volume 3 uses all of the information on the data and a brain storming process to focus on actual policy implications (e.g., federal or local policy) and ease of application. For example, the

data feasibility score coming from a technology perspective (e.g., an app) could be very easy, but from a policy perspective, it might be very difficult to ask a TNC to provide access to their data. Data sharing agreements (e.g., individual agency or locality level), in general, need to addresss policy and how people respond. There are measures yet to be envisioned, but that could be required for certain grant applications, requiring standardization, policy implications and the opportunity for the development of templates to facilitate collection and interpretation.

Contributions

Considering the proposed measurement framework, Eno is identifying areas of data policies that need to be assessed, suggesting possible policy actions to remove barriers, provide alternative funding mechanisms, and further research needs (e.g., multimodal comparisons). Of particular concern are data sharing agreements, data ownership and management, and proprietary information, including trade secrets. Other considerations include impacts on equity and civil rights using aggregation methods. Measuring traveler-centric performance, mobility system effectiveness, and regional mobility, can help connect regional agencies and the USDOT through national interests while emphasizing and aligning with the public's best interests.

USING BUS-STOP LEVEL DATA TO MEASURE THE RIDERSHIP ELASTICITY TO FREQUENCY IN FOUR CITIES

Simon Berrebi

Background

Cities have experienced bus ridership declines for the last six years. Data tracked since 1965 indicates the lowest bus ridership ever reported was in 2018. Factors typically associated with bus ridership do not appear to explain this recent trend. In 2012, bus ridership versus service miles for the 40 largest transit agencies in the U.S. indicated a linear relationship. The transit agencies that provide the most service had the most riders. However, with respect to the percentage change between 2012 and 2016, there is no clear relationship whatsoever. To understand the trend requires a hyper-local level analysis.

Methods and Measures

The research focused on TriMet in Portland, Oregon, Miami-Dade in Florida, Metro-Transit in the Twin Cities in Minnesota, and MARTA, in Atlanta, Georgia. These four agencies are very similar in terms of size—they all served from 50 to 57 million trips in 2017—but they are very different in other aspects. In particular, the percent of populations living in transit supportive density differs across service areas. For example, in the Miami metropolitan area, 59% of people live in places deemed transit supportive according to the transit capacity and quality of service, while only 11% of people in the Atlanta-region live in places that are dense enough to support a bus system. One of data sources used in the analysis is automatic passenger counters (APCs), which are small lasers mounted on transit vehicle doors that count the number of legs crossing in and out. These devices, connected to GPS, count how many passengers board and alight. These data are not typically used for many planning tasks as they are quite difficult to manage (e.g.,

errors, very large volume of data, missing data, lack of standards), and require independent cleaning and processing. The second data source is the General Transit Feed Specifications (GTFS), an Application Programming Interface (API) for schedules. The final data, the Longitudinal Employer-Household Dynamic (LEHD), is a product produced by the U.S. Census Bureau, which reports how many jobs and how many people are within each Census Block, by year. There were some challenges reconciling these three data sources between 2012 and 2017, while assembling route segments and population and jobs within a quarter-mile radius, the typical walking distance according to the transit capacity and service manual.

Frequency determines ridership as total daily frequency affects productivity in terms of passenger boardings. The most productive routes are already the most frequent because transit planners strive to maximize transit ridership and allocate service to places where they believe latent demand exists, measured at one point in time. However, between 2012 and 2017, the trend was different. The routes that were increasing in frequency, lost productivity. For example, in Portland, OR, increasing in frequency occurred when productivity was decreasing. Typically, every bus added to a route generated less ridership than the average bus already on the route, demonstrating diminishing returns on frequency. Therefore, doubling the frequency all over the system would not double the ridership, described as the elasticity of ridership to frequency as a function of the previous frequency. When increasing frequency by 1%, if ridership increases greater than one, ridership is elastic to frequency. However, the data trends show ridership is inelastic with respect to frequency. In Portland, Miami, and Atlanta, the most frequent routes are also the least sensitive to changes in frequency, showing diminishing returns, and particularly diminishing where frequency is increasing (see Figure 13). The most promising market segments are the ones that have the least potential for growth.

This trend has implications for service allocations. For bus networks, where they have already achieved diminishing returns, if a transit agency became interested in increasing ridership, then just increasing frequency would not accomplish this. There is a need for strategies to increase demand (e.g., implementing bus lanes, congestion pricing, or transit-oriented development). Just working on the supply by itself, is a limited strategy because the demand is constrained by the land use and the car-orientation of urban settings. Controlling for frequency allows for the analysis of other factors that affect ridership in a systematic way. For example, demographics are closely associated with ridership. In the four cities, the ridership per capital (productivity per capita) is a function of the proportion of residents who do not have a college degree and there is a clear positive relationship. The neighborhoods with a high proportion of people whose highest education is high school, use transit the most as they earn less money, have less access to vehicles, and are more likely to be dependent on transit.

To understand why bus ridership declined since 2012, an analysis of neighborhood demographics indicates race as most significant factor, with the proportion of white residents correlated with the decline in ridership. In all four cases, whiter neighborhoods lost more ridership where residents were more educated, with high car ownership, with a higher proportion of choice riders. If buses have already reached the point of diminishing returns, to use them to tackle climate change will require more inclusive approach than just increasing frequency (e.g., address land use patterns, congestion pricing, and bus lanes). In addition, it is important to look at declines in vehicle ownership costs, including low lease interest rates (e.g., 5% or lower) since 2012. People who were transit-dependent could now afford to purchase and drive their own private vehicle. There may be a counter effect as the economy is better, unemployment is lower, and people who still depend on transit for basic mobility are making more trips.

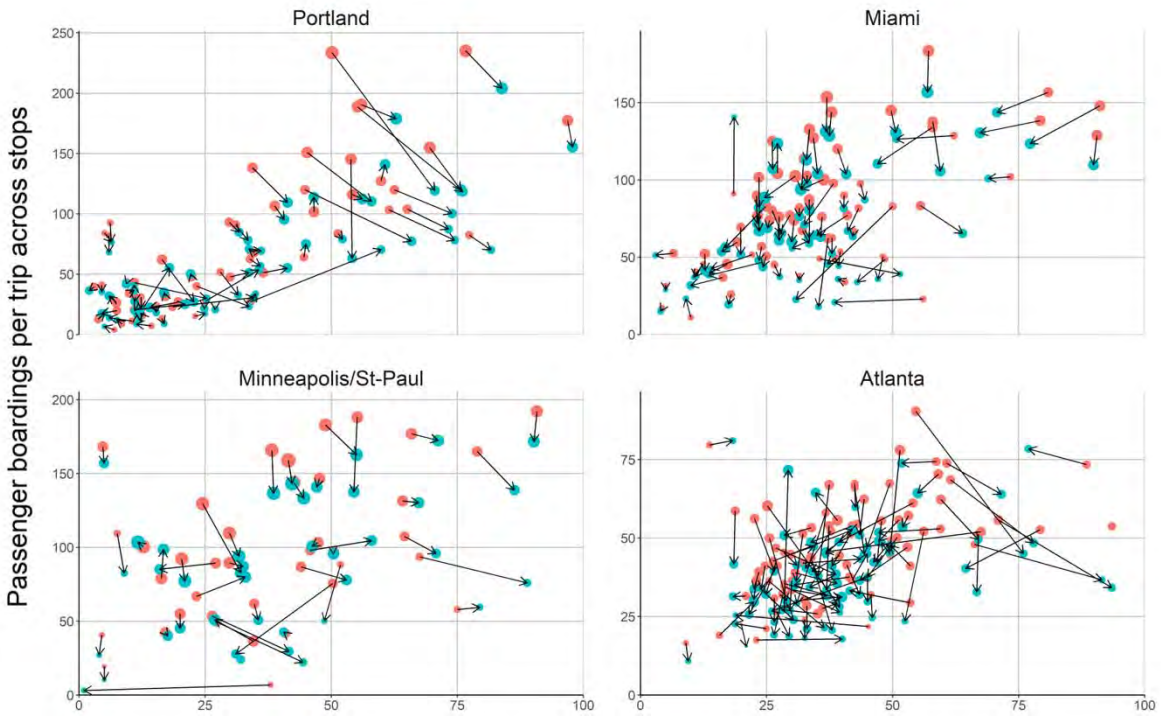


FIGURE 13 Illustration of relationship between increasing frequency and productivity using total daily trips.

It seems like that this effect is counteracting the increase in vehicle ownership. On the other hand, white neighborhoods are losing ridership at a faster rate. Another factor is the increase in telecommuting since 2012, with greater participation and penetration, particularly in white collar jobs. Another source of loss in transit ridership is rider hailing, which has been around since 2012, and which currently represents about 1/3 of the mode share of buses in cities, coinciding with the decline of ridership.

Contributions

The goal of this analysis is to understand the elasticity of ridership to bus frequency over time in order to predict the impact of service changes like adding a new bus to a route. Looking at cross-sectional results for the four case studies (TriMet, Miami-Dade, Metro-Transit, and MARTA) over time indicates ridership is inelastic to frequency. As a result, adding a new bus to a productive route will generate less ridership than buses already on the route. In Portland, Miami, and Atlanta the most frequent routes were the least sensitive to frequency. However, in Minneapolis-St. Paul, ridership was elastic to frequency.

Audience Dialogue

Question: Along with characteristics of residents and other strategies, have you been able to model those impacts?

Response: In Maryland, we are going to analyze the impact of bus lanes and Bus Rapid Transit (BRT) on ridership. Riders appreciate frequency, reliability, and time. Maryland is experimenting with bus priority to try to realize ridership increases, looking at both signal priority and bus lanes.

Question: How might displacement in urban areas be affecting ridership?

Response: Due to data limitations, we could only look at demographics from 2011 to 2015. Demographics have not shifted drastically in three out of four cities. In Miami, which is gentrifying, it was observed that neighborhoods that became "whiter" lost ridership.

Question: What would you expect to find in larger metro areas compared to smaller ones?

Response: We chose to focus on cities that could be more generalizable to other large cities. In the very large cities, you might expect lack of maintenance of subway systems affects bus ridership.

Question: What is the impact of day of week on bus performance measures? How sensitive is bus performance to vehicle congestion?

Response: Researchers do not regularly analyze these factors.

Question: Is it possible that people are traveling less?

Response: Nationwide, the rise in number of trips taken is slowing down, but is still increasing, so that does not seem to explain the drop in ridership.

Question: Agencies conduct O/D transit studies, but usually for model calibration. Are there examples that look at customer satisfaction?

Response: There is research underway to use surveys in California and Washington. The hope is to use survey data less because of the expense, and to use electronic and mobile data more to replace surveys.

Question: What has been the response from MTA board and senior leadership?

Response: Internally at MTA, the response has been positive and pushed throughout the agency at all levels. There is buy-in from leadership. Other agencies are taking the performance measurement and dashboard approach.

Take Aways

- Lessons learned at MTA Baltimore include aligning performance assessment with agency goals, developing processes related to factors you can control, and automating scoring and reporting when possible, so you can focus on the service analysis.

- Eno recommends the development of a new approach to consider performance from the rider's perspective, including pre-trip, trip, and post-trip. Another goal is to capture additional equity concerns that are not currently measured (e.g., aspects of spontaneity time). Paratransit riders have to order a ride 24 hours in advance, whereas other riders can use more on-demand options, or take spontaneous trips as needs arise.
- Berrebi points out that bus ridership has already attained the point of diminishing returns. People who rely on buses have remained loyal (vehicle ownership costs) while white, educated, choice riders are losing ridership, perhaps due to shifts like telecommuting and ride hailing. The current approach of increasing frequency on popular routes will likely have limited effect on increasing ridership.
- Lingering gaps remain in our understanding of impacts on captive riders, including lower income riders and people with disabilities. In addition, there is a need to look across modes to understand transit trip-making and potential ridership (e.g., connections with bike, micro transit).

SESSION 7A: HOW TRANSIT AGENCIES ARE REVAMPING THEIR DATA ANALYSIS TO MAKE COLLABORATION WITH CITIES AND MPOs MORE EFFECTIVE, EFFICIENT, AND MEASURABLE

Madeline Zhu, *Swiftly, presiding*
Robert Hazlett, *Maricopa Association of Governments, recorder*
Krae Stieffenhofer, *Kimley-Horn*
Adam Burger, *Santa Clara Valley Transportation Authority*
Tamiko Percell, *Santa Clara Valley Transportation Authority*

BETTER DATA, BETTER ARGUMENTS, AND BETTER DECISIONS

Adam Burger and Tamiko Percell

Background

Santa Clara Valley Transportation Authority (SCVTA) operates transit services in the city of San Jose and Santa Clara County. San Jose is the nation's tenth largest city, with heavy suburban growth patterns. The community faces a housing shortage, with eight jobs created to each new home created in the last seven years. People living in areas well served with public transit (e.g., downtown and along major corridors) are no longer able to afford to live in those places. They are moving to the periphery of the urban area where the transit service is weaker or unavailable. In some cases, these people are moving outside of Santa Clara County entirely, in which case they are very unlikely to use transit to commute to their jobs. More people are choosing to drive and are driving longer distances, causing very negative impact on traffic congestion in the area and undermining the performance of the bus network. For example, bus speeds have decreased by nearly 20% and ridership has declined nearly 25%. In 2006, a 30-year sales tax was passed that was set to deliver $6 or $7 billion worth of transit infrastructure and transit operations and was widely supported by county voters.

After several years of analysis, in 2008, staff proposed a Bus Rapid Transit (BRT) solution, releasing a vision for the county that would convert the three highest ridership corridors to BRT corridors. BRT was a new concept at the time, portrayed with renderings of a street transformation (e.g., six lane urban highway into a multimodal street with transit and bicycle facilities, a nice pedestrian realm, and transit supportive land use). The public was concerned over the loss of general-purpose lanes used primarily by commuters. The perception of the public and some elected officials was that BRT was being forced on their community, even though these same officials supported and adopted the concept of denser communities next to transit in the general plan. Staff put the BRT plan on hold.

Methods and Measures

To address the public concerns, staff decided to take a new approach to transit planning. At the end of 2019, SCVTA is launching a new transit service plan to increase frequency across the network. By improving speed and reliability, stakeholders will realize why fast transit will help their city. The focus is on the message that "fast transit is good," using data to help reinforce this message. Another important factor is that fast transit is cheaper to operate. In 1998, average transit speeds were 14.1 mph and it decreased to 11.5 mph in 2016, with a cost impact of nearly $70 million per year. When assessing travel time components, it was determined that signal delay accounted for 32% of time, dwell at stops for 24% of time, and buses moving for 43% of the time. The Swiftly planning tool helped inform the analysis.

People like fast transit as it is more respectful of passengers' time, is more reliable, and is cheaper to operate. Some cities have extremely aggressive mobility goals (e.g., calling for mode percentage changes by 2050 to include 70% for transit and 30% for vehicles). Achieving these goals will require fast, frequent, and reliable transit that provides more access to opportunities. Slower transit is expensive, just getting faster transit could solve some financial problems. This has resonated very well with the board of directors, but for other stakeholders like city staff, the fact that SCVTA was losing money does not resonate the same way. The message for them is more frequency and more routes for residents requires faster transit. The way forward is to quantify everything (not included in the previous plan), including dwell time, signal delay, and the time in transit. Buses spend 24% of their operations in dwell time. Signal delay and the time spent traveling is something that cities and counties can demonstrate to leadership as they control the right-of-way where transit is operating. The board of directors appreciated the data analysis as it allowed them to see the role of city operations in making transit faster.

The key is using the data to educate all the stakeholders. Having the Swiftly data makes is possible to see what is happening route by route, by direction, and with speeds (especially where variability creates more unreliable trips). For example, the data indicated transit traveling 6 mph in one block caused by signal timing issues, or narrow lanes, with dwell time at different stops (see Figure 14). The analysis exposed every single speed problem in the system, making it possible to prioritize solutions with leadership, elected officials, and city staff. They all have something to champion or at least know what in their city matters most to SCVTA. A fast transit toolbox helps cities think proactively about transit issues while they are in their planning phases. SCVTA staff realized that through this process, as transit planning is just one aspect of their planning routine. Provide as much information as possible, as much data as possible, and work as hard as possible to empower them to include transit in their planning.

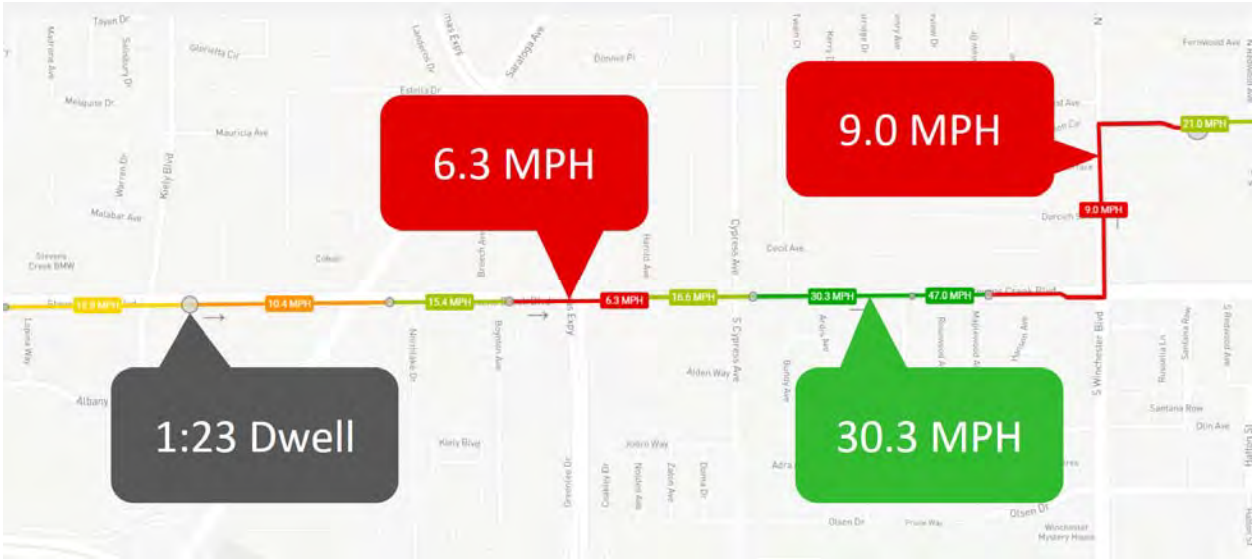


FIGURE 14 Illustration of ability to quantify delay at specific locations.

Contributions

Cumulative travel time changes calculated with the tools use data on existing conditions for any given route, or for the entire network, and then add in bus stops, consolidations to get travel time savings, and add farecard improvements. Currently, farecard penetration is 20%, with most routes using cash payment. By moving cash payments over to farecards, what kind of improvements would this produce? What is the cumulative effect of transit signal priority, or creating a transit lane? Each analysis helps all the stakeholders understand their contributions to faster transit. City staff are coming to ask about bus lanes and coming with plans for bus stopping and bus boarding islands, and seeking out input on their strategies very early, which is new and welcome. While it is early in the implementation of this program, people are already thinking differently about prioritizing buses. The "FAST Transit" Toolbox has a variety of strategies including bus stop balancing, faster boarding, transit lanes, transit signal priority, and more.

Audience Dialogue

Question: How do you communicate speed and reliability to stakeholders?

Response: Staff works to make technical analysis relatable in human terms. For example, they compared the speeds of buses to a person running or a chicken running, and then asked groups, which one they thought was faster. This approach resonates with the public and officials.

Question: How did you develop that message?

Response: Staff put it together and discussed it with policy officials and developed the ultimate message of "fast transit is good." The initial approach was overly technical, requiring this adjustment of the message to make it more user-friendly.

Question: What have you found worked or did not work when communicating with non-technicians?

Response: It is important to use metrics that explain the human experience without over reliance on charts. People should be able to relate to the data.

Question: What did you find works best when identifying incremental steps and measures?

Response: Programs should be manageable. An important part of the process focuses on smaller, more implementable, and incremental improvements.

Question: What happened to the funding from the sales tax and do you have an overarching framework?

Response: The funding is still there and project implementation continues. Funding for BRT shifted to other modes. Some funding is going to the program through smaller projects. The list is still being prioritized based on support levels from the different cities.

Question: What are the best ways to approach prioritization?

Response: It is challenging because the transit authority does not own streets, so they must be pragmatic in making recommendations. Prioritization is not only a technical exercise, but also a political exercise and must consider local feedback.

TRANSIT SIGNAL PRIORITY: HOW TO HELP KEEP TRANSIT TRAVEL TIMES PREDICTABLE ON THE CITY'S MOST CONGESTED STREETS

Krae Stieffenhoferr

Background

Maryland Department of Transportation Maryland Transit Administration (MDOT MTA) is a state agency, responsible for the vast majority of the transit services located in the Baltimore metropolitan area (e.g., local bus, LRT, Metro, commuter rail, commuter bus). They also support local transit systems in the rest of Maryland. Ridership for the agency is 110 million per year, with a workforce of 3,300 MTA employees. Launched in June 2017, BaltimoreLINK is a $135 million transit initiative in Baltimore that includes new branding, routes and schedules. BaltimoreLINK is the backbone of the transit service, with twelve routes running 24 hours a day, with high frequency service during certain periods. The work led to a grid and spoke network with three classes of services, including frequent service defined as a minimum headway of 15-minutes between 7:00 a.m. and 7:00 p.m. For the transit priority initiative, the goal is to enhance the high frequency routes that could benefit from coordinated infrastructure improvements.

Methods and Measures

The transit priority initiative produced a toolkit to help guide future implementation that includes dedicated transit lanes; intersection queue jumper lanes; peak period transit only lanes; and curb extensions. Developing a prioritization strategy required several steps. The first step was to split all of the routes within the Frequency Transit Network (FTN) into segments. The project team created segments using visual inspection via Google Maps, to split routes into common roadway characteristics. The process included parking restrictions, roadway medians, and lane counts. These segments could receive a uniform treatment (e.g., each segment within itself could be suitable for bulb-outs—curb extensions that align bus stops with parking lanes—or dedicated transit lanes). The process split routes into segments depending on the particular route. These route segments served as building blocks for the rest of the analysis, prioritized one against another. Figure 15 provides a comparison between the old system Frequent Service and the new Frequent Service.

The transit priority initiative is to enhance all of the frequent network corridors. Using physical enhancements improves some corridors. MTA provided communities with a toolbox document with suggestions for local improvements (e.g., transit lanes, bulb-outs, bike lane interactions with bus). For the purposes of this project, the 12 city links and six local links were evaluated by segments for similar roadway characteristics (e.g., same number of lanes, same parking restrictions, exist on same road name when it turns onto another major corridor) with eight to 18 segments per route. These scored building blocks, ranked against each other, determine where more investment could best impact service. After cutting the segments, a quantitative analysis ranks and scores each segment. Combining the segments into corridors allows stakeholders to hold informed discussions.

Ranking metrics included a reliability transit speed ratio and a dwell time per boarding. Ridership thresholds included passenger activity, primary route load, and total peak bus load. For transit travel time reliability, the focus is consistency on travel times, rather than on-time performance. Informing this process were metrics, including the coefficient of variation at the segment level. The Swiftly tool was applied to support technical analysis. Ranking metrics focused on the transit/traffic speed ratio. Transit speeds were compared to the available Regional Integrated Transportation Information System (RITIS) data, which utilizes probe data for general traffic analytics. Assessing dwell times per boarding revealed locations where boardings per passenger were taking abnormally long. Automated passenger count data informed the analysis.

Ranking metrics and ridership thresholds were the two major quantitative analysis techniques. The selected metrics tackle problems (e.g., reliability, speed, dwell time). Ridership thresholds inform investments in locations heavily utilized by the ridership. Even though these are all high frequency routes, it does not make sense to invest money at the end of a route, or somewhere where there is little ridership potential. After mapping all the corridors, staff ranked and scored projects on 26 corridors. Reliability analysis focused on consistency of travel within segments instead of looking at on-time performance. The schedule used for the analysis can skew on-time-performance analysis. The travel time can be consistent through a segment, while the schedule is off causing misleading results.

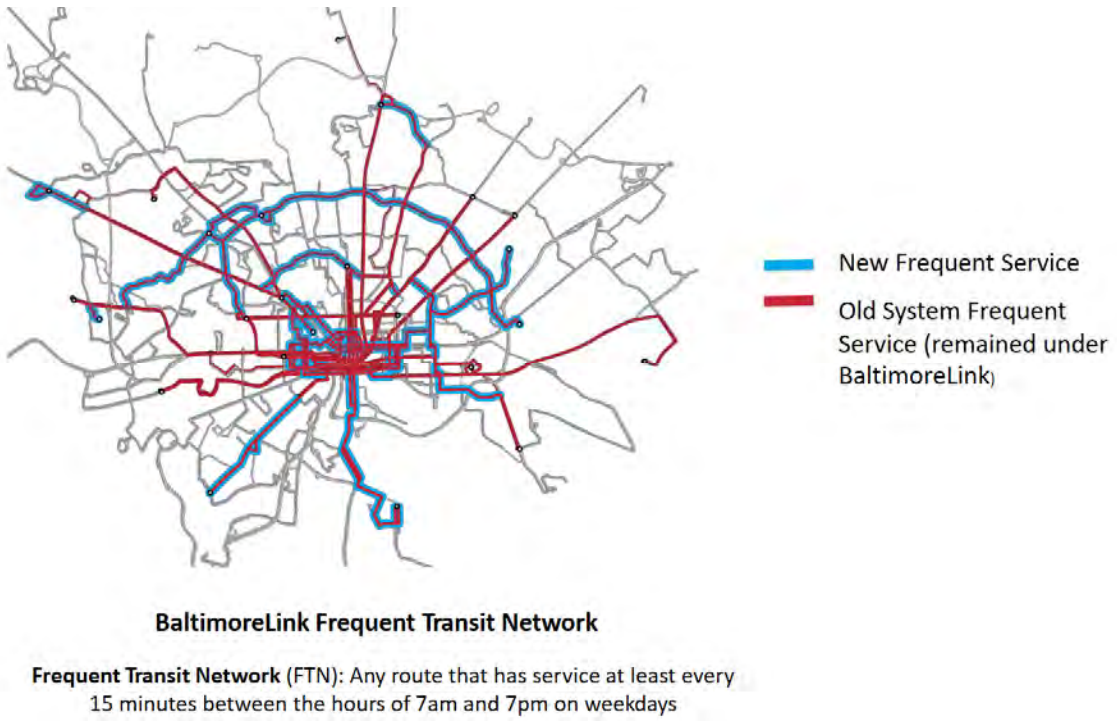


FIGURE 15 Comparison of service strategies to improve the frequent transit network.

The dwell time analysis first found locations where dwell time was abnormally long relative to boardings. These locations might be places where a bus never fully pulls up to the curb, increasing the time required for the passengers to have to step down off the curb and back up to the bus, which is especially difficult for the elderly to do. Bulb-outs are one of the solutions as an easy fix to implement in our system. All this data came from the automated passenger counters (APCs) tied to door open and close time. For ridership thresholds, the research team evaluated all the segments on several factors including volume of boarding and alighting and number of riders on the bus traveling through that segment. Even though lower frequency routes may be using the same roadways, total bus ridership aggregates for every single route affected by these segments.

After scoring and ranking all the segments, a desktop review determined the potential for bulb-outs, transit signal priority (TSP), or dedicated bus lanes. An actual on-site tour followed the analysis, including interviews with bus operators to get their thoughts on whether they agreed with data analysis. In addition, interviews with service staff gathered their thoughts regarding bus stop consolidation or removals. Staff discussed outcomes with Baltimore City DOT to identify any projects to enhance operations, with an emphasis on quick fixes for low hanging fruit.

Contributions

Plans are underway to improve upon the complexity of the current ranking methodology for value-based project selection (e.g., comparing bulb-outs to TSP). The many aspects of the toolkit address the value of quantifying time savings for each of the treatments. Working with the Downtown Baltimore DOT staff was not included in this round as it is difficult to build anything

in the Downtown due to space limitations. However, there may be opportunities in the future to use the data-driven approach to get acceptance for using TSP. Using the desktop review helped to identify options and contributed to fruitful follow-up meetings (e.g., bus operators, service development staff, City DOT). Throughout the project, developing low-cost, high-impact projects took priority (e.g., the Gay Street/Belair Road projects). Strategies implemented included bus bulbs as well as identifying the opportunity for stop consolidation. For example, Patapsco Avenue included recommendations for the potential for a bus-only lane and bus bulb-outs.

Audience Dialogue

Question: What have you found worked or did not work when communicating to non-technicians?

Response: A ranking map was an important tool to present findings and recommendations to decision-makers on priorities without the technical details.

Question: What worked best when identifying incremental steps and measures?

Response: The team worked with the City DOT to address concerns over losing SOV capacity from potential transit lane conversions. Recommendations emphasized smaller, efficient, projects such as bulb-outs vs. taking away a lane in a heavily congested corridor.

Question: What were the results of bus lanes analysis on routes?

Response: The travel times are highly variable and in certain areas, a bus lane will help travel times.

Question: What was the geographic extent of the work?

Response: It was primarily in the city of Baltimore, with only limited service in the county. There are some examples of dedicated transit lanes in the downtown network.

Question: What are the best approaches to prioritization?

Response: A critical consideration is including a value proposition in a ranking method.

Take Aways

Developing a ranking methodology is a complex process and there may be process refinements in the future. Future steps include the goal to improve buy-in from the DOT to work on downtown corridors (space and signal timings are at a premium). The public reacted well to a data-first approach, but it is critical to have clear visualizations and diagrams. With transit, communicating speed is challenging because dwell times are included. Trying to explain relative speed is critical in order to identify a benchmark of comparison (compare against general traffic).

Chapter 3

Performance and Data

SESSION 1B: BENCHMARKING: COLLABORATING TO DEVELOP COMMON PERFORMANCE MEASURES

Amy Van Doren, *Marin Transit, presiding*
Laura Moeini, *Washington Metropolitan Area Transit Authority, recorder*
Sui Tan, *Metropolitan Transportation Commission*
Brian Brooke, *Sound Transit*

OUTCOME-DRIVEN PERFORMANCE MEASURE FOR FUNDING ALLOCATION THAT MAKES PARADIGM SHIFT: MTC's STREETSAVER TOOL

Sui Tan

Background

The San Francisco Metropolitan Region (SFMR) has a population of 7.5 million, consisting of nine counties, one hundred cities, with 43,500 lane miles of local streets and roads, 6,850 lane miles of state highway (under the control of Caltrans), 23 transit agenices, and seven toll bridges. Performance-based management is a crucial aspect of the Fixing of America's Surface Transportation (FAST) Act. State DOTs have historically been required to report progress on pavement condition metrics based on the *Highway Performance Monitoring System (HPMS) Field Manual*. These requirements now include coordination of target setting with relevant metropolitan planning organizations (MPOs). In the early 2000s, the SFMR *Regional Transportation Plan* highlighted the fact that local streets and roads were not receiving their fair share of investments; instead, investments favored other forms of transportation. The challenge for the Metropolitan Transportation Commission (MTC), the MPO for the region, was how to fund projects more equitably, allocating investments appropriately across all modes of transportation.

Methods and Measures

MTC set out to make the case for local streets and roads, using creditable and defensible data to facilitate discussions. Their goal was to have all 109 cities and counties in the San Francisco Bay Area region using one common pavement management software, StreetSaver. This decision makes it possible to gauge the conditions and funding needs of the region's local streets and roads more easily. It also facilitates the setting of performance targets and the measuring of progress towards those targets. Further, the use of a common pavement management system by all Bay Area local agencies allows MTC to monitor maintenance activities and inform local agencies that practice pavement preservation strategies. To strengthen the connections between planning and preservation, the region continues to support the "fix it first" emphasis to ensure that the region directs a majority of funding to maintain existing transportation assets.

Pavement condition alone does not provide a full picture of the state of their road network. In order to improve local agency's overall performance and promote increased transparency and accountability in performance management reporting, MTC developed a set of key performance indicators (KPI) that are readily available from StreetSaver to local agencies. To achieve the regional goal of state of good repair, it is important to include KPIs as a way to evaluate progress. To incentivize and promote local agencies to adapt the pavement preservation principle, MTC set up a performance-based policy, using KPIs, based on effectiveness of pavement preservation as part of the factors to allocate federal funding for road maintenance.

MTC started collecting pavement condition data in the early 2000s, and saw consistent data starting in the late 2000s. The data showed small pavement condition index (PCI) increases year-to-year. The group conducted a 30-year needs assessment to answer the question, "How much money do we need to maintain our local streets and roads (pavement, non-pavement, and local bridges) at a state of good repair?" The assessment considered available funding versus maintenance needs, which highlighted a $3-billion per year shortfall. MTC then set a target for a PCI of 75 or greater, as signifying a state of good repair. The group developed and introduced new measures to analyze PCI in different ways across the region's cities and counties, and benchmark their status and progress. Because MTC tied these measures to funding, it triggered enhanced performance by cities and counties.

Performance-based funding allocation is the goal behind using their database of pavement data, and a common tool to address Bay Area local streets and road conditions. This approach makes it possible to have an outcome-driven performance measurement system. It used an easy to compute formula, with no advantage, or disadvantage, across the region due to the age of a network. The measures used in this strategy included a variety of approaches. For example, the Pavement Preservation Index (PPI) is a qualitative indicator that measures efforts toward pavement preservation. With this measure, a county gets full funding if they achieve a score of one or more. The Asset Sustainability Index (ASI) is a measure to determine if a county's pavement asset is sustainable. The backlog over asset value determines the level of effort needed to reach a state of good repair. Other KPIs allow local agencies to track effectiveness of maintenance strategies for their system. The use of "% good, % poor condition" as a way of conveying the issues proved to be a good method for sharing quantitative measures that are easy share with the public.

Contributions

It is important to make the performance measures easy to understand and compute, and outcome-driven. This changed the way Bay Area cities and counties did business, motivating them to be proactive and shift their behavior from a "worst-first" to a pavement preservation mindset. Outcomes-based funding allocations encourage cities and counties to improve operations.

Audience Dialogue

Question: How have stakeholders reacted to being ranked against others?

Response: They are using percentages rather than actual dollars helps equalize the playing field. Moreover, some cities and counties want this information available so that their shortfalls and issues are communicated (ultimately to get additional funding).

Question: Are you encouraging cities and counties to learn from other high-performing cities and counties?

Response: This is a good idea, but MTC has not yet taken this approach.

Question: Is it possibly problematic to simplify things down to numbers as opposed to something more holistic?

Response: There is always a possibility that someone will try to game the system, but these numbers are just one part of it. Moreover, the targets are realistic. If a city or county is doing the right things, they will beat the performance measure and get funding.

COMPARING APPLES TO APPLES—INTERAGENCY SCORECASE FRAMEWORK

Brian Brooke

Background

There are three transportation organizations in the Seattle area: Sound Transit, King County Metro, and the Seattle Department of Transportation. Each had formed some sort of new mobility innovation program with similar characteristics, and all were facing similar challenges. Developing an Interagency Scorecard was an opportunity to measure success of these groups' projects in a standardized way, as well as measure project success across all three organizations. Each of the agencies had a mobility program underway including Seattle Department of Transportation (New Mobility Program), Sound Transit (Innovation and Technology Program), and King County Metro (Innovative Mobility Program). The three agencies were looking for ways to measure success of individual projects but also across projects.

Methods and Measures

The goal of the Interagency Scorecard was to measure success consistently within these three mobility programs—for reporting out, and to help inform project prioritization. The agencies mapped out each of their goals and guiding principles to find similarities across all three, and to determine how to measure performance down to the program level, and ultimately down to the individual key performance indicator (KPI) level. Goals and Guiding Principles are a selection of goals and guiding principles shared across the three agencies. The Framework makes it possible to drill down from agency-level goals to program level objectives to pilot-level performance metrics.

Contributions

The initiative forced the agencies to think about and define categories (e.g., seniors, youth). It also encouraged the group to develop a standardized data collection system, giving them a useful regional data source to track other types of pilots or initiatives. Finally, the Scorecard introduced a standardized way to score project success. The Scorecard asks for:

- Objectives: *What improvements are we seeking?*
- Performance goals: *Which goals will be affected?*
- Data sources: *How do we gather data to track performance?*
- Key performance indicators: *What are the KPIs that drive performance (particularly, KPIs that all three agencies share—and bonus points if the agencies have data to track them)?*

Types of projects piloted using the Scorecard include:

- TNC service partnerships;
- Ride hailing pick-up/drop off;
- Carpool formation; and
- Mobility-as-a-Service app.

Originally, the three agencies defined certain metrics and terms in different ways. For the success of the project, it was important to reach common ground on the tracked data and its interpretation.

SESSION 2B: THE ROAD TO HIGH-VALUE BI OPPORTUNITIES: BRINGING TOGETHER THE DECISION MAKER, DATA, ANALYTICS, AND THE KITCHEN SINK, PART 1

Vaishali Shah, *AEM Corporation, presiding*
Jordan Holt, *WMATA, recorder*
Pat Noyes, *Pat Noyes & Associates*
Emanuel Robinson, *WESTAT*

NCHRP 03-128: BUSINESS INTELLIGENCE TECHNIQUES FOR TRANSPORTATION AGENCY DECISION MAKING—PART 1

Pat Noyes and Emanuel Robinson

Business Intelligence (BI) is assisting organizations with increased efficiency and effectiveness, both with operations and with finances. A number of industries are directly benefiting from the use of data using BI. For example, construction inspectors, once tied to administration tasks, have redesigned and replaced paper-based processes with electronic processing using mobile apps. Approximately 1,600 inspectors (contract and staff) changed their processes using these new mobile technologies. The benefit of this change is the reduction of 1.5 hours per day spent

on administrative tasks at a savings of $2 million in productivity in the first two years. Another example is from the health care industry where staff were experiencing too many readmissions in a major hospital group. Using their data, they developed a predictive model that identifies patients with a high readmission risk. Hospital staff were able to take appropriate actions with this information, resulting in 6,000 fewer patient readmissions, $4 million potential Medicare penalties avoided, and $72 million in medical cost savings. For transportation, the question includes how to rebuild destroyed assets, while considering future risk and costs associated with disasters.

A Risk Analysis and Management for Critical Asset Protection (RAMCAP) approach assisted in prioritizing improvements. Researchers used a probabilistic model of external risks to estimate user and owner risk costs associated with floods, avalanches, and bridge failures. It also included prioritizing betterments for buying down risk. For example, in Washington State, transportation employees were spending 15% and 50% of their time looking for the data and information they needed. The solution used a cluster analysis and text mining to create a taxonomy and ontology to tag content. In the energy sector, wireless sensors and machine learning replaced monthly manual monitoring and reduced stress on green energy strategies equipment. During the testing phase, the system issued alerts prompting an immediate fix, avoiding a ten-fold cost if the malfunction had occurred. There was a 15% decrease in overall maintenance costs and a 2% decrease in unplanned downtime. Finally, in the education industry, freshman retention rates were a major problem. Using student IDs, researchers developed a program to track locations of student activity. The program was able to predict, with 85% accuracy, who would not return to continue their education. Strategic interventions were then able to keep these students in school. All of these solutions relied upon BI, the people, the processes, and the culture. Transportation issues could benefit from using similar applications.

NCHRP Project 03-128, “Business Intelligence Techniques for Transportation Agency Decision Making” focuses on cataloging new techniques to extract actionable information from traditional and new data sources to enhance decision-making processes among transportation agencies. BI shifts leadership, governance, and change from imperialism and obfuscation to federated systems and democratization of data. Data catalogs use traditional and new data, data encumbrances, proactive analysis on data access and use, and data management. The BI catalog requires an understanding of the new BI world, techniques, processes, and tools, with an adoption path for top-down and bottom-up approaches.

Leadership in an agency sets the context for a successful BI culture by defining a vision for such a performance-driven culture, promoting defined, consistent, loosely integrated processes. These processes leverage BI to support strategic goals and objectives, establishing and supporting collaborative data management, and engaging all levels and business areas. Pennsylvania Department of Transportation (PennDOT) is an example of a BI culture where the focus is to have specific, measurable goals and decisions that are metric-driven. Their BI Technical Team supports a data warehouse and BI initiatives, with a BI section as part of the Data Administration Division of the Bureau of Solutions Management. Washington State Department of Transportation (WSDOT) has agency-wide BI applications that are business-driven and IT-led, with a focus on strategic decision making through the project development cycle. WSDOT leadership uses data-supported decision making for traffic operations and long range planning, particularly with traffic data and travel time reliability performance measures for operational and investment decisions. Agencies need to know if there is a formal BI program or policy underway.

Audience Dialogue

Question: Is there a formal BI program or policy in your agency?

Response: Yes (23.33%), Informal (16.67%), Developing (23.33%), No (23.33%), Don't know (13.33%).

Data governance (DG) is the exercise of authority, control, and shared decision making over the management of data assets. DG ensures data meets standards, as well as business rules, regulations, and organizational needs. It is a process, not a project, rooted in people, processes, and technologies. DG is most effectively delegated to business units rather than implemented by IT, using a top-down approach. To develop a modern DG program, an agency needs a mix of centralized and decentralized approaches, a process for defining roles and responsibilities, good data management practices, data protection from internal and external threats, and compliance with laws, regulations, and standards. DG includes: data modeling and design; data storage and operations; data security; data integration and interoperability; document and control management; reference and master data; data warehousing with BI; metadata; data quality; and a data architecture. An agency with good DG has policies for data structure, accessibility, usage, integrity and integration, with responsibilities delegated to the business unit rather than a rigid, singular centralized approach. Technology considerations in governance at the enterprise level should strive not to over-regulate, and should limit the prescription of data stores and analysis tools. The agency should provide tools that allow data provenance and quality, and offer training on data management and control. IT should be willing to serve as an auditor of what enters and exits, to focus on the security of the data, and to support guiding architecture and governance. Yet today, 60% to 70% of data remains unused in the U.S. If the IT department decides and controls where data should be stored and what tools should be used for these data, groups of potential users may not be able to use the tools that best fit their needs. Transportation professionals should try to evolve from "imperialism" to federated systems and democratization of data.

Question: Do you have a formal approach to data governance?

Response: Yes (50.00%), No, Informal (33.33%), No approach (16.67%), Don't know (0%).

Change management fosters the implementation of BI. Leadership, governance, and change go hand-in-hand to foster the necessary culture for BI. Leadership sets the vision and provides the business case for BI. Governance defines processes, roles, responsibilities, and data management to make data-enabled, performance-based decisions. Change management offers the mechanisms by which leaders can evolve governance and culture towards better decision making. Effective aspects of change management include starting at the top and involving every layer, making rational and emotional cases together. To be successful, an organization needs to emphasize engagement throughout the organization, while leveraging formal solutions (e.g., policies, procedures, training to formalize a decision-making process).

BI can help overcome decision-making error or bias. Decision making is a process to choose actions among several alternative scenarios, while problem solving uses methods (and

making decisions) in an orderly process toward a particular goal. There are individual differences in decision making. Age is one example where there appear to be differences in how younger and older adults interpret information, strategies, and metacognition, the framing effect differences, emotional frames, and the alternatives and number of options generated. Personality can explain preferences, types, and styles. The following affect decision-making:

- Fatigue (including sleep deprivation);
- Stress;
- Perceived or real-time pressure;
- Political pressure;
- Erratic eating habits (high or low blood sugar);
- Caffeine; and
- Lack of information, conflicting information, or uncertainty.

Decision makers are often under stress and try to seek out certainty (less tolerant of ambiguity), fast decisions, with narrow perception due to sensory overload ("tunnel vision"), perception distortion and possibly sub-optimal judgment, and a decreased ability to handle complex or difficult tasks. They can experience greater conflict with risky alternatives, focusing on short-term survival goals, sometimes at the expense of long-term benefits. For example, an eastbound highway is closed and drivers start making U-turns, insisting authorities told them to. The authority denies this and only admits to telling drivers to go up an off-ramp. Errors in decision-making occur in many ways (e.g., following a sub-optimal data policy to keep everyone happy.) BI can help mitigate decision bias by being purposeful, having data available, with recognition of data quality, peer review, a target audience (user-centered design), stakeholder participation with good communication, and metrics that prove success. The need is to get the right information to the right stakeholder, at the right point in the workflow, through the right channel, and in the right format.

There are many different BI techniques, with a number of tools to prepare data, assist with decision support tools (e.g., reports, dashboards), and ad hoc analysis tools. A BI catalog introduces trends in the evolution of BI tools and their capabilities, demystifies common techniques available in BI tools, referencing them from the context of traditional statistical techniques, and providing examples of the application of BI techniques in the context of transportation. Tool innovations for BI focus on data preparation tools that gather, combine, structure, and organize data that facilitate analysis. Decision support tools generate reports, dashboards, and other visualizations, support business users in making data-driven decisions, and tackle complex ad hoc analytic tools that advanced analyses. These analyses go beyond the simple descriptive statistics, creating and evolving models for predicting and prescribing systems (e.g., AI and its elements reside).

Analytical techniques use standard statistical methods (e.g., measure of central tendency) using R, Python, RapidMiner, SAS, or SPSS, and the traditional practice of collecting and analyzing numerical data to infer from a sample characteristics of the whole. Real-time analysis, on the other hand is useful for:

- Calculating metrics over time windows;
- Monitoring notifications or alarm triggers;
- Chaining and branching analyses to create more complex processes;

- Augmenting data to detect correlation or divergence;
- Creating dashboards to visualize trends and variations in real-time; and
- Training and performing machine learning analysis.

Tools for real-time analysis include Apache Kafka, Apache Storm, Amazon Web Services (AWS) Kinesis, Google Cloud Dataflow and Microsoft Azure Stream Analytics. The trend is to analyze data as soon as that data becomes available, requiring a shift to modern BI tools.

Classification analysis was traditionally performed manually. Modern BI performs these analyses automatically, using data mining techniques for grouping records into categories. However, now real-time versions can perform analysis on very large graphs with modern BI. Four widely used types of graph analysis include path analysis, connectivity analysis, community analysis, and centrality analysis. Methods structure data as a graph of connected nodes in order to better analyze the connections between these nodes. Tools used include Apache Spark GraphX, Titan, Neo4j and Microsoft Azure Cosmos DB.

Text analysis or mining is not a traditional BI capability beyond word counts. Modern BI is now capable of text categorization, text clustering, taxonomies extraction, sentiment analysis, document summarization, and entity relation modeling. The purpose is to analyze human readable text, such as social network feeds, emails, survey responses, and corporate documents. Tools include tm, NLTK, GATE, Apache Spark Machine Learning Library (MLlib), and Microsoft Azure Cognitive Services text analytics API.

Artificial intelligence (AI) (e.g., prediction, neural networks, machine learning, deep learning) and regression techniques use machine learning techniques including Bayesian and Backpropagation methods, support vector machines (SVMs), recurrent neural networks (RNNs), and convolutional neural networks (CNNs). Tools include Amazon Web Services (AWS) machine learning, Google Prediction API, Tensorflow, Keras and Apache Spark MLlib.

Evolving models through ‘conditioning’ are only available through modern BI to augment and classify data, or predict future conditions. Two main categories for analytical techniques include image and video analysis, possible only through modern BI, now in real-time using deep learning technologies. Techniques include perimeter monitoring, object count, object and speed tracking, image categorization, and image segmentation. Tools include OpenCV, AWS Recognition, Google Cloud Vision and IBM Watson Visual Recognition. Geospatial analysis is becoming more and more predominant in modern BI as more than three quarters of all collected data is geolocated. Moving forward from GIS to spatio-temporal real-time analysis requires modern tools including QGIS, Grass, Esri, uDig, PostGIS, Oracle Spatial, Tile38, Geomesa, AmigoCloud, or Soar.

Traditional data can range from paper documents, scattered spreadsheets, relational databases and large GIS repositories. These data vary in quality (due to human collection), and in many cases, have limited standardization. At the same time, very few are of the volume, velocity, and variety of Big Data. Opportunities to use Big Data exist in asset management and engineering, GIS and mapping, operations, as documents and library, bids and contract, IT services, environmental services, public outreach, photo and video services, financial services, and illustrative domains. The video and LiDAR data are both very large and difficult to deal with. In addition, crowd-sourced data are very large, constantly changing, and perhaps associated with legal issues. Some of the most recent additions to data types include the Internet of Things (IoT) data and CAV data.

Modern data management practices recognize the many possible different uses for the same data so staff need to think twice before throwing away data. Cellular probe data providers are now mining the "trash" of low to very low speed data to sell pedestrian and bicycle data. To accommodate the archived data, consider using cloud-based object storage solution (a "data lake") without imposing any filtering or transformations to the data prior to storing it. This practice allows each end user the ability to define and perform their own filtering. The least expensive cloud storage solutions are best for inactive, but still value data storage. Isolated cloud storage solutions meet the strongest security requirements. For greater efficiency, open file compression standards can limit storage space used. Recommended practice does not separate experiments and trials from the main BI environment.

Important aspects for modern data ownership are security in the ability to monitor and control end users' data access and data use in real time. Control data analysis activities occur at the data level, not at the software level. The business area that develops an analytics product is ultimately responsible for the product's accuracy and quality. In addition, every business area needs to perform its own custom extract, transform, and load (ETL) procedures to support its data analyses. A designated data owner should hold and maintain their own data (e.g., a designated Annual Average Daily Traffic (AADT) for a location/time used by all).

BI data management requires modern organization, adequate metadata and openness. Organize data using the traditional "file system" with structures offered by cloud-based object storage. Augmenting or enriching raw data by adding metadata to each record helps end users understand what is in the data and how to use the data. To maximize data discoverability, maintain searchable metadata repository and to maximize accessibility of the raw data, use open file formats and standards. It is critically important to beware of proprietary software to develop modern data analysis, and try to use cloud provider services, or open source solutions.

Modern data processing for a BI system needs to support many data analytics tools to leverage unique capabilities and strengths among tools. In many cases, the data is now too large to move to specialized data processing environment. The necessary data tools to use the data need to reside with the data. Distributed algorithms are now required to perform data analysis, with an understanding of the nature and limitations of these modern data analysis algorithms. It is important to become familiar with new concepts (e.g., leveraging containerization and microservices to develop custom data analysis). Given the ephemeral nature of modern data analysis, imposed analytics solutions and BI tools that limit access are ill advised.

Cloud providers are moving towards proactive analytics by offering tools to help manage and control large data stores. By using tailored data services, the same analytical methods used to derive insights from data can improve the data preparation process. For example, automated monitoring of incoming data flags for any data that differs significantly from expectations for human review, provides alerts as a legitimate outlier or if there is a data quality issue that must be addressed. In addition, in a BI environment, with data access and users' behaviors identifiable and preventive action taken when suspicious commands occur, improving data security.

Data lake architectures broadly fall into one of four categories: proprietary software on local infrastructure (not recommended), proprietary software on cloud infrastructure, open source software on local infrastructure (not recommended), and open source software on cloud infrastructure. The cost of storing acquired data in a centralized data lake architecture will nearly always be less than the cost of maintaining equivalent storage across multiple data silos.

BI adoption approaches come from the top-down or the bottom-up. Top-down focus practices that executives can help facilitate begin with understanding the data and existing IT,

followed by the development of a BI decision hierarchy that is linked to strategic goals and is a collaborative effort between IT and the business units. After reforming governance, pilot projects can be migrated while fostering a data sharing culture in the new data environment. A typical bottom-up approach requires the identification of current decision-making voids or pain points. An agency needs champions within a business unit who desire the adoption of BI approaches to remedy pain points. The initial setup needs to be flexible (e.g., an IT playground environment) where the project can evolve. It is important to publicize successes, engaging the business unit community and expanding pilots. An example adoption path from a manual to an enterprise decision support operation begins with desktop Excel with manual analysis and reporting, moving to a shared collaboration environment, using Excel in SharePoint. The next step is to migrate the Excel data to a relational databased hosting with Power BI, or Tableau, as examples of web-based, front-end dashboard software options. With this strategy, both a top-down and bottom-up approach is possible. Take both a top-down and bottom-up approach where data management and decision-making form the basis of a BI system. Important aspects for an agency to consider include:

- *What are your Agency, Program, or Project BI successes?*
  - *What specific techniques, tools, changes were involved?*
- *What are your Agency, Program, or Project BI failures?*
  - *What specific techniques, tools, changes were lacking?*
- *What are the most significant areas of resistance?*
- *What do you plan to do differently based on the information we shared?*
- *What do you want your organization, program, or team to do differently based on the information we shared?*

SESSION 3B: THE ROAD TO HIGH-VALUE BI OPPORTUNITIES: BRINGING TOGETHER THE DECISION MAKER, DATA, ANALYTICS, AND THE KITCHEN SINK, PART 2

Vaishali Shah, *AEM Corporation, presiding*
Jordon Holt, *WMATA, recorder*
Pat Noyes, *Pat Noyes & Associates*
Emanuel Robinson, *WESTAT*

NCHRP 03-128: BUSINESS INTELLIGENCE TECHNIQUES FOR TRANSPORTATION AGENCY DECISION-MAKING—PART 2

Pat Noyes and Emanuel Robinson

NCHRP Project 03-128, “Business Intelligence Techniques for Transportation Agency Decision Making” produced a number of work products from the research. An example of using BI for transportation is an application for winter road maintenance. Previously, agencies used “blind” road weather treatment practices, and now can use real-time sensor driven road weather operations. For asset management, previous paper, autonomous documentation and asset-specific

decision-making moves to a multi-source advanced data systems and constraints based cross-asset optimization. Traffic Management Center (TMC) operations, previously conducted as independent, unplanned, reactive incident response to information-based, coordinated, planned real-time response. For infrastructure investment and programming, engineering judgment based State Transportation Improvement Plan (STIP) planning transformed to democratic data-driven prioritization. Traffic signal systems used a time based infrequent corridor retiming transformed into a dynamic IoT driven corridor and localized optimization. BI is also transforming business processes in procurement and contracting with the use of process streamlining.

BI information strategies analyze and present data in different ways, with the ability to change the context of the information with colors, and labels. BI can help mitigate decision bias with an understanding of the purpose or need, data availability, data quality, and peer review. The analyses are user-centered in their design, with stakeholder participation and communication feedback to those same stakeholders. Most importantly, it is possible to measure success and evaluate progress. One of the key elements for BI is the use of integration, making it possible for many services to be provided by a number of different players (e.g., data preparation, visualization and advanced analytics) now all in one tool using a BI approach. Trends for BI are shifting toward self-service (tools ease of use for all) using a modern data infrastructure model. Previous practices of outsourcing decisions now found in-house. The change to BI fosters success, while avoiding pitfalls when transforming agencies into BI-centric enterprises.

Considerations for a BI process include vertical integration of the data. Some vendors offer generalized tools useful across multiple industries, while other offer specialized BI to support an industry or unique functions. Some services prepare data, perform visualizations, and conduct advanced analytics, all in one tool. Self-service data analysis is currently the focus of modern data tools. The latest tools eliminate IT skill requirements, reducing the Time To Insight (TTI). However, there is a risk with making analysis too easy when inexperienced staff using self-service can lead to misinformation.

As BI becomes more prevalent in transportation research and practice, staff need to make key decisions. For example, it must be determined whether an organization should outsource or establish BI in-house. In-house BI can require significant up front investments and more time to build technology and skillsets before seeing results. At the same time, when fully developed, it allows for more specialized products and deeper insights. It allows for the ultimate control over intellectual property (IP) use and security options. The set of necessary BI practices include the following:

- Identifying the business need;
- Obtaining executive support;
- Identifying data sources;
- Utilizing proper training;
- Making use of data visualizations;
- Encouraging experimentation;
- Investing in research; and
- Measuring success through multiple perspectives.

SESSION 4B: USING DATA TO INFORM DECISIONS

Jordan Holt, *Washington Metropolitan Area Transit Authority, presiding*
Mara Campbell, *Jacobs Engineering Group, recorder*
Nate Reck, *GeoDecisions, a Division of Gannett Fleming*
Madison Metsker-Galarza, *Texas A&M Transportation Institute*
Mark Seaman, *New York City Department of Transportation*
Mark Egge, *High Street Consulting*

GIS ENHANCES ASSET MANAGEMENT AND OPERATIONS

Nate Reck

Background

PennDOT had a need to combine all their data systems to improve planning scheduling of maintenance activities. They already were using Esri's ArcGIS-based mapping technologies. Any approach would need to be consistent with their entreprise geographic information systems (GIS) initiatives that focus on reusability, scalability and affordability. With mounds of maintenance-relevant data stored in disconnected technology silos throughout the state, it was a hardship for PennDOT staff members to find, decipher, or communicate information quickly. Without a clear picture of the latest maintenance program data, PennDOT risked performing out-of-cycle assignments.

Methods and Measures

To meet their needs, PennDOT developed the Maintenance-IQ solution that serves as a nationwide model for state DOTs when using geospatial technology to efficiently plan and schedule capital improvement projects, while improving bridge, roadway, and pavement asset management. The application allows PennDOT to use GIS mapping to connect with a long-term enterprise IT plan. The approach also produces immediate and beneficial infrastructure project results that enhance collaboration and save time and money. The system provides a visualize engine to tell the story, while indicating the planned versus the actual processes. Maintenance-IQ provided a GIS solution capable of identifying coordination opportunities (regionalization) and eliminating out-of-sequence rework, such as repaving a road before replacing underground pipes. Maintenance-IQ increases PennDOT's operational efficiency. GIS empowers PennDOT staff members and other transportation stakeholders to analyze, visualize, and share statewide infrastructure data. The application synthesizes maintenance-related data from information management systems dealing with bridge maintenance, contracts and document management, environmental protection, highway performance monitoring, multimodal project management, pavement management, roadway management, and even spreadsheet visualization. With actionable intelligence delivered through the application's GIS repository, PennDOT's maintenance community is better equipped to map planned and completed improvement projects, understand bridge and road assets and conditions, and prevent unnecessary and costly rework. Figure 16 provides an example of the interface with maps, data, and photos to inform decisions. Because PennDOT maintenance staff members can better detect

highway deficiencies, determine roadway treatments, plan operations, and monitor production, the traveling public realizes greater service and savings. PennDOT is also developing a mobile asset management tool to track the end-to-end process of the guide rail repair and maintenance workflow to ensure guide rail policy compliance.

Contributions

Maintenance-IQ was used to develop a "cycle-sectional" maintenance crack sealing program (four-year cycle). By working within geographic zones, it is possible to optimize the efficiency of the operation by reducing mobilization costs via travel time. The GIS system map allows managers to visualize the prep work activities planned after surface improvement projects (paving). The proactive map helps to eliminate costs associated with out-of-sequence rework (i.e., prep-type activities performed soon after a surface improvement). This helps them identify where needs are as an inventory review and then, matching that with funding streams, provides efficiencies. PennDOT employed field data collection using a mobile app to help with GIS inventory, bringing in field data on the fly, and then mapping them with GIS.

The end result is the ability to make decisions more efficiently, specifically with costs and cycle time. It also improves regional paving crews, making them more effective and able to implement more regionalized strategies. Finally, it has helped with customer and public education.

Another opportunity for Maintenance-IQ is for extreme weather analysis and the determination of the resiliency of assets based on extreme weather. It makes it possible to understand how certain storms and environmental factors affect the assets. Another opportunity as an extension is van pooling. By looking at ridership data, it is possible to detect and view trends to make improvements.

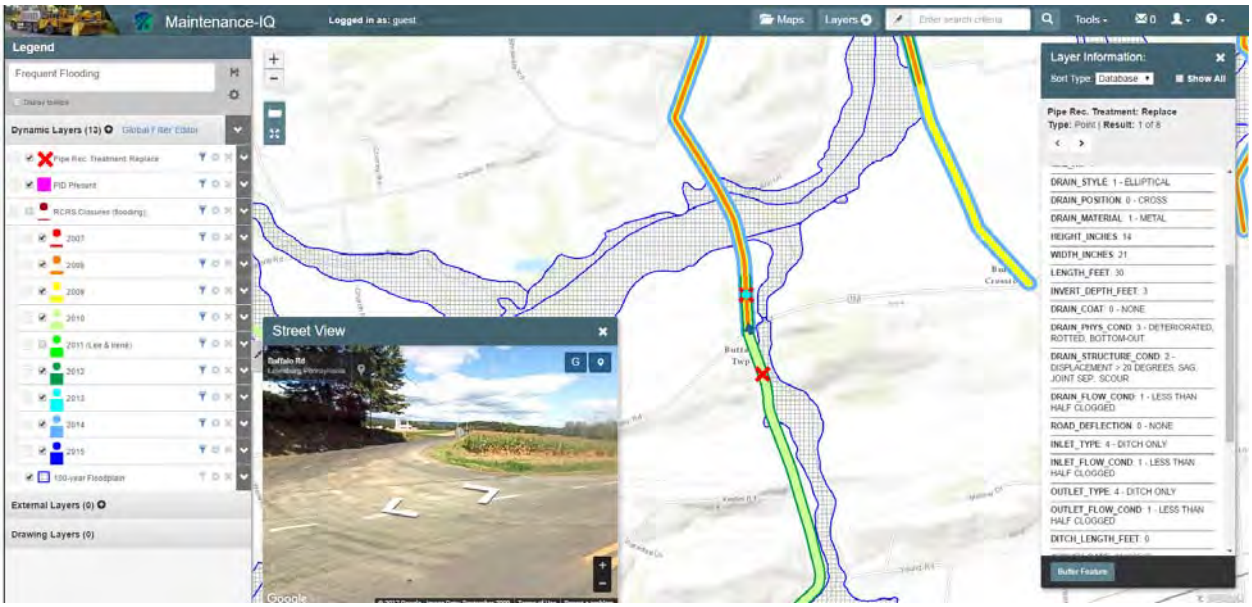


FIGURE 16 Example of interface to address frequent flooding and pipe conditions.

MANAGING DATA, TRAFFIC, AND EXPECTATIONS: FOOTBALL GAMEDAY OPERATIONS PERFORMANCE MEASURES

Madison Metsker-Galarza

Background

In 2013, Texas A&M leadership made the decision to enhance and expand their sports stadium. The following year, a $485 million stadium investment expanded seat capacity by 20,000 to accommodate 102,733 sports fans. At the same time, no increased road capacity was planned, even though the local area experienced heavy commute traffic on a daily basis. The sports calendar includes games on Thursdays when classes are in session. As a result, students, staff, and faculty, compete for the limited road capacity with all the fans coming from the region to participate in game activities. The challenge was how to accommodate 120,000 attendees and workers, without expanding freeway capacity, with very constrained existing infrastructure (e.g., parking spaces).

Methods and Measures

To create a premier game experience for the fourth largest college stadium in the country, while allowing community residents to enjoy their town, dozens of groups and agencies collaborated beyond the seven scheduled game days and developed the Kyle Field Transportation Plan. Real-time data and performance measures identified garage and parking lot clearance rates, remotely adjusting intersection signal timing, and identifying times when traffic patterns could shift from pedestrian priority to vehicular traffic. Evaluation reports prepared for the Monday afternoon postgame meeting used metrics to evaluate traffic congestion, bus ridership, parking counts, and traffic management and law enforcement activities. Performance measures played a key role in week-to-week and end-of-year changes, which were subject to approvals by event management, athletic booster, and university donor organizations.

Contributions

Data and performance measures, along with relationships built by engaging fans, agencies, neighborhoods, law enforcement, and event management professionals, have contributed to a successful game day transportation plan by creating a space for transportation operations groups to adjust to changing circumstances and make different on-the-ground decisions when required. Trust and accountability, supported by the measures and communicated to game attendees, allows fans to easily choose their best option. Transportation professionals around the country can use this concept to create solutions to big city traffic problems that occur in smaller towns. Evaluating and communicating traffic conditions among many groups during special events can demonstrate successes that might be useful to solve every day problems.

Part of the strategy was a big media “roadshow” (e.g., opportunity for members of the media to receive presentations on a particular topic) that focused on key messages. This included student leaders producing videos that help spread the message. It was necessary to meet with faculty and staff and external groups to gather input on what worked and what did not. An analysis, using INRIX data (proprietary probe data that provides time to transverse information for planning), examined segments of various roads by time of day to determine levels of congestion at peak times and over the day in 2018 and 2019 (see Figure 17). The Kyle Field Transportation Plan demonstrated the levels of success when strong partnerships help spread the word about how best to tackle a potential traffic problem. Targeted messages were made to specific target audiences. Travelers were given numerous travel options, and the system was manageed by an experienced and attentive gameday staff.

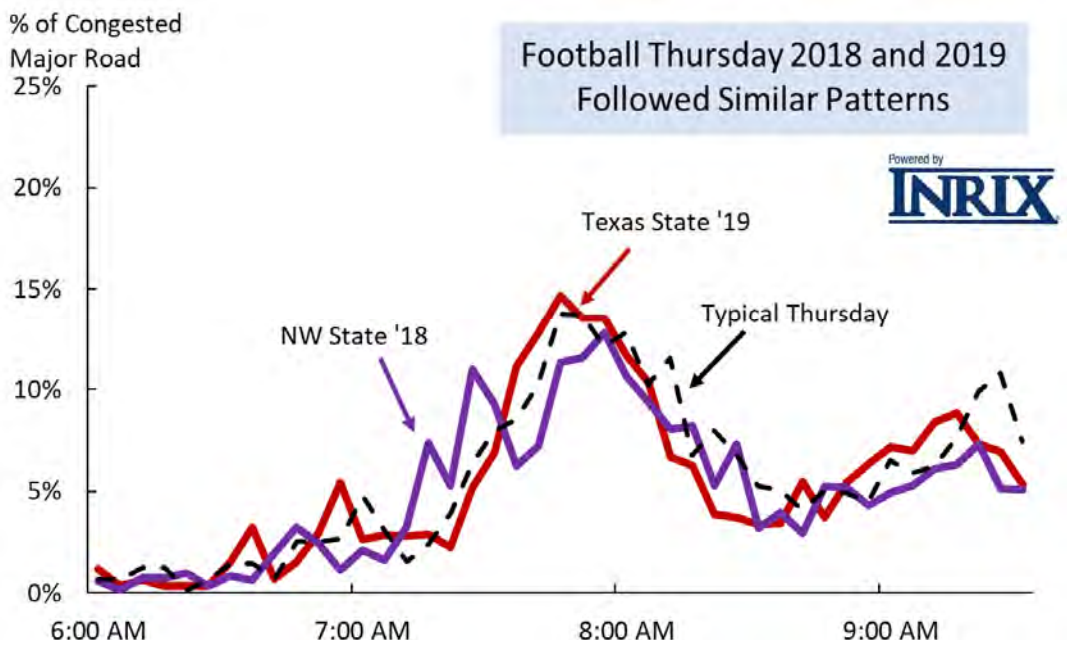


FIGURE 17 Comparison of typical Thursday morning peak behavior between 2018 and 2019.

USING BENEFIT-COST ANALYSIS

Mark Seaman

Background

Transportation has increasingly used benefit-cost analysis (BCA) to inform decision making. To assist with decision making regarding capital projects in the densely developed environment in New York City, New York City Department of Transportation (NYCDOT) committed to the development of a triple bottom line methodoology for assessing capital projects in 2016.

Methods and Measures

A BCA "weighs the potential benefits of a project against its costs" and at the same time, it is not about jobs or property values. NYCDOT used a BCA approach for the Fourth Ave project, in Brooklyn. The location was not a safe environment due to traffic conditions, was not aesthetically pleasing, and was very densely populated. An original concept developed in 2011, focused on turning the streetscape into a "great street" with wider sidewalks and landscaping for a more pedestrian friendly environment. The initial design needed modification, and the new design then proposed that included a protected bike lane. How much more would this change cost? What benefits are gained?

To answer questions regarding the proposed change, the first step was to look at the baseline and measure the benefits and costs against the initial design. The identified benefits were for safety, increased opportunities for bicycling, enhanced livability, vehicle travel and diversion from other modes. Using a benefit-cost analysis forces the designer to rethink how they designed things and then, ultimately, can result in going back and re-engineering the design. Most of time, benefit-cost analysis leads to cost savings. The process requires data, including spatial analysis (see Figure 18).

Contributions

For their livable streets project, NYCDOT currently scores projects against their strategic plan goals. They are in the process of developing standardized benefits estimates to ensure they prioritize projects that deliver results most efficiently. NYCDOT has also been using benefit-cost analysis to explore alternatives for proposed projects and have found that the insights gained from the analytical process are often as valuable as the bottom line benefit-cost ratios. All of this analysis relies on existing datasets developed within the department (e.g., crash data), but it is also forcing staff to develop new tools and data sources (e.g., methods for estimate bicyclist volumes). The interim project achieved major safety improvements. There may be operational solutions that can reduce high capital costs and are worth investigating. The process of conducting the BCA identified cost savings. The selective list included project specific crash reductions, opportunities for plazas, landscaping, and benches, and contributed to bicycle ridership growth.

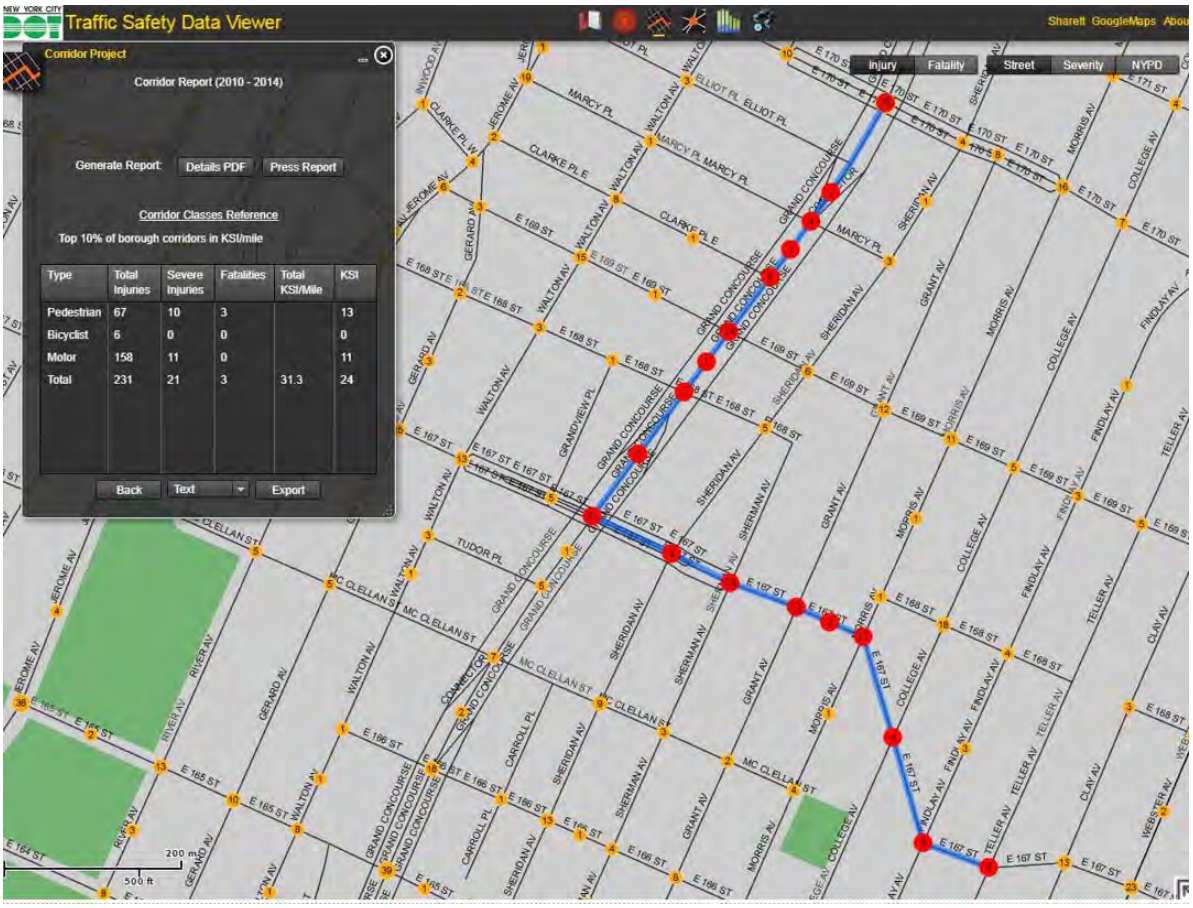


FIGURE 18 NYCDOT Traffic Safety Data Viewer with Benefit-Cost Analysis.

NDOT LESSONS LEARNED FROM LEVERAGING DATA SCIENCE TO SUPPORT OPERATIONAL DECISION MAKING

Mark Egge

Background

Data science is a relatively new discipline that uses techniques for identifying useful regularities into voluminous, varied, and high-velocity data. It is useful for identifying and describing relationships, forecasting the future, grouping and clustering, and accelerate pattern identification. Nebraska DOT (NDOT) is employing data science to assist in efficient transportation decision-making.

Methods and Measures

Nebraska Linking Infrastructure Challenges with Data (LINK-D) addressed how NDOT could modify their letting practices to increase the number of contractors participating in a letting. The analysis used 607 federally funded projects between 2011 and 2018, and it revealed that above a threshold of thirteen or more projects for lettings, the more projects in a letting, the fewer the bidders. The recommended solution would be to increase project size, lengthen advertisement

period, allow extra working days, modify the Disadvantaged Business Enterprise (DBE) goal, evenly distribute lettings, and optimize the letting schedule. More specifically, separate models identified that larger projects generally attract more bids, with no ceiling. That is, the data shows that the rate at which increasing project size increases the catchment area of regional contractors is greater than the rate at which projects get too large for local contractors. Staff advertised most of the projects for three weeks. Some projects, advertised longer, resulted in more bids. They also found that allowing flexibility with working days was associated with more contractor participation. Finally, their new Civil Rights office has new information about DBE goals that affect bidder participation, and their construction division is starting to try to even out the number of projects per letting, to avoid lettings with more than 30 projects.

The cable median barrier benefit-cost analysis (BCA) provides another example of benefits from the application of a data science approach. Crossover median crashes (CMCs) occur when a vehicle crosses the median and strikes an oncoming vehicle coming from the opposite direction. Due to the nature of these crashes (high speed, often head-on collisions), they tend to be particularly bad. Cable median barriers (CMB) are “soft” barriers installed in the median. They act as a safety net, catching out of control vehicles. FHWA recommends CMBs on divided roads narrow medians and higher traffic volumes. Because the medians on this stretch of road are wide (64 feet) and traffic volumes are relatively low, CMB were not cost effective for the rural sections of I-80 (see Figure 19). Nebraska saw an unfortunate spate of fatal CMCs on the stretch of I-80 between Lincoln and Grand Island in the spring of 2018, generating press coverage and speculation that CMBs could have prevented these deaths, and creating renewed interest in the topic. The data science approach app developed can conduct cable median barrier sensitive analyses. It helped to change the conversation, taking stakeholders from being told to “trust us” to being able to “see for yourself” as the data told the story.

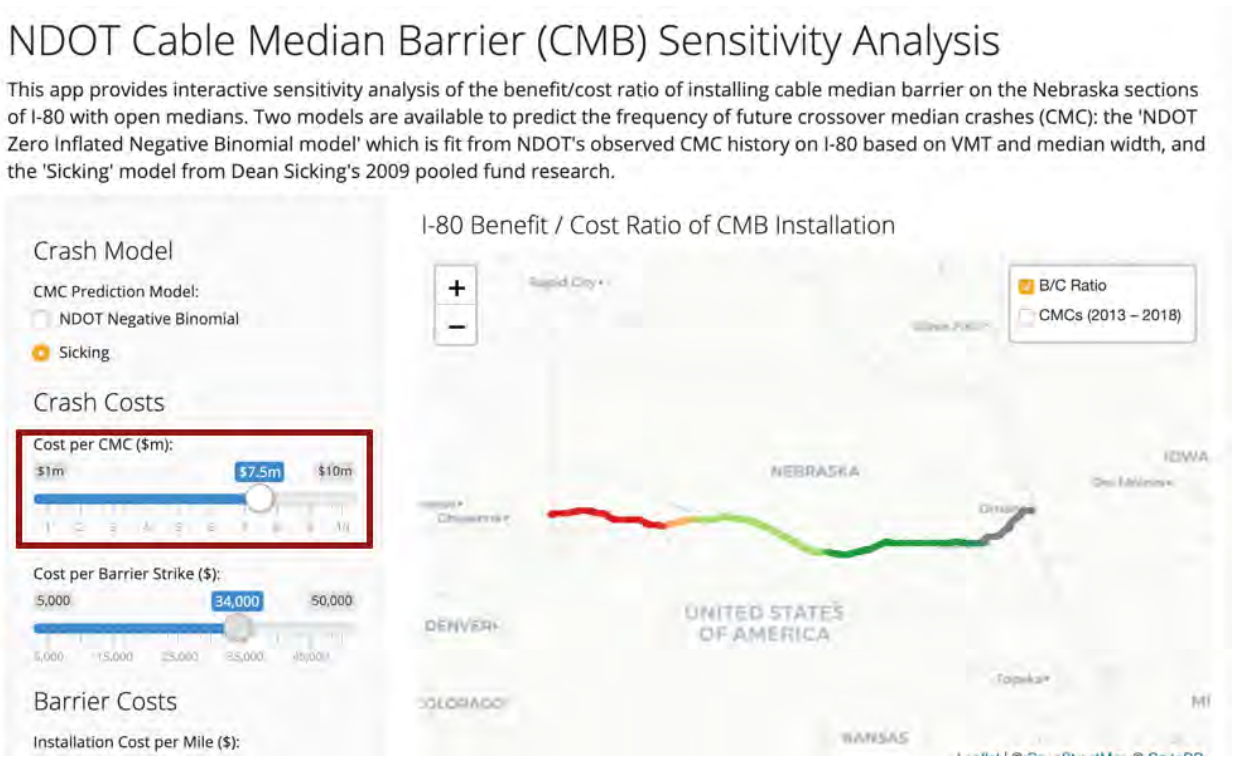


FIGURE 19 Web interface demonstrating I-80 Benefit-Cost of Cable Median Barrier.

Contributions

Data science offers a number of new advantages, including being able to fail fast and to fail with confidence. Data science makes it possible to try a variety of approaches with a large volume of data, with options for exploration. At the same time, it is not a silver bullet, and just working with the data provides new insights and possible directions to take an analysis.

Audience Dialogue

Question: In capturing societal benefits, property values and jobs are not included. How do you capture the value of livability if you exclude jobs?

Response: Equity is a high priority and is included in several aspects of a BCA. A BCA can tell what the benefit is, and what group is benefiting the most, and if others are being hurt. The analysis considered all people in NYC equally. While the researchers have been looking at ways to quantify access to jobs, it is not part of BCA. There are tools beyond BCA that deal with jobs.

Question: Bridge projects tend to have a much lower BCA, is there a rule for that? State of good repair tends to suffer from a BCA.

Response: For the most part, bridge analysis does not use BCA. At this time, for bridges, Life Cycle Costs approach is used.

Question: What is the role of the data analysis to make sure the "correlation" makes sense?

Response: Not everything correlates and there is a need for a better understanding of the issues. The best approach is to look carefully at the relationships, and then consider if there is a correlation. Integration of the two is essential.

Question: How did NDOT develop the contract vehicle for this project?

Response: The DOT drove the process. It was an open-ended contract with a defined general scope that allowed for the trajectory of the work.

Question: What is the right time horizon, and how do you consider that in the BCA?

Response: The recommendation is no longer two decades. It is difficult to envision beyond that time. In some respects, discounting provides a tool for BCAs for future consequences.

Question: With respect to real-time operations, are you using any crowd-sourcing data to help with event planning?

Response: Yes, we push notifications and partner with the university for events. We are able to tag all of the different groups and can push out information.

Question: If a data office is just beginning with GIS, what practical tips can you provide without having to tap into it with expensive methods?

Response: We would recommend tagging or any type of reference is key, even if it is point data (e.g., latitude/longitude) or linear data. Reference markers are necessary and there are a number of open tools that can help convert the information appropriately. If you can collect a little more (e.g., physical location), then you are on the right path.

Question: How was the "shining app" received at the DOT? How are they taking the work in?

Response: Our shining app is an open source app. The "black box" approach breeds uncertainty. We did not run into any acceptance challenges, but we did run into issues deploying it on the NDOT IT platform. There were also concerns regarding NDOT IT being able to support it. To date, we are not sure if it will become daily practice.

Take Aways

- Visualizing the data makes it easier for PennDOT to make decisions. In addition, geocoding and GIS make contribute to better and faster decision-making for DOTs.
- Texas A&M found real-time data helped communicate to end users, improving decision-making. Using different communication messages and tactics are instrumental to reach all the different target audiences.
- According to NYCDOT, it is not possible to conduct a BCA without large volumes of data. BCAs provide intelligence that inform designs, making it possible to perform "reengineered" solutions.
- Large data sets help improve daily processes when data science techniques are employed at Nebraska DOT. The approach encourages attempting new ways of solving problems and facilitates a greater willingness to fail as a cultural norm of data science.

SESSION 5B: LESSONS LEARNED ON DATA GOVERNANCE

Harlan Miller, *Federal Highway Administration, presiding*
Bill Keyrouze, *Association of Metropolitan Planning Organizations, recorder*
Richard Boadi, *Wood Environment & Infrastructure Solutions, Inc.*
Jim Padilla, *Texas Department of Transportation*

IMPROVING DATA ASSESSMENT AND GOVERNANCE TO SUPPORT INFORMED DECISIONS: LESSIONS LEARNED

Richard Boadi

Background

Transportation practitioners often have difficulty managing their data in a systematic and strategic manner, while at the same time, they are experiencing increasing regulations,

expectations for improving data-driven decisions, and transparency. The key to accomplishing these expectations is a thorough understanding of data governance. It is critical to policy development and is essential for accountibility and credibility. Data governance is fundamental to informed decision-making. Performance-based planning, asset management, system operations, and traveler information, all require significant investments and require data. Data governance is a process of applying formal and structured principles to the identification and gathering of relevant and quality data to address multilevel business needs. Data governance leads to improvements in data quality and completeness, and improves decision making by enhancing data accuracy and consistency. It assists in communicating consistent information and gaining trust from the public and stakeholders. It contributes to the maximization of resources by following the policy of measuring once and using data multiple times.

Methods and Measures

As transportation professionals become more dependent on high quality data for decision-making, data governance is a criticial consideration. A Data Governance Maturity Model measures the maturity of a state DOT's data program. It must incorporate the agency's prioritized goals and can be quantitative or qualitative. Figure 20 provides an example of a Data Governance Maturity Model with five measures (e.g., data quality, data collaboration, data architecture and integration, data life cycle and management, and data strategy and governance). There is a great deal of variation across different agencies with respect to their data programs. An effective Transportation Performance Management (TPM) program requires easily accessible, quality and consistent data, as well as the seamless flow of information produced and shared among different entities within the transportation agency. One of the critical enablers to

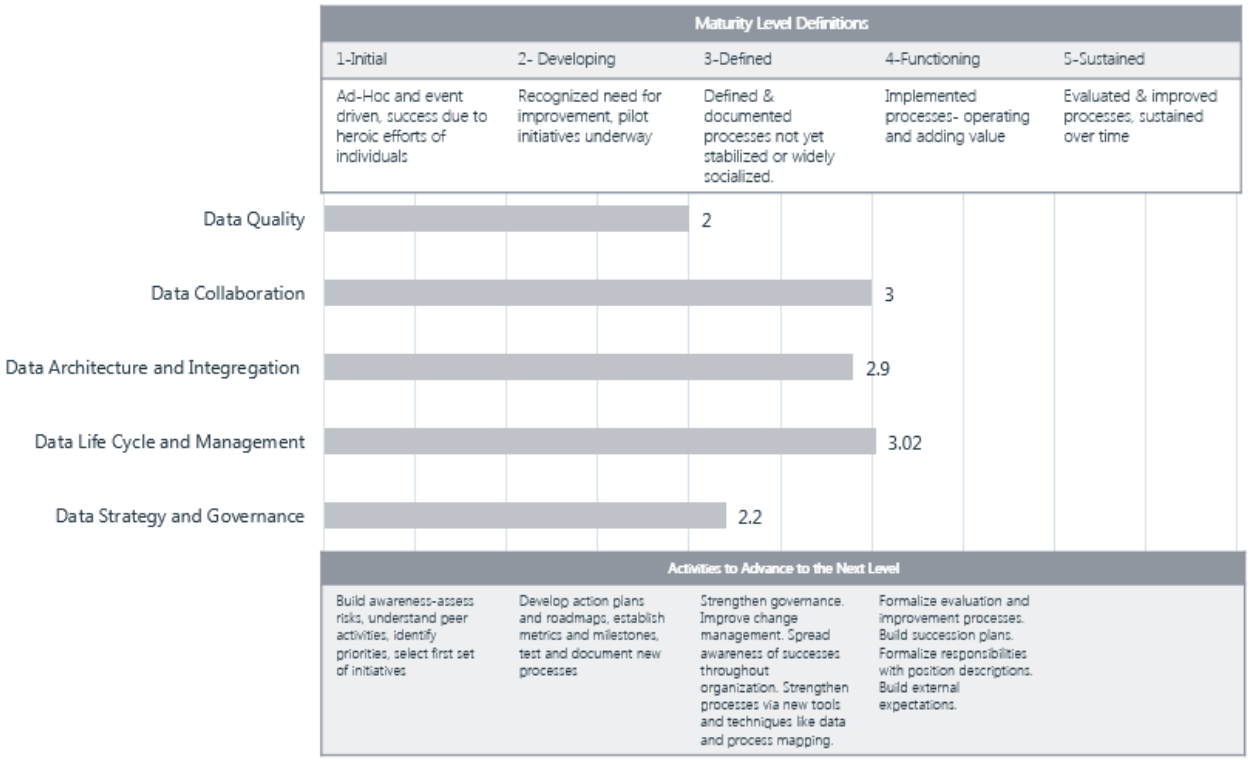


FIGURE 20 Data Governance Maturity Model.

achieving this level of effectiveness and efficiency in data and information use is to build a receptive Enterprise Asset Management System (EAMS). EAMS is a unified application software package(s) that supports business processes, information flows, data analytics and reporting across (horizontal and vertical domain) an agency. A receptive EAMS is a system that serves and balances the needs and skills of all staff at the strategic, operational, and tactical levels. Currently, state DOTs are transitioning from the more traditional approach of maintaining multiple datasets in fragmented management systems to implementing integrated software applications that maximize the use of data and information across different entities. The conventional approach presents its unique challenges associated with maintaining multiple management systems and replicating data standards across numerous, standalone systems. Similarly, transitioning to a unified approach requires strong coordination (stakeholder engagement), improved skills (capacity building), and effective governance (institutional shift).

Contributions

There are a number of lessons that have been learned as state DOTs take on a larger role in the use of data. These lessons are listed below.

- Lesson 1: We are all learning and moving into a data-driven decision-making environment that requires a significant effort initially and added responsibilties. It may also require new expertise and positions. In addition, current practice is now focusing on data pertinent to critical business processes.
- Lesson 2: Data governance is resource intensive.
- Lesson 3: You need a champion for data governance.
- Lesson 4: Proper governance can have multilevel impacts.
- Lesson 5: Data governance thrives on a strong data management strategy.
- Lesson 6: Establish data policies and standards.
- Lesson 7: No one-size-fits-all approach or a one-time project is recommended as a solution. It can always be improved and needs to be monitored and focused on incremental benefits. It requires support from all dimensions of the organization and does not guarantee perfect data.
- Lesson 8: Data governance is a process requiring the ability to identify and avoid major pitfalls, and to identify what they will do repeatedly.
- Lesson 9: Learn from your peer organizations, including how to manage the change process properly, aligning your data governance program with organizational/business goals, and recognizing the need for awareness and an understanding the impact of data governance on your stakeholders. It will require the implementation of effective support programs, training, and communication.
- Lesson 10: No one likes change. Data governance is a multi-year effort and will require setting short- and long-term goals and the identification of critical milestones and effective metrics to measure progress.
- Lesson 11: Measure your progress and increase understanding through simple messages by emphasizing benefits, costs, and risks and sharing consistent information through multiple avenues. It will require listening to stakeholders and find common grounds.

- Lesson 12: Communication is key to success.
- Lesson 13: Make data governance a part of your day-to-day process. Good data governance is critical to our business and the data governance maturity models are valuable tools. Data governance is an ongoing process and requires focusing on your organizational needs, without getting carried away. Strategic communication is a key to success and may require outside assistance.

HOW TxDOT TACKLED GROWTH IN PERFORMANCE MEASURES VOLUME *Jim Padilla*

Background

Texas Highway Department was established in 1917 and renamed the Texas Department of Transportation (TxDOT) in 1991. Today, TxDOT is responsible for maintaining more than 196,000 lane miles, over 54,000 bridges, and supports aviation, rail, maritime, and public transportation across the state. It coordinates with the state's 25 metropolitan planning organizations (MPOs), seven state-authorized rural planning organizations, nine regional mobility authorities, and a variety of local entities. TxDOT has approximately 12,000 employees in 25 districts and 34 divisions. Over the next ten years, TxDOT will program approximately $76.9 billion in projects. To prepare for this task, TxDOT saw the need for new department goals, including establishing a foundation for performance management. This transformation would require collective input, executive buy-in, and internal marketing.

In 2016, TxDOT began work to develop key performance measures (KPMs) that support the new values, vision, mission, goals, and objectives they were seeking. A number of workshops were held with representatives from divisions and districts. In addition, facilitated staff dialogue was needed to inform what is valuable to measure. The transformation faces a number of challenges, including the need for many measures to accommodate many consumers and many owners. To accomplish the new department goals and KPMs, and the development of interactive performance dashboards, TsDOT was prompted to take stock of performance management as a whole, including addressing *MAP-21* and *FAST Act* requirements. How does a DOT know and keep track of all that is being reported externally and applied internally? Do multiple definitions of the same basic measures exist? Does the internal calculation method differ from the federal requirement?

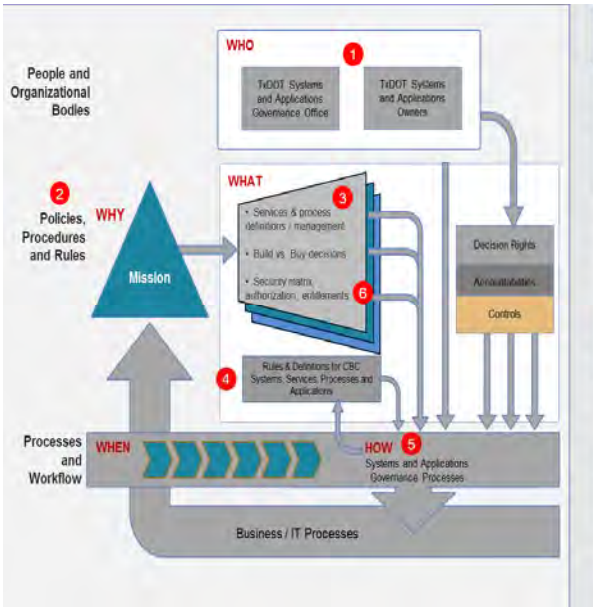
Methods and Measures

In 2017, TxDOT deployed an Enterprise Governance structure, a cross-functional approach to managing business processes, information (data and content), and technology, that impact the majority of the business functions. This created an opportunity to integrate performance management and would require the establishment of Enterprise Governance performance measures. In October 2017, TxDOT set up a performance measures workgroup to provide governance and coordination around TxDOT enterprise, departmental activities, and performance measures, and to keep open lines of communication. Executive sponsors included the Executive Director and Director of Strategy and Innovation. The working group was composed of twelve members with designated areas of representation, and members from

divisions and districts. The primary deliverables were to establish and maintain a single source of department performance measure information, and standards and guidelines for data visualization. This required a Performance Measures Inventory, a baseline set of 99 recommended department performance measures that was approved in December 2018. It was followed by the launching of the Performance Measures Governance Documentation database. It contains defaults to all measures and can be filtered by select fields, with keyword search capability, the ability to export information into Excel, and allows for the the data to be reviewed and updated quarterly. Figure 21 illustrates the flows and components of an enterprise information management system.

Contributions

With an enterprise inventory of performance measures established, and maintenance underway, TxDOT's Enterprise Governance structure promotes collaboration and coordination between working groups. There is strong recognition that performance analysis and management are linked to information management and data governance. Its analytical capability is bolstered by sound information management. Looking towards the future, what are the expectations for governed data? It should be a single language of communications across the enterprise for using data. The users of the data will be able to trust in the accuracy of analytical dashboards and reports and safely share data with internal and external parties. The system will need the capacity to rapidly design and implement enhancements based on changing business needs, or source system changes and maximize business value associated with data-driven actions and decisions due to high data quality and synchronized changes in data structures. Moving forward, the system will require continuous improvement of performance measures governance. The future uses will need to pivot from capturing documentation to assessing what is most important to measure, and the ability to leverage data automation to support real-time analytics.



Components	What it is	What it Does
Organizational Structure	A Data Governance (EIM) function with roles and responsibilities such as Owner, Custodian, Steward, etc.	Charged with facilitating and coordinating Agency data governance and stewardship activities
Policy & Standards Definition	Documented guidelines to ensure proper management of enterprise data and information	Establishes policy and standards around taxonomy, classification, integration, distribution, security, privacy, etc.
Data Quality Monitoring	Status reports for data quality and data integration	Shows where data is not supporting business expectations
Data Integration Definition	Documentation of key data integration artifacts	Maintains source documentation for all aspects of data integrations
Change Management	Control the introduction of data related changes	A way to keep technical components working
Data Security Enforcement	Control data elements, data usage, and data definitions	A way to manage data access to appropriate users based on roles and business needs

FIGURE 21 Role of Enterprise Information Management System with six organizing components.

SESSION 6B: IMPROVING DATA GOVERNANCE TO SUPPORT DECISION MAKING

Anita Vandervalk, *Iteris, Inc., presiding*
Ehren Meister, *North Carolina Department of Transportation, recorder*
Tarun Malhotra, *Michigan Department of Transportation*
Chad Baker, *Caltrans*
Leni Oman, *Washington State Department of Transportation*
Cassie Jordan, *Texas Department of Transportation*

DATA GOVERNANCE TO SUPPORT PERFORMANCE MANAGEMENT AND DECISION MAKING WITHIN STATE DOTs

Anita Vandervalk

Transportation agencies are at a critical juncture with connected and autonomous vehicles (CAVs), shared mobility, and smart cities. While the data continue to proliferate from both public and private sources at an astounding rate, methods of data analysis are also rapidly evolving. With continuing resource constraints and the need for transportation agencies to maximize the operation and maintenance of their systems, combined with the explosion of new available data sources and analytics capabilities, it is even more important for DOTs to leverage data. The key to overcoming challenges associated with leveraging, integrating, and providing data to customers is to organize it with data governance (DG).

DG is a critical element of data management and data business planning. It provides for the following: a central focus to identify and control the collection; storage and sharing of data; identification of stakeholder roles and responsibilities; enterprise data standards; data dictionaries; and metadata. In addition, DG includes standardized data quality assurance processes, knowledge management processes for sharing and retaining critical organizational knowledge related to data and information, and alignment of data program investments with agency needs. Many state DOTs are recognizing the need for more structure around DG and many are assigning chief data officers. States are at varying maturity levels with many lessons learned to share with others.

DATA GOVERNANCE

Tarun Malhotra

Background

Data is one of the most important assets of any organization today, requiring attention to its creation, governance, use, and access. Data should be created once and have a system of record (as an authoritative data source) throughout its life cycle, leveraged multiple times and used to address a variety of business needs. Industry best practices and guiding principles for DG offer direction for transportation professionals. Data must be governed, managed, and cared for, in a structured, tactical and replicable way. Whenever applicable, DG affects projects, maintenance and support, and daily business operations and use. Maryland DOT (MDOT) has five guiding

principles for DG: data is an asset, create one data record (source), use industry best practices, data should be governed and managed, and understand how data is to be used. DG is also called "info governance" and is the structure and formal process around data, with three categories of governance: proactive, ongoing, and reactive.

There is a cost associated with deviations from DG. For example, as organizations go away from data governance, costs goes up (e.g., the cost of salaries, duplication, wasted time) (see Figure 22). Setting up MDOT's DG has been a learning experience, requiring the highlighting of the "what's in it for me" to business practices.

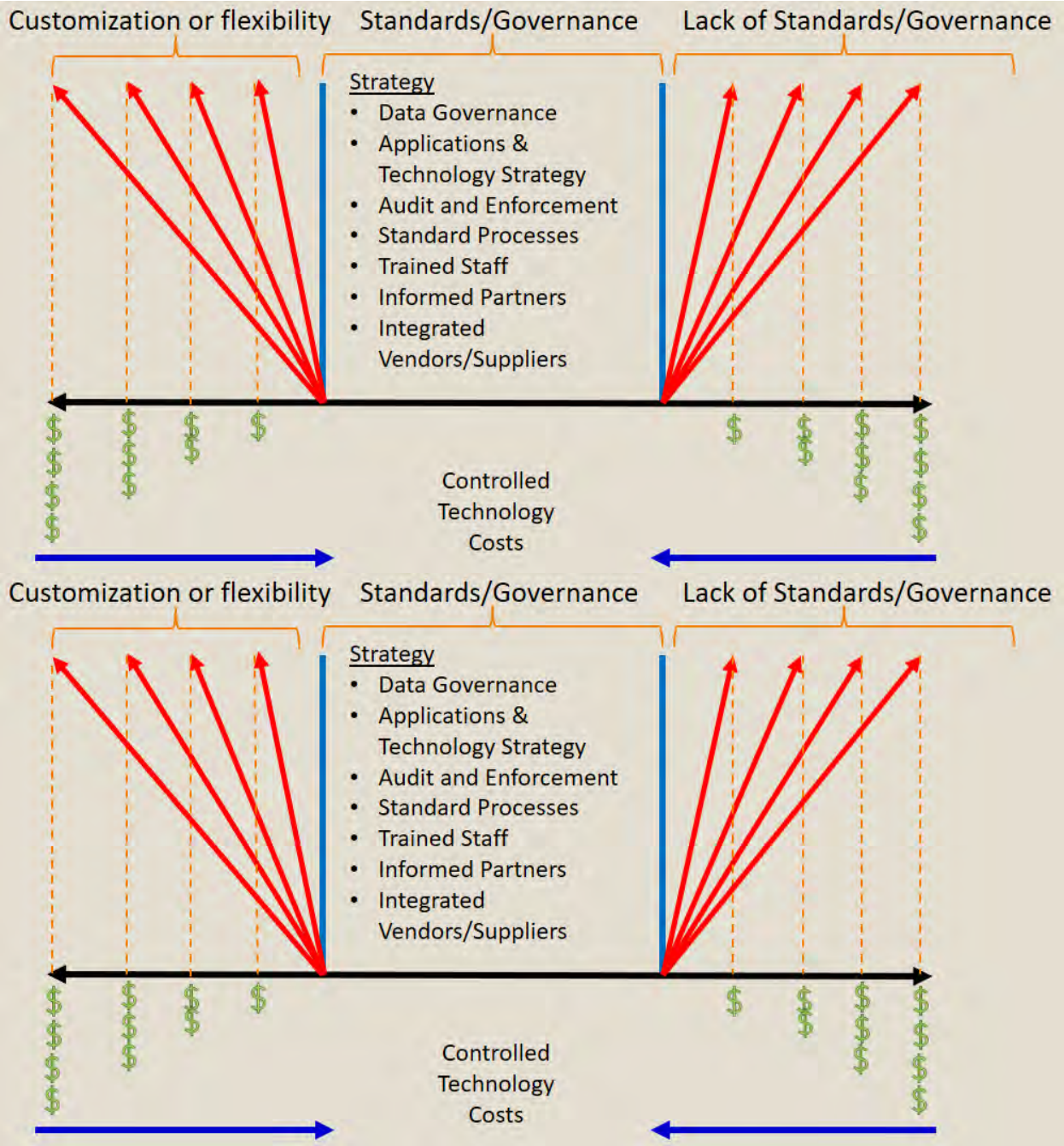


FIGURE 22 Cost of Deviation from Standards/Governance.

Methods and Measures

Incorporating data governance into an organization requires establishing standards with a governance structure and process to ensure compliance, and the development of a clear strategy aligned with the direction of your business needs. A successful DG program must be setup to facilitate an organization-wide strategic approach and structure to caring for data, one of our most important assets. A phased approach requires a set of steps. First, setup the structure, principles, policies, standards, controls, and decision-making authority, to facilitate a phased approach to better data governance as a repeatable, core business practice rather than a standalone "once and done" project. A structured, formal process for making additional policies and decisions provides a strategy for going forward and conducting business. It is necessary to build a process to validate, prioritize, or address identified business problems whose root causes could be attributed to data quality and governance issues.

Realizing value from DG begins with a series of tightly scoped initiatives with clearly articulated business value and sponsorship, by picking specific processes, or projects. Items related to master data management, transactional data quality, data architecture and design, data sharing and access, and data security, are in scope for discussion and resolution during the formation stages of a program. Each item or activity needs to be clearly scoped, with defined outcomes, metrics where possible, timeline for completion, and level of effort from key participants. Starting small allows for adequate training for a specific number of people working in the governance structure, as well as the identification of a finite number of business pain points to be addressed, with explicit understanding of the hours of effort saved, dollars saved and costs avoided. Those items executed without project management and additional funding, receive approval from the governance structure. Otherwise, IT Steering Committee approval is required.

Contributions

Organizations need to demonstrate tangible value of good data practices to the business to build partnership by conducting accurate reporting and analytics, cross-functional reporting, and increased operational efficiencies. There are opportunities for potential innovations in data (e.g., predictive analytics), leading to better strategic alignment and management of the applications and reporting portfolio. DG is not an IT-led effort. It is difficult to get previously siloed business units to work collaboratively toward organization-wide data governance, instead of business-area, or system-specific, governance. In addition, operational priorities tend to take precedence over longer-term strategic initiatives like data governance. Mitigating this risk requires an internal communications plan, demonstrating value to business areas.

ENTERPRISE DATA GOVERANCE AT CALTRANS

Chad Baker

Background

The California Department of Transportation (Caltrans) operates from their headquarters and twelve district offices (see Figure 23). They use a Centralized Information Technology (staff in headquarters and district offices). Caltrans has approximately 18,000 employees (field and office

staff), 15,092 centerline miles of state highways, and a $3.5 billion per year construction program. The passage of Senate Bill 1 Program provided for $5 billion in annual funding. At Caltrans, IT is located within the Department of Transportation. With the passage of Senate Bill #1 in 2017, which added $5 billion to their program, there was growing pressure for accountability. This motivated the need to lay the foundation for a data governance program. There was executive management support, including top leadership and the establishment of a special position. In the organization of a data governance (DG) program, it is best to leverage existing work (e.g., the Transportation System Data Business Plan, GIS Strategic Framework), trying not to start over, but using any available momentum.

Methods and Measures

In preparation for DG program, Caltrans conducted a self-assessment to determine Caltrans' status regarding their awareness, action plans, and operational plans. Careful attention needs to be paid to how to set a governance structure, with a major concern regarding bad data. Necessary steps include establishing definitions (what is enterprise data) and creating roles and responsibilities (e.g., what, who, why).

FIGURE 23 Twelve Caltrans regions.

Contributions

To get underway with the implementation process at Caltrans, they needed to motivate participation. The strategy of incrementalism appears to work best. The "Building California" program has three key aspects that include people, process, and technology. The DG program needs to be a priority of appropriate staff, the construction of a data dictionary, and tools to improve data quality with technology, always striving for constant improvement. There is strong need for partnerships (especially with early adopters or eager units). For organizational change management to succeed, it is necessary to remove problems, be compassionate, and remove any excuses. To deal with WIIFM (what is in it for them), staff need to show value throughout. Guidance should come from previous planning documents (e.g., mission, vision, goals, and strategic plans). It is also important to learn from others (e.g., peers), particularly similarly situated DOTs. Recommendations for a successful DG program include the following:

- Executive support a must;
- Constant communications;
- Dedicated resources to data governance, starting with one person and then adding more;
- Keep it simple and do not overwhelm yourself or the agency;
- Do not expect everything to be perfect;
- Shoot for quick wins;
- Do not do it all at once;
- Use existing requirements; and
- Provide constant support from DG office.

DATA GOVERNANCE AND KNOWLEDGE MANAGEMENT

Leni Oman

Background

An understanding of data governance (DG) and knowledge management (KM) begins with an awareness of KM, how KM and DG come together, with key aspects of the people, the process, the information, and the technology. Often, systems are fragmented and fragile, with issues regarding structure and process (see *Enterprise Architecture as Strategy* by Jeanne W. Ross). Washington State Department of Transportation (WSDOT) is "in season 5" of their data advancement initiative. They began their fourth generation of DG in January of 2019. WSDOT views data as an "information ecosystem" where numerous data relationships exist.

Methods and Measures

Deploying a project life cycle approach to KM requires people, process, and data (see Figure 24). In order to create a data-oriented foundation at WSDOT, staff worked with Spy Pond Partners, LLC, and developed the "enterprise architecture cake" with all the data and IT layers. The DOT provides some elements and some are separate and come from individuals or groups.

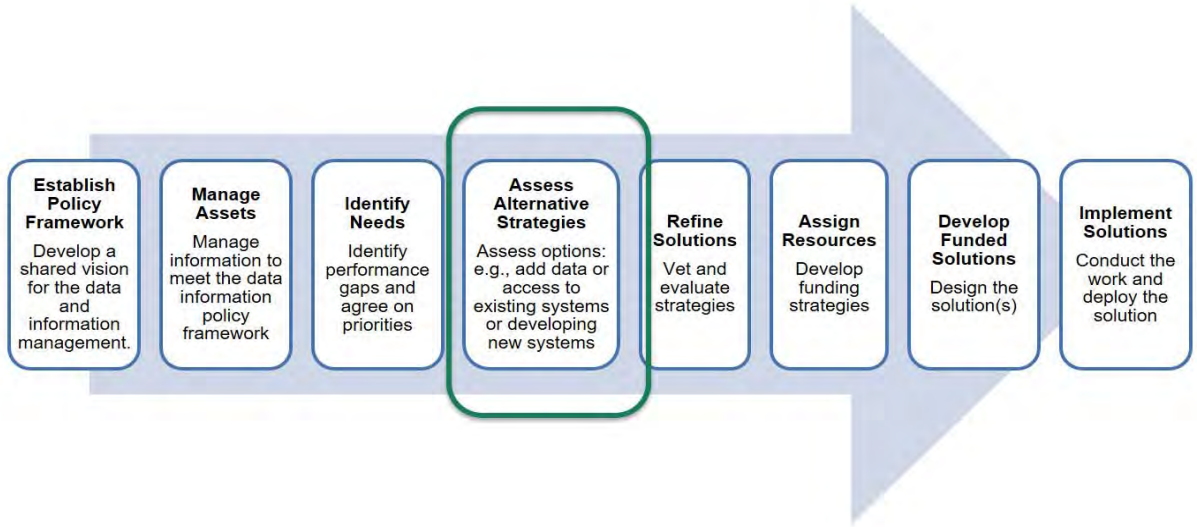


FIGURE 24 Visualization of a life cycle for information management.

Contributions

A one-size-fits-all program for KM is problematic. At the same time, it does not need to be a completely unified system to be functional. WSDOT continues to conduct research on data governance to support their system. Vocabulary management is important, including the development of glossaries and taxonomies. Often, there are too many definitions. WSDOT continues to work with Spy Pond to consolidate resources, including introducing a business function classification schema with five different areas to address how WSDOT conducts their work. The research is investigating functions and areas, processes, sub-processes, activities, and resources management (e.g., people and data).

ENTERPRISE INFORMATION MANAGEMENT

Cassie Jordan

Background

The Texas Department of Transportation (TxDOT) is a large organization with numerous divisions, districts, and technology solutions. Its data landscape is complex and spreads across the organization. This requires appropriate governance of data and information at each level, with common processes and policies that are enterprise-wide. Within their current federated model, each Operation Governance Team (OGT) controls a majority of their business and governance operations, with limited coordination from the enterprise. There is a desire for a future with governed data. Such an approach would use a single language of communications across the enterprise for using data. Having this type of data program contributes to building trust in the accuracy of analytical dashboards and reports. It allows users to more safely share data with internal and external parties. Having a harmonized data program also facilitates the ability to rapidly design and implement enhancements based on changing business needs or source

system changes. It also helps to maximize business value associated with data-driven actions and decisions due to high data quality and synchronized changes in data structures.

Methods and Measures

Providing staff with a stable, reliable data program supports core capabilities including organizational structure, policy and standards, monitoring data quality, data integration, and sources of truth. Data within an organization faces constant change to meet management needs, with trackable evidence of its importance. The environment requires a desire to address data security, with support from executives and material systems. At TxDOT, work groups dealt with tactical needs to address Enterprise Information Management (EIM), along with a data governance team. As mentioned, their operational model is a federated model because TxDOT is a large organization with the need to manage data with common rather than competing processes. Figure 25 depicts the relationships of the governance support system.

Contributions

TxDOT has gained a number of benefits with their model. Data ownership addresses where the data exists and how it is gathered. It is part of the job description for those involved in data processing. Having an EIM roadmap is key resource that assists getting buy-in from variety of stakeholders. The data architecture strategy depicts the process of flow from acquisition to delivery and solutions to dashboards. An important note is that no one should be able to alter the original, raw data.

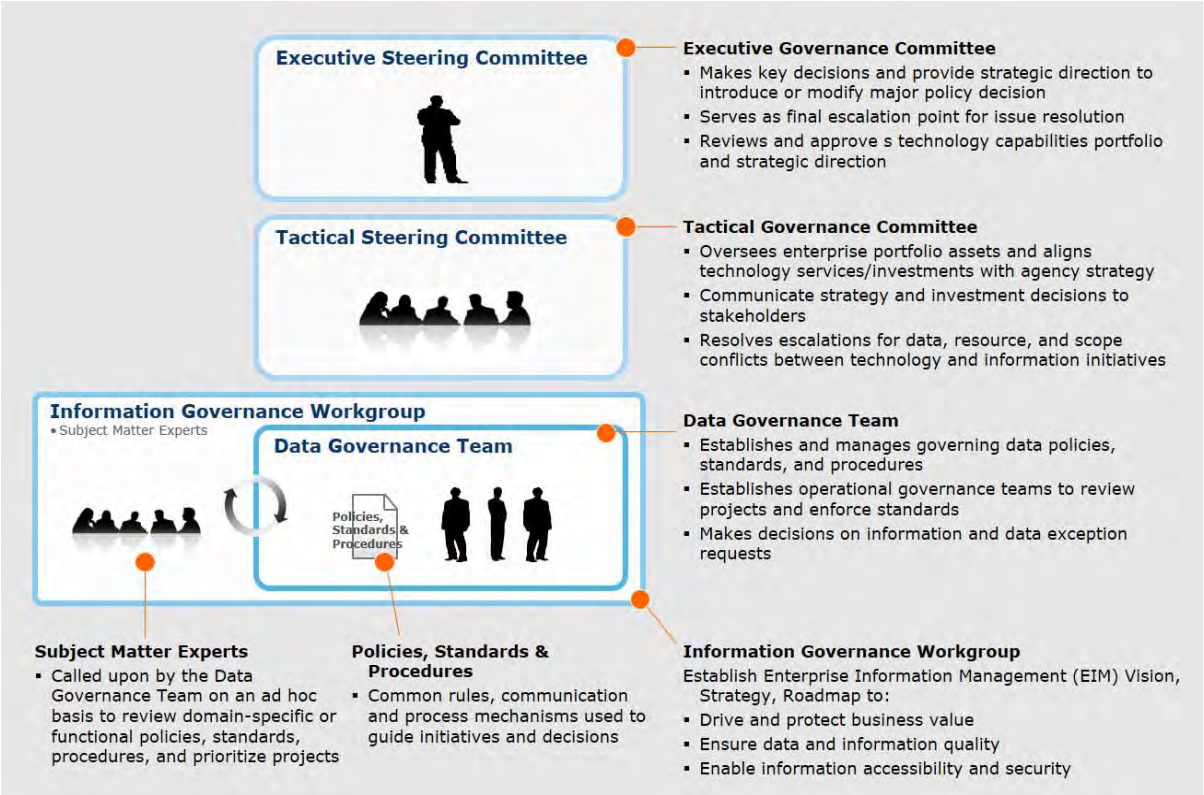


FIGURE 25 TxDOT Governance Support Structure.

RETURN-ON-INVESTMENT (ROI) OF DATA GOVERNANCE

Cassie Jordan

Background

"To know something is there and it's yet to be discovered" provides a reason for valuing data. Both policy and technology staff need to relate to data governance as both can gain insights from data. It is hard to define data governance (DG). It is a process and a journey, not just something pulled off the shelf. For any organization to take on DG, their executives need to agree to sponsorship. It is important to establish the goals for a DG program and to define them. The data provide a critical context, making it possible to tell a story when questions are asked of the data. Once the inquiry begins, more and more questions arise, sparking creative problem solving. In fact, data can lead to other data findings as well. The purpose of trying to understand return-on-investment (ROI) for these data is to understand the future and better navigate today.

Methods and Measures

ROI for DG is two pronged: qualitative and quantitative. Determining the ROI for data moves the process from reactive to proactive, while solving problems. Key elements for consideration include quality, utilization, accessibility, analytics, and discovery (QUAAD). In addition, consideration of integrating legacy systems and analytics platforms includes creating a workbench to test data theories. To truly understand ROI, ask: What can you do today that you could not do without DG and how does DG change that? For example, Colorado DOT (CDOT) uses a meta data template with twenty elements and a data readiness framework. The question to ask is: "What does data quality look like?"

Contributions

At CDOT, the ROI focus was geospatial. In transportation, the focus is on location data as everything has a location, making it a priority. It was exciting to have data talked about. Their data initiative updated their data to a one-source approach. The basis of ROI is analytics, situational awareness, and new knowledge.

Audience Dialogue

Question: When setting up a DG program, what did your self-assessment process look like? How did you get started?

Cassie Jordan: We found that a good practice was to develop use cases, identifying data pain points from business activities, and starting from there.

Tarun Malhotra: When we were first starting a DG process, it was "we need this, we need that." As time went on, we found it was better to start with a strategy and a business case. The business side must be involved.

Leni Oman: We started by conducting interviews with senior managers and wrote white papers on why DG was important.

Question: Why did your executives support DG?

Chad Baker: Our executives wanted to get answers that were accurate and timely, not outdated and wrong.

Cassie Jordan: At TxDOT, there had been an IT failure several years ago, that resulted in a loss of $10 billion on project delivery. The leadership recognized the value and took up the challenge of producing and using good data.

Leni Oman: Executives knew that data was the foundation for performance management.

Question: What were the qualifications for a chief data officer (CDO) for agencies that did not have it in IT?

Tarun Malhotra: Leadership thought the DG process included a "data trustee" relationship and that they needed to have ownership of it. The background of the CDO includes a strong footing with both IT and policy, and a good knowledge of the organization itself.

Chad Baker: Leadership wanted DG to be seen as an enterprise responsibility and not owned by one function (e.g., IT or in project delivery). Leadership decided to locate the DG function at the top of Caltrans rather than in a specific function, under a certain division.

SESSION 7B: PRIVATE DATA

Mara Campbell, *Jacobs Engineering Group, presiding*
Jennifer Libby Weeks, *Transportation Research Board, recorder*
Mei Chen and Xu Zhang, *Kentucky Transportation Center*
Bob Pauley, *Cellint*
Jason Lemp and Nick Caccamo, *Cambridge Systematics*
Leila Azizi, *Florida International University*
Anita Vandervalk, *Iteris, Inc.*

DATA AND TECHNOLOGY TRENDS—HOW DO THEY IMPACT DECISION MAKING PROCESS?

Anita Vandervalk

Background

Technology is changing the way transportation data is generated, collected, maintained, and utilized. Transportation agencies are at a critical juncture as sweeping innovations bring the potential to transform both transportation and our communities. Data points are proliferating with the near-term significant market penetration of connected (not yet autonomous) vehicles,

Vehicle-to-Infrastructure (V2I) deployments that facilitate delivery of safety and mobility benefits, and rapidly evolving shared mobility platforms, and smart community transformations. As the data continue to increase from both public and private sources at an astounding rate, methods of data analysis are also rapidly evolving. Transportation agencies are trying to keep pace. New data sources and trends will affect the way agencies use data, generate performance measures to measure, and predict outcomes. The newer techniques will allow DOTs to become even more predictive, and even prescriptive with mobility and safety improvements and treatments. The focus is on urban data and activity with challenges in accessing and harnessing the data from so many places. While smart cities may be mostly "hype", they are providing a model for public-private partnerships. The expectation is to harness key data and tech trends, using this new source of information. There are challenges including: getting people with the skills to harness and use the data; accessing data from so many sources; and determining which data is useful. Smart cities are both a source and a model for connectivity (e.g., smart intersections as an opportunity for multimodal safety, operations with signals). Transportation Systems Management and Operations (TSMOs) can also take advantage of this form of connectivity.

Methods and Measures

Technological aspects have expanded in size and type (e.g., cloud adoption, 5G, Empowered edge, IoT, AI, neural networks, ubiquitous connectivity). Industry has played a role in the development of products requiring new ways of thinking. For example, advancements in connected vehicle and autonomous vehicles has spawned interest in safety and Vision Zero. Another example is data analytics with an orientation towards smart cities. Users of these technologies have a solutions orientation, with opportunities for development public/private partnerships. The smart city focus also includes cybersecurity. Traffic management devices are a rich source of data. For example, 3% of traffic signals today are connected. Some private sector firms are venturing into this area of study.

Many decisions in transportation are in operations and are more real-time. These data reflect what is happening now. The challenge is developing uses for long-term planning. The transportation industry is ahead of many others in collecting data, but we are behind in the use of that data, and making decisions using the data we now have available. Another opportunity to use the data to change behaviors now, in the real time (e.g., signal timing to protect pedestrians in an intersection). Figure 26 illustrates the relationships in a Transportation As a Service (TaaS) approach.

Contributions

Transportation professionals will have even more partners in the future as the "data economy" continues to grow. There are data marketers and data producers. However, there are implications for agencies and the public with respect to the gap in the sensors. As TaaS continues to grow, there will be impacts on decisions. For example, from an economic perspective, will private sector sales and producers create monopolies? The growing volume of data is pushing towards a city focus because that is where the data is generated. As a result, there are implications for rural areas and the ability as an industry to plan for and serve rural communities. The access to large

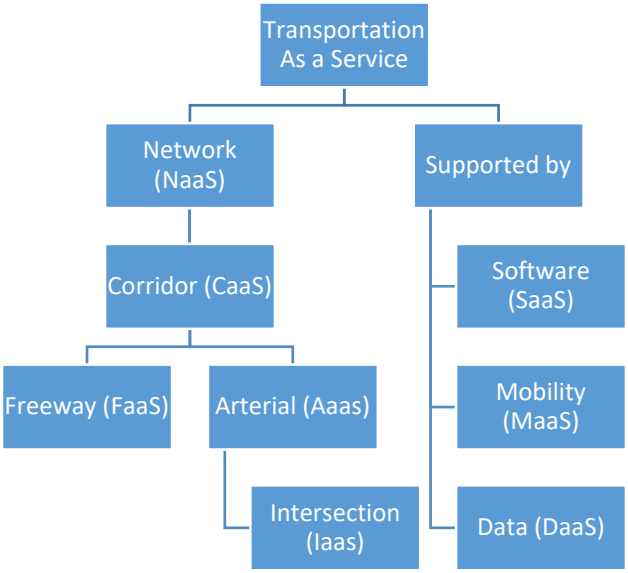


FIGURE 26 Elements to a Transportation as a Service (TaaS) operation.

volumes of data will fuel performance management. Using all this data effectively suggests a need to understand the ramifications of full utilization (e.g., signal timing, traveler information, route management, Integrated Corridor Management [ICM]). The goal will be to manage the transportation system based on desired results to meet public expectations, and at the same time to keep up with other industries already moving more quickly in the use of their data.

BIG DATA—PROCESSING, LICENSING, AND USE

Jason Lemp and Nick Caccamo

Background

Private sector data is becoming particularly important for the transportation industry. Location-based services (LBS) data are often referred to as "breadcrumb" data from mobile devices. Apps operating on mobile phones also generate data. The characteristics of these data include huge sample sizes, can identify individual trips, can track a device as it moves over days and weeks, and can be anonymized. The uses include origin/destination (O/D) flows (may be better than travel survey data); trip rosters as complements to survey data; a source for trip rates with high granularity; trip chains; and day-to-day changes in travel. The data can be geofenced for a better understanding of movements within a specific geographic boundary.

Methods and Measures

LBS is by its very nature disaggregated. Research can aggregate it to Block Group geographies by time of day. With some analysis, these data can also provide inferences of trip purpose. At the same time, LBS data faces a number of challenges. For example, technological challenges stem from the need to understand LBS and its composition. Many of the assumptions attached to the data are inferred, not observed, requiring care to avoid misuse. While the sample sizes are

massive, they are still samples. They will have omitted some behaviors and it is unclear what is missing. It is not possible to know who is missing. There are legal and contractual issues to consider. For example, some personally identifiable information (PII) exists in the raw data, requiring post-processing to protect privacy.

When there are public data requests, the data requests should protect the individuals. Pressure is increasing on consumer protection, with questions on data collection techniques and data potentially sold for profit. Facebook is an example of how people are affected by private sector use of data. These data are often sold to third-party vendors who compile, reformat, anonymize and aggregate the data, repackage it, and license it to other industries. The California Consumer Privacy Act (2020) is a direct response to public pressure for more privacy, affecting the collection and use of data. It gives consumers the options to "opt out" of data distribution to third parties and could have implications for transportation planners and researchers. Since it is still a new bill, the impacts are yet to be determined. There may need to be some changes to the application of the law through legal interpretations and it could be modified by amendments. The California law is broader than other states currently, but if successful, other states may follow California's lead. These legal actions may affect the availability and use of personal data from the original source collecting it. Data rights arise from the fact the data are proprietary intellectual property. The industry is moving towards a subscription and licensing strategy of data to protect the anonymity of the data. At the same time, there is a need to consider vetting LBS data.

The transportation industry needs to know what these data can and cannot tell users. This is important when comparing data collected from third parties with more "traditional" transportation sources (e.g., National Household Travel Survey [NHTS] data). Data expansion is problematic because data collection practices disregard traditional statistical practices. The sheer volume of the data requires new skillsets to handle the data in a cost-effective way. Figure 27 provides a comparison between LBS and the NHTS with respect to trip details. As an increasing

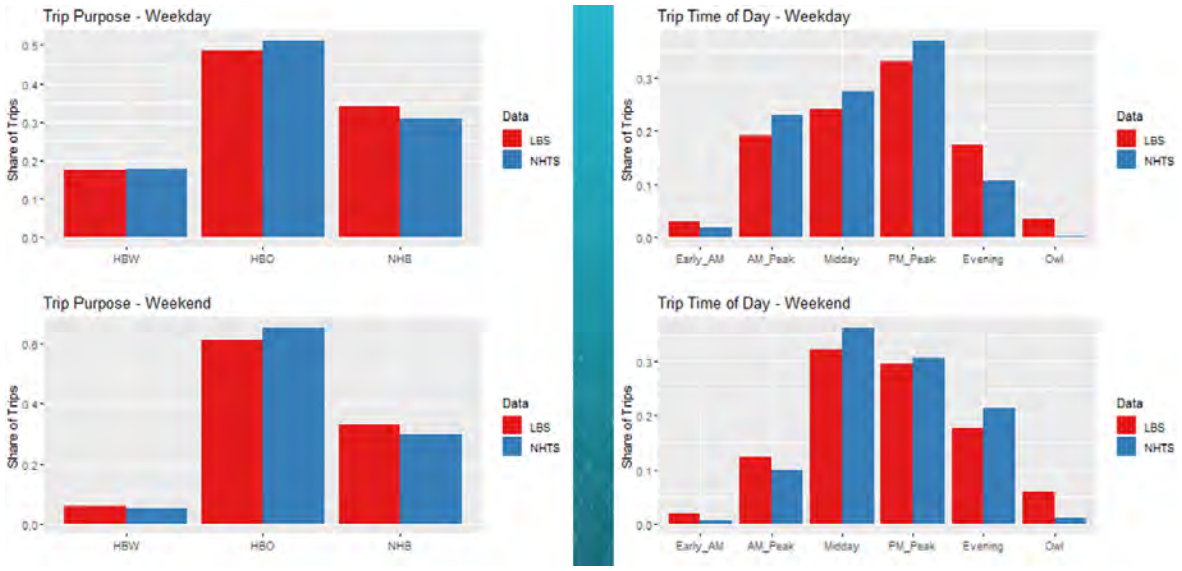


FIGURE 27 Comparison of location-based services (LBS) and National Household Travel Survey (NHTS) trip details.

number of companies have access to consumers' personal data, there remains the challenge of validating the patterns observed in the data in terms necessary for transportation planning applications. One strategy is to attempt to validate trip origins against the Southern California Association of Governments (SCAG) Model.

Contributions

Transportation professionals are now taking advantage of LBS, but face challenges with the nature of the data and vendor practices. Most public sector agencies have contracting terms based on an ownership model. As LBS data become more prevalent, it will be necessary for public agencies to have the flexibility to reshape their contract terms to move towards a licensing, or subscription model as a contract structure. While measuring travel movements is becoming more important, agencies look to private sector data (including LBS) as a source. At the same time, these data cannot answer all the questions necessary for transportation planning. Questions remain on whether it will replace other data sources, or become a supplemental source. The actual contractual language in the data procurement process could be the key moving forward. It remains a question for public policy if the data are being collecting in public spaces (e.g., right-of-way of roads). Should the public sector expect access to the data harvested on rights-of-way? On the other hand, what about the licenses that could result in states and the public sector being faced with additional costs instead?

OPPORTUNITIES AND CHALLENGES OF USING PRIVATE SECTOR DATA

Mei Chen and Xu Zhang

Background

Recent technological advancements have led to new types of data that can provide insights into a wide range of travel characteristics. Third-party providers collect and process the probe data into various products such as speed, origin-destination (O/D), volume, and incident alerts. They are playing an increasingly important role in transportation agencies' some core function areas. There are many new types of transportation data becoming available (e.g., GPS-based vehicular location data, cellular data, location-based services [LBS]). Traditionally, transportation planners have relied upon user-reported data, but now these sources, including smart phone apps, are providing similar data. There are challenges associated with acquiring and using such data including contracting, open record laws, the data quality, and the need for data integration. FHWA provides the National Performance Management Research Data Set (NPMRDS) aggregated probe data for the National Highway System (NHS), however is it not sufficiently comprehensive for many agencies. As a result, some agencies are purchasing additional probe data. How can agencies integrate data from FHWA for the NHS when the formats and content may not match? Do these two sources now reflect the true condition of the system?

Methods and Measures

NCHRP Synthesis 541: Practices on Acquiring Proprietary Data for Transportation Applications reviewed data acquisition and use practices, including the types of data acquired

and the procurement process. It provides information on agency experiences using the data, including how agencies handle legal and privacy concerns. The research used a survey to collect responses from 42 state DOTs, with the additional challenge of locating the right person(s) with the necessary experience to provide input. Thirty-three of these agencies have acquired proprietary data for planning purposes. The synthesis study compiled practices state DOTs and MPOs have leveraged to acquire and use these emerging forms of proprietary data, focusing on the types of data that have been acquired, agency experience on data use including integration, evaluation and caveats, the procurement process, and legal and privacy concerns.

These new sources of data have a number of challenges. For example, there is generally sparse coverage on arterials and lower functional roadways. There is an absence of traveler and trip characteristics (e.g., O/D data). The data itself as a source may be biased (e.g., demographical bias in O/D distributions, lack of non-motorized travel data). There are also concerns that there could be a bias toward certain carriers and source data providers in freight data. An overall concern is the lack of ground truth for data validation. Another challenge surrounds the ability to integrate the data and particular network discrepancies. A major challenge often cited by agencies pertains to the integration of proprietary data. Third-party providers attach these data to a separate (and often proprietary) network whose referencing system and segmentation scheme differ from the networks maintained by state and local agencies. Figure 28 illustrates Kentucky's network conflation process. Kentucky developed a robust network conflation tool that links the high-resolution network from HERE Technologies with their highway network. Kentucky developed this tool to facilitate the integration of private sector speed data with agency inventory data for the purpose of statewide network screening and highway project prioritization.

Contributions

Looking forward, there will be new types of data and emerging products for agencies to consider as their needs evolve. It is a challenge for DOTs to keep up with the latest advances in technology, market conditions, and issues surrounding data availability. To meet these challenges, state DOTs will need to have a continued dialogue with peer agencies and potential data providers. There are also important administrative needs (e.g., Request for Proposal (RFP) specs, vetting). DOTs will need to determine the right product for their needs. One strategy is to use a Request for Interest (RFI) to get a better sense of what a contractor or vender will be able to provide, given the needs identified. The cost factors require consideration of needs and available products during this process. In addition, legal issues of concern include terms of use (e.g., single project or multiple uses), data sharing with MPOs or other places, and the implications for open records. An understanding of staff expertise and current IT resources and support will affect some purchasing decisions as well.

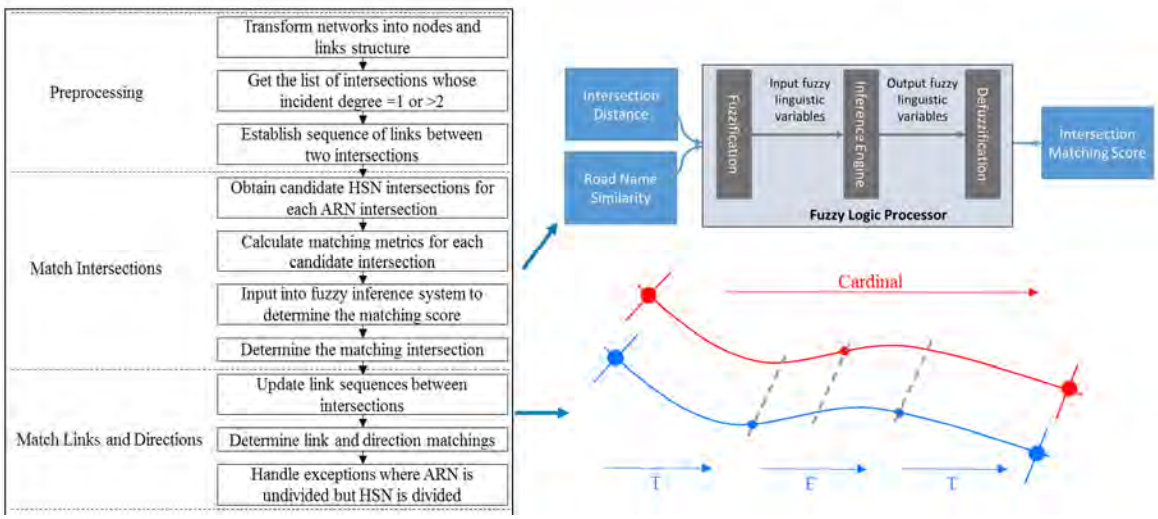


FIGURE 28 Kentucky network conflation process.

ESTIMATION OF MOBILITY PERFORMANCE OF FREEWAYS BASED ON TIME EXPOSED TIME TO COLLISION USING TRAJECTORY DATA IN A CONNECTED ENVIRONMENT

Leila Azizi

Background

There have been limited efforts to investigate the potential of using detailed trajectory data obtained from image-based sensing, connected vehicles (CV), and other sensors. These data sources are useful for deriving measures for assessing traffic mobility performance and the activation of management strategies based on this assessment.

Methods and Measures

The method for the mobility assessment of freeway traffic streams based on emulated CV data can support off-line and real-time decision making. Stop-and-go traffic is associated with traffic state transition to congestion, traffic breakdown, and instability. There is a relationship among the number of stop-go events, the number of vehicles in platoon, and a measure widely used as a surrogate to safety, the time exposed time (TET) to collision. The data available is from Basic Safety Message Part 1 (BSM I), which includes vehicle position, heading, speed, acceleration, steering wheel angle, and vehicle size. Part 2 includes air temperature, wiper status, light status, road coefficient of friction, Antilock Brake System (ABS) activation, Traction Control System (TCS) activation, and vehicle type. Researchers characterize these data as high-resolution data with microscope measures. The data statistics developed from the raw data include the standard deviations of the speeds of individual vehicles, standard deviations of speed between vehicles, acceleration/deceleration of individual's vehicle, and spacing between vehicles. The macroscopic measures include mean speed, traffic flow rate, occupancy, and trajectory data.

Investigating the use of microscopic factors contributes to the understanding of traffic flow perturbations as indicators of breakdown, in addition to the commonly used macroscopic measures that provide a disturbance metric. There is an algorithm for traffic state identification and prediction based on disturbances by individual vehicles, especially in transition from uncongested to congested condition. In addition, investigations on accuracy of estimation of disturbance metrics at low market penetration contribute to our understanding of traffic behavior. Oscillation (stop and go) is a deceleration phase followed by an acceleration phase occurring as a traffic state transition during congestion, related to traffic breakdown.

These data are surrogate safety measures (see Figure 29). For example, platoon stability and traffic flow stability uses the fact that the stability of platoon can be associated with spacing between the vehicles. Traffic flow stability can be determined graphically, with a platoon and standard deviation of speed. There is a relationship between location of the vehicle in a platoon and its standard deviation of speed. Traffic breakdown events can occur over a wide range of traffic conditions. Finding relationships between traffic perturbation at the individual vehicle level and shockwave formation will improve the identification and prediction of the congestion formation. Indicators of perturbation in traffic flow is a method for state identification uses K-Means Clustering, with different combinations of the factors tested based on: the ability to represent certain states correctly and visually inspecting trajectory data to isolate stop-and-go conditions from other conditions. The average silhouette is the relationship between disturbance metrics and standard deviation of speed.

Currently, there is a low market penetration of CVs. The TETIndex estimation requires the location and speed of both the leading and following vehicles. The probability of two vehicles following each other and being equipped with CV technologies to get this data is very low at low market penetrations of CV data. A regression model was developed to estimate it based on speed parameters. Researchers tested the model using real-world trajectory data from two locations not used in the development of the model. There is a relationship between TETIndex and speed parameters. Researchers plan to develop a model to estimate TETIndex where there are low market penetration of CV data.

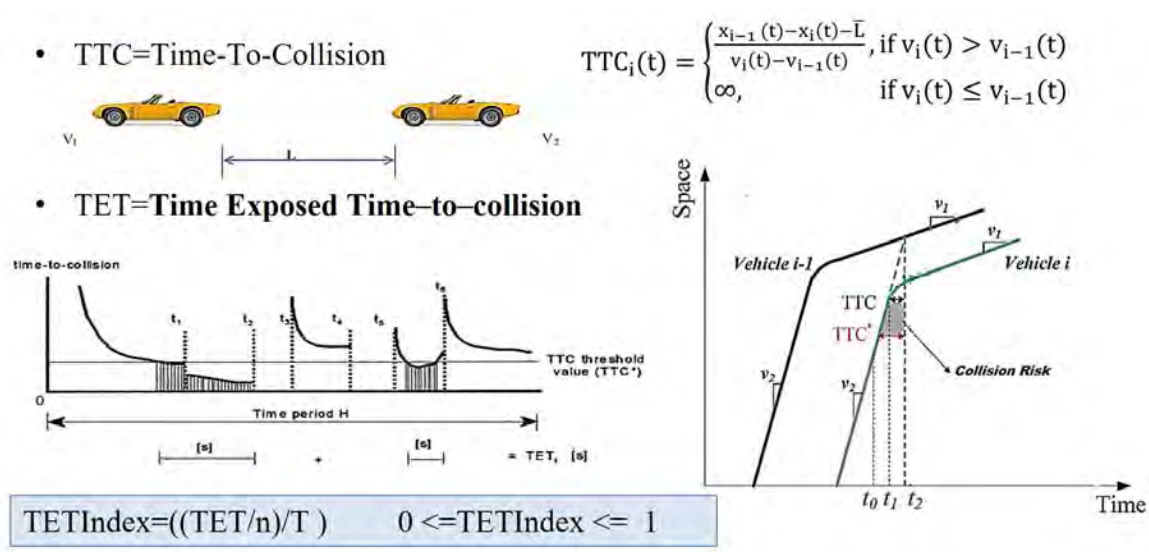


FIGURE 29 Surrogate Safety Measures for connected vehicle operations.

Refinements for mobility assessment using disturbance metrics (TETIndex and number of oscillations (NO)) have potential use in real-time operations. Researchers can estimate TETIndex with low trajectory data sample size based on speed parameters with an error of around 15%-20%. Adding TETIndex and NO, in combination with speed and occupancy in data clustering will result in accurate traffic state recognition. TETIndex greater than 0.05 And NO greater than 20% provide criteria for breakdown identification.

Contributions

CV data can be an alternative source of data for planners. As a high-resolution data, it has capabilities other sources may not have at the micro (individual travel) and macro levels of analysis (e.g., average speeds). Patterns of travel disturbances in the data include traffic flow, speeds and delays, stop-and-go travel associated with construction and other sources of interference. The micro data is useful for safety analysis (e.g., access to incidents). Possible strategies for validating the data include using VISSIM and NGSIM to assess the quality of the trends with observations of the macro data. TET is a mobility measure, in addition to a surrogate traffic safety measure. In the absence of a large sample size of trajectory data, researchers can estimate TET based parameters, measured at low market penetration of trajectory data. The proposed methodology provides a decision support system for traffic management center operations.

Audience Dialogue

Question: Regarding low market penetration of CVs, why do you need the position of both of the connected vehicles if the position of one indicates of the position of the other?

Response: Because there are so many cars without CV capacity, you might have several vehicles between them.

Question: How long will it take transportation agencies to shift the risk of data collection and use of the private sector?

Response: From a private provider perspective, the public sector should make this change to using private sector data collection. For LBS and other probe datasets, the public sector has already looked to the private sector to provide these data

Question: Concerning LBS data, what about equity issues?

Response: There is a bias related to populations who do not have access to their own mobile devices (e.g., lower income community members). At the same time, people who travel with and use their phones more often, will be represented more often in the data. People who opt out and turn off their location sensors would not be included in the data and create a form of bias.

Take Aways

- Using private sector proprietary data creates concerns for public sector agencies relying on these data for analysis and policies. For example, are there risks regarding data quality, particularly over time?
- Without knowing what the actual source is for these data, what are the appropriate steps when analysis shows conflicting results?
- While agencies have been striving to become more transparent with their data programs, what are the consequences of using proprietary data going forward?
- Some transportation agencies currently view any functions that are core to their operations as being better conducted in-house rather than being outsourced.
- At this time, agencies are making use of local universities (e.g., the Kentucky research with conflation) to support their in-house capacities to analyze third-party data sources.

Chapter 4

Plenary Session: How Data is Changing the Structure and Role of Public Agencies

Matt Hardy, *American Association of State Highway and Transportation Officials, presiding*
Joseph Schofer, *Northwestern University, recorder*
Samantha Biddle, *Maryland State Highway Administration*
Tim Henkel, *Minnesota Department of Transportation*
Ryan Huff, *Nebraska Department of Transportation*
Michael Pack, *University of Maryland, CATT Lab*

DATA CHANGING AGENCY FOR THE INSIDE

Samantha Biddle

A great deal is changing for transportation planners and decision-makers (e.g., operational data, data governance, modernizing hardware and software, organizational structure). There are benefits from using communication tools, data-driven decision making, real-time information, analytical insights, and scalable business processes, with a cultural shift towards inclusion. The environment has become more inclusive where anyone can pitch an idea. Using business analytic support produces more outcomes. These changes are spawning new offices, new teams, new recruitment tools, knowledge management platforms, and IT help desks.

Maryland Department of Transportation (MDOT) has a centralized data management system with a strong data governance team. Data is the foundation of MDOT's operations, as demonstrated in their organizational structure. Data is front and center for planning, engineering and design, operations engineering, and administration. It is also predominant in their asset management groups, planning, maintenance, and financial management.

Over time, the data governance function has been moving up and more central within the organization. It is now in a new structure under IT and deals with IT operations, project management, and data governance. Special attention to data governance is occurring with wireless access and modernization. In addition, cultural shifts are encouraging more emphasis on data governance and its impact on assuring the right public face. Progress in new uses for data are being made for mobility, safety, and asset management.

Question: Why does context for information matter?

Response: Staff take care to adapt planning and design analysis to one of the five statewide contexts. In addition, policies have been adapted to these contexts.

STRUCTURING YOUR AGENCY TO DISSEMINATE INFORMATION TO DECISION-MAKERS

Tim Henkel

Today's planning processes need to be structured, continuous, and use risk- and performance-based approaches. Most agencies are developing a family of plans so they can show decision-makers where decisions have been made that are based on these plans and can be understood internally, as well externally (especially by members of the legislature). Having plans available ensured decision-makers know where to go for information. The information they are seeking are located in a number of plans for transit, pedestrian, bike, highway, freight, aviation, rail, ports, and waterways. These plans help to document and guide what planners are doing, and that they are doing what they committed to do. It is important to connect planning, investments, and reporting, by connecting the objectives to investments to performance reporting. To ensure accountability, an organization needs a structure to inform all decision-makers in a timely manner. The communication provides information on measures, targets, and information sources. In some cases, automated reporting can provide a single source of data for consistency in response to questions. Often this process can be web-based, assuring availability inside and outside.

A good image for guiding an organization is a 3-legged management stool, with a leg for performance management, another for risk management, and the third for asset management. Using this approach helps to clarify to leadership the importance of organizational and governance structure. It can also assist in identifying responsibilities throughout an agency. The appropriate roles include executive, leadership, staff in policy (governance committee), people (resource investment committee), and project areas, including transportation program investment committees. These committees make recommendations to upper levels of Minnesota DOT (MnDOT). Enterprise risk management extends to areas of concern including enterprise level, program level, and project level risks. All of these levels are important to address, at the same time, tying risk management to decision making, to ensure leadership is informed regarding risks at all levels. Agencies can use simple tools to disseminate risk and risk management information.

Question: Given the frequency of plan updates, how do you address assurance of consistency among them?

Response: Having an overall vision helps assure consistency across all the plans over time.

NEW AGENCY APPROACHES TO FULFILLING PERFORMANCE ANALYTIC NEEDS

Ryan Huff

Before 2017, most agencies conducted very little data analytics on a routine basis. They might participate in data governance and were able to produce individual performance dashboards, when needed. Subsequently, most agencies are now engaged in data analytics. Salaries for serious data scientists are very high (e.g., $128,000–$165,000). In most cases, these salaries are higher than agency directors on an annual basis. Instead of having in-house staff, some agencies use consultants for their data analytics needs. These consultants can be engaged in multiple

projects. For example, taking a data analytics approach to a winter work policy allows an agency to address the question of whether or not to allow winter work on construction. Will this approach save or cost more money? In fact, a data analytics approach indicated that winter work saved money. While inspection costs may be higher, other costs will be lower. Using data analytics to study multiple policy questions is also possible with today's technologies. The data analytics is now driving a number of decisions. In addition, an agency can engage in open-ended consulting exploration at the intersection between analytics, dashboards, and visualization.

To introduce data analytics into an organization, it is necessary to describe the nature of the work with the consultant. Each small study could cost approximately $10,000, for 40-60 hours, for 4-8 weeks, with 4-5 one-hour meetings. In some cases, the studies can confirm previous decisions, providing validation and building confidence within an organization. In some cases, the studies can make other, counter-intuitive findings more credible. "You can lead horse to water, but cannot profoundly change its business practices"—even with the data. It is important to remember the need for having the right data, and having an interesting, important question that can be answered with this data. For example, what is the effect of electric vehicles (EVs) on motor fuel tax (MFT) revenues? Other examples include what is the effect of EVs on MFT revenues. The appropriate data can be compiled data from multiple sources and used with an interactive tool to explore this relationship. The data analytics, along with visualizations, can be useful in determining whether a policy is working. Having this type of analysis receives strong positive response from a CEO.

HOW CAN AGENCIES BETTER PREPARE FOR DATA TODAY AND THE UNKNOWN OF TOMORROW?

Michael Pack

There has been rapid growth in data availability, with new sources emerging and new types of data. Today, external organizations are trying to sell these new data products for a profit. This requires agencies to develop an understanding of data purchases and vendors practices. Just having new data alone is not the answer. Agencies need policy guidance, research, and support to get the most value from their data investments. To be useful, the data need to be accessible, understandable to managers, and to planners.

To be effective with data, agencies will need tools for fusion, statistical analysis, integration, and visualization. Importantly, agencies will need domain experts in transportation involved in the development and processing of the data to ensure its usefulness to an agency. The expectation is that the data will assist in communicating circumstances and be able to assist in storytelling (perhaps a lost art). The data should make it possible to tell a compelling story about a compelling issue, and promote important discoveries and observations. For stories to be effective, they need to be well understood and capable of reaching multiple audiences. Data-driven journalism provides illustrations of how this could work (e.g., Alan Alda's communication training).

Agencies need to focus more on their data policies. For example, agencies should not necessarily give away their data, only to have to buy it back again. A new source of data will be in the realm of connected and autonomous vehicles (CAVs). They are slowly gaining a presence and they are definitely generating data when they operate. A key question is who owns the data. Is it the manufacturers or the integrators? A suggested practice is to require in early negotiations

that data come back to planners and public infrastructure owners. Such a requirement would require action now to secure access to this data for agency management and planning. Why not hire data scientists and train them to do transportation? We normally train transportation planners to do data science.

Another approach would be to establish a trusted relationship with a consultant in order to build a long-term relationship, so that agencies do not fall into a cycle of hiring, firing, and then having to rebid for services. Establishing a long-term relationship preserves the knowledge that consultants gain about an agency's system. Another approach is to work with universities interested in research. Agencies do need to beware of distractions and hypes (e.g., block chain, machine learning, AI). Most likely, these methods are not relevant to agency-level transportation problems. Agencies need to be aware of technology "hype." For example, cloud computing is not a solution for everything.

To be a good consumer of data products, agencies need to know and understand the terms and technologies. In attempting to predict the future, most likely, data is not going to get any smaller, so agencies need to be ready for more and more data. They should expect data collection infrastructure to become less necessary (e.g., special sensors versus crowd-sourced data). The time is here for agencies to get their houses in order with respect to data so they can understand options and effective determine future needs. Tools should make things easier (e.g., Tableau) and expectations will continue to rise for staff (e.g., data visualization skills expected). A final thought in regards to the nature of the U.S. transportation system: It is a fragmented system, which is an obstacle and a risk that affects quality of service, life, and efficiency. Perhaps the creation of a national resource for transportation data is the way forward.

Chapter 5

Keynote Speaker

Patricia Hendren, *I-95 Corridor Coalition, presiding*
Jordon Holt, *WMATA, recorder*
Keith Parker, CEO, *Goodwill of North Georgia, (former CEO of MARTA)*

TRANSFORMING TRANSIT: USING COMMUNITY INVOLVEMENT TO TURN AROUND A BELEAGUERED AGENCY

Keith Parker

Before I agreed to take the position of Chief Financial Officer (CFO) in September of 2012, all of my career moves were going from a good situation to a better one. For example, when I was in San Antonio, I had already received two "CEO of the year" awards, and then had a leadership position for a transit system with the fastest growing ridership in the entire nation, winning accolades and promises of future salary and contract benefits to come. However, at Metropolitan Atlanta Rapid Transit Authority (MARTA), it was not the same type of situation because the system was struggling. Since the construction of the MARTA system, there were no expansion measures. There were dozens of bus stations and bus ridership serving the Cobb County and Wootton County, but not the 18 counties around Atlanta. The top issues for MARTA were employees, customers, and community.

On the customer front, MARTA had eliminated more service and raised fares more than any other transit system in the country. For example, they eliminated one third of all the bus routes, dramatically increasing wait time in between train rides, particularly with trips that included transfers, and then they raised fares by 40%. As a result, they lost 26 million passengers over a five-year period. In addition, two-thirds of all the bathrooms for customers closed, upsetting the existing customer base.

The voters rejected the biggest transportation tax measure in decades, by a two-to-one margin, and most blamed MARTA for it. There was no positive news about MARTA in print, or on television. For example, there was a high profile shooting where MARTA police officers shot and killed a customer, and concerns regarding use of overtime for bus drivers—some who were making more than $100,000 per year by working lots of overtime. An audit conducted by KPMG revealed that the agency was losing $50 million per year and would be bankrupt within a five to seven year period, with a prediction of insolvency by spring of 2017. Although other cities were having issues, Atlanta was still trying to decide if mass transit was an important urban service. The plan was to go out in the first 90 days and solicit comments from everyone who would participate, using round tables, and outreach to Fortune 500 CEOs, neighborhood associate presidents, and others. The purpose of this outreach was to learn what they thought of the transit system now, what they would like it to be, and what they were willing to do to help. Internally, the concern was how to take better care of our team and our customers. Then if these areas are resolved, the question was whether it would result in sufficient funds to keep operating. The strategy was to make major promises (e.g., if staff meet goals, they would get raises). Other concerns were the high turnover, stability of the workforce, and being able to keep talent. While there were huge cost cutting and efficiency improvement programs, never once did we raise fares

or cut services. Instead, we focused on other efficiency measures that dramatically turned around our financial fortune. All of the efforts paid off. MARTA went from a projected deficient of $3 million in December 2012, to a $9 million surplus six months later.

Safety is another customer service issue. Many people simply did not believe the transit system was safe and choice riders stayed away. The strategy was to promote an aggressive campaign, "A Ride with Respect." The agency established a zero-tolerance approach to uncivil behavior on buses and trains, resulting in the suspension of up to 10,000 people from the trains at different times, and resulted in two positives outcomes: MARTA became the second safest large transit system in the country and did not have a one single civil rights complaint about racial profiling. The plan relied upon the training of bus and rail operators. In addition, the police force received training to respectfully handle even the most unruly riders.

MARTA implemented more improvements. For example, MARTA service to the airport became the best airport service in the country (e.g., 16-minute ride downtown with 97.5% reliability for $2.50). Staff launched an ad campaign to publicize this success. Additional successes resulted in credit rating increases, with a strong initiative to push positive news to the media every month. As a result, leaderships and corporations began paying attention. State Attorney General Chris Carr was trying to convince various companies to relocate to Atlanta, based in part on its public transportation successes. Business owners wanted MARTA to serve their developments to increase their customer base and to allow their employees to have MARTA service for their commutes.

MARTA used the train stations as a catalyst for economic development (e.g., live performances of the Atlanta Symphony, Jazz Roots, fashion shows, and dances). MARTA worked with the United States Department of Agriculture (USDA) and a number of other groups to open up "fresh MARTA" markets in the train stations, providing fresh fruit and veggie drinks for reduced prices. MARTA became the first transit agency in the world to open up a soccer field in the train station (https://www.itsmarta.com/station-soccer.aspx). Staff worked with groups to allow young people to hold soccer tournaments right at the Five Points MARTA Station. All these improvements contributed to growing positive attitudes towards the system and kept people wondering: what are they going to do next to add amenities for riders and communities? At the same time, MARTA was preparing for crises. For example, MARTA ran 24-hours during the ice storm of 2014, and was able to carry more people than normal during that day when the rest of the city and the region shut down. Moreover, when the I-85 Bridge collapsed, MARTA was able to move the thousands of people who could no longer drive to their destinations on to the mass transit system during that period. Additional partnerships developed during this period as Uber and Lyft agreed that they would provide half-price rides to the train stations during the bridge outage. By working with our employees and our customers, our financial situation completely turned around. Instead of being fiscally bankrupt in the spring of 2017, MARTA had a quarter of a billion dollars in budget reserves. Voters gained confidence and passed two major tax pieces, one to extend services into Clayton County, and another to build more rail and more bus services, with more commitment to transit here in the city of Atlanta.

Turning to my career now at Goodwill. It is another challenging story as the Brookings Institute indicates that Atlanta is the worst place to be born poor in the entire country, with the likelihood of getting out of poverty the worst in the country. I made a commitment to move people from poverty into middle class and beyond by putting people to work. When people donate to Goodwill, many good things happen. Goodwill is now the largest non-profit employer in the state of Georgia. In fact, Goodwill has more stores than Target, helping 25,000 people find

jobs in North Georgia, in some of the most distressed populations anywhere. People with disabilities, people coming out of the criminal justice system, people with enormous barriers to work, can now find the dignity of work. The plan is not just to get them a job, but then to move them to a better job, and then a career, moving more and more people into middle-income life. For people who we cannot help find jobs, we help them create their own job. We have a program called "good biz" where we are the busiest business incubator where people can get loans to start their own businesses underway. We collaborate with technical colleges and several dozen high schools where we provide support services. We see success everywhere and plan to continue to improve the lives of the people of Atlanta.

Audience Dialogue

Question: In transportation today, we are looking at the issue of equity. I was wondering with your experience with the transit sector and Goodwill, what you see as the ways we can make progress on equity?

Response: I think equity needs to be at the top of every design element, every discussion with the public, and any new allocation of resources. It is almost like a ticking time bomb as people in communities around the country who feel left out. I always try to get out in front of these issues before they mushroom into something more of a problem. Yes, we address equity, inclusion, making sure everybody is at the table, and everybody is benefiting, particularly for these extremely big and expensive projects.

Question: Your thoughts on data?

Response: Data fuels everything. One of the good things we did at MARTA, we opened up much of our information and were able to use that strategy working with a number of different collaborators. For example, we knew how many, or what percentage of elderly Hispanic people rode the bus on a Saturday afternoon from point A to point B because we had very granular data and we were able to shape our services based upon it. At Goodwill, we are doing at similar things. Data should inform the way we try to put services out to the masses. I believe that political considerations have led to the formation of where the transit lines have gone in the past rather than using data that could delineate the needs of the public for transit services. I think a skilled CEO and the skilled executives are the ones who are able to convince the political leadership and the business leadership that data is the best way to inform your decisions.

Chapter 6

Poster Session

Siddiqui Chowdhury, *South Carolina Department of Transportation*
Penelope Weinberger, *American Association of State Highway and Transportation Officials*
Sylvan Hoover, *Oregon State University*
Kenji Chigusa, *East Japan Railway Center*
Nancy Lefler, *UNC Highway Safety Research Center*
Amy Simpson, *Wood Environment & Infrastructure Solutions, Inc.*
Sareh Kouchaki, *Wood Environment & Infrastructure Solutions, Inc.*
Mshadoni Smith, *Federal Transit Administration*
Dena Khatami, *Wood Environment & Infrastructure Solutions, Inc.*
Bobby Cottam, *Burns McDonnell*
Jerry Zhiron Zhao, *University of Minnesota*
David Ederer, *Georgia Institute of Technology*
Satvinder Sandhu, *Federal Highway Administration*

METHODOLOGY TO CAPTURE THE EFFECTS OF CONRACTION PROJECTS ON TRAVEL TIME RELIABILTIY MEASURES IN SOUTH CAROLINA

Siddiqui Chowdhury

South Carolina used the National Performance Management Research Data Set (NPMRDS) to assess performance of the National Highway System (NHS) as part of the National Transportation Performance Management (TPM) rulemaking. A methodology was developed to capture the effects of construction projects on the travel time measures on the highways of South Carolina. Two areas of measures (the performance of the National Highway System and freight movement on the Interstate system) used travel time reliability as the performance metric. During the process of setting future year targets in these two areas, it became important to understand the effect of construction projects on such reliability measures. Therefore, analysis of pre-, during-, and post-construction speed data provides understandings of the behavior of the travel time reliability metric. Based on the pattern of variations in travel time reliability, several statistical models quantified such variations using the available parameters that come with the dataset. The research produced findings from assessing the variability in the construction-induced travel time reliability in the South Carolina's Interstate system. In addition, the generalized linear models developed for the truck travel time reliability experienced challenges from data limitations. Future research will address the path forward to maintain and recalibrate models for other jurisdictions.

INTRODUCTION TO THE CENSUS TRANSPORTATION PLANNING PRODUCTS PROGRAM DATA SET AND ITS MANY APPLICATIONS

Penelope Weinberger

Since 1970, the Census Transportation Planning Products Program (CTPP) has supported the development and dissemination of a large custom tabulation of Census data cut for transportation planning and decision-making. Now in its seventh iteration, this mature, well-curated data set provides the ground truth of demographic transportation data, with a rich national data set that includes commuter flows and small geographies. The CTPP is useful for long range planning, travel demand modeling, equity analysis, mode choice studies, performance and trend analysis and many other endeavors. The CTPP program holds a unique data philosophy, with many lessons learned over the last 50 years.

METHODOLOGY TO VALIDATE ACCURACY OF AUTOMATED SYSTEMS USING CELL PHONES

Sylvan Hoover

Transit agencies try to deliver a high level of service with limited resources. Agencies use automated systems (e.g., automatic passenger counters or roadside bike counters) to measure system utilization, and results to drive decisions and confirm effectiveness. The data collected by these automated systems can confirm an increase in ridership following higher frequency service, or more pedestrians using improved streetscapes. However, such data is only useful if it is accurate. Mode-specific data collected via automated systems are subject to equipment error. Therefore, a challenge faced by organizations is to determine whether the data collected is accurate. A common solution is periodic equipment calibration, but the ongoing cost of this can dissuade financially limited organizations, and result in staff discarding or misapplying the collected data.

With 95% of American adults owning network-connected wireless devices, data that is incidental to network operations (e.g., WiFi probe logs or call detail records) allows spatio-temporal analysis of mobility for much of the population. By overlaying such data onto likely transit modes, a secondary source for mobility counts allows a comparative analysis. Training a long short-term memory recurrent neural network allows anomaly detection techniques to discover when mode-specific counters are likely operating outside of their desired tolerance. Anomaly detection employing modern machine learning techniques has been used in manufacturing and infrastructure (e.g., highways, bridges, and electrical grids) to reduce maintenance costs and predict likely failures. This research develops a framework for detecting anomalies in counts, with a demonstration of the methodology using real-world data. The periodic validation of mode counts is a costly process for transit agencies and planners. Anomaly detection using already collected mobility data will allow organizations to save maintenance costs by only intervening when anomalies may exist and to provide reassurance that collected mobility data is accurate.

FRAMEWORK FOR IDENTIFYING SYSTEMATIC SERVICE DETERIORATION FROM THE PASSENGERS' PERSPECTIVE TO URBAN RAIL SYSTEMS (HONG KONG) USING EXCESS JOURNEY TIME AS A MEASURE OF THE GAP BETWEEN SERVICE EXPECTATIONS AND PASSENGER EXPERIENCE

Kenji Chigusa

With the increasing availability of transit information from journey planners and other apps, passengers on urban rail systems are more and more aware of how long their journeys should take. This also means that passengers are becoming more sensitive to the gap between the service they expected and service received. On the other hand, in urban rail systems with heavy ridership and operating high frequency services, incidents and demand surges delay trains. Passengers can also experience delays associated with train overcrowding with boarding denials for one or more trains due to capacity constraints. These passengers' out-of-vehicle experience can become a serious concern not fully captured with conventional performance measures. This research develops a framework for identifying systematic service deterioration from the passengers' perspective in urban rail systems operating near capacity. This framework aims to support rail agencies' understanding of current operations from the customer perspective and assist management in the development of service improvements. Specifically, the framework uses excess journey time as a measure of the gap between service expectations and passenger experience. Using train-tracking and passenger-flow data from automatic vehicle location and automatic fare collection systems, the framework estimates journey time for each origin and destination station pair. Based on the median excess journey time, the framework identifies the time, location, frequency, degree, and (in some cases) causes of service deterioration. The researchers apply their framework to the Hong Kong Mass Transit Railway, which is one of the most heavily utilized rail systems in the world. The results of analysis are hotspots that identify points with significant shortfalls in the passengers' out-of-vehicle experience.

PERFORMANCE MEASURES TO EVALUATE THE QUALITY OF SAFETY DATA

Nancy Lefler

There has been a growing understanding of the need for detailed roadway and traffic data in safety analysis. Ideally a state would have safety data (roadway, traffic, and crash) for all public roads that would provide the capability to perform statewide safety data analysis resulting in more informed decision making for better safety investments with the goal of fewer fatalities and severe injuries. While state safety data systems are improving, challenges remain with the collection, analysis, integration, and management of these data sets. Collection of the data is only the first step. Ensuring the quality of the data is paramount to be able to have confidence in the decisions made from the data. Data quality control is part of a formal ongoing data management program.

Performance measures are tools for measuring data quality and establishing goals for data improvement. This research provides an overview of how performance measures can improve the quality of safety data as part of a formal data management program, including the "6-pack" of safety data quality: timeliness, accuracy, completeness, uniformity/consistency, integration, and accessibility. The research also has examples of performance measures for each of these metrics, as well as criteria for developing performance measures, including how to incorporate performance measures into practice to improve safety data quality. The findings are based in part

on the workshop developed as part of the Federal Highway Administration Roadway Data Improvement Program (RDIP).

EVOLUTION OF HPMS PAVEMENT CONDITION DATA

Amy Simpson

Review of Highway Performance Monitoring System (HPMS) pavement condition data beginning with data collected in 2009 through data collected in 2017, reveals a number of changes to the HPMS database. For example, pavement condition data collection requirements in 2009 included collection of each of four metrics: International Roughness Index (IRI); percent cracking; rutting; and faulting on a two-year cycle. These data are now to be collected annually on the full extent of the Interstate Highway System (IHS). In addition to changes in collection frequency, there have been a number of changes in definitions that have occurred over the period identified. In 2009, for example, percent cracking on asphalt-surfaced pavements was the percentage fatigue-type cracking. This version included an additional field for transverse cracking on asphalt pavements. In 2016, the transverse cracking field eliminated and only wheel path cracking was stored. Perhaps most importantly, data completeness and quality have shown vast improvements over this period. Comparisons of 2009 and 2010 HPMS data, to contractor collected data, showed significant differences between cracking, rutting and faulting for a selected corridor. Review of 2013 HPMS data demonstrated that 51% of the IHS had cracking data in the system. Additionally, six miles of the IHS were unpaved. In 2016, the availability of percent cracking data significantly improved to approximately 80% of the IHS. Data for incorrect surface types had faulting on asphalt-surfaced pavements and rutting on concrete-surfaced pavements in 2016, but there were significant improvements (i.e., reductions) in the mileage of these types of quality issues with the data observed. This research details some of the major changes in the HPMS pavement condition data set from 2009 to 2017, illustrating the significant improvements in data completeness and quality.

PAVEMENT PERFORMANCE MEASURES AND CONDITIONS IN 2018 VERSUS 2015

Sareh Kouchaki

As part of Moving Ahead for Progress in the 21st Century (MAP-21) transportation legislation, the Federal Highway Administration (FHWA) launched performance measures to evaluate the condition of the pavements on the Interstate Highway System (IHS) and the National Highway System (NHS). As proposed by FHWA, the performance measures are calculated using the percentage of pavements on the IHS and NHS (excluding the IHS) in good and poor condition. The performance measures are evaluated based on four condition metrics: IRI, cracking percent, rutting, and faulting. FHWA uses the data stored in the Highway Performance Monitoring System (HPMS) to report the condition of the pavements and calculate the national pavement performance measures. Accordingly, an essential step toward the execution of the performance measures is to validate the collected data in the HPMS. In 2015, FHWA conducted a study to determine if HPMS accurately represented the pavement condition of the IHS. Data were collected on a sample of approximately 8,500 miles of the IHS. These data are used to estimate the performance measures on a national basis, and are compared to the HPMS data. Three years later, FHWA began a follow-up study with the same objectives. In this study, researchers

surveyed a sample of approximately 7,500 miles of the IHS, with approximately 50% duplicating the 2015 data collection sample. There is a three-year difference in time between these two datasets. Additionally, the definition of percent cracking has changed. This research compares the data collected in 2018 to those obtained in 2015 and includes comparisons of the condition metrics and performance measures of these two datasets at both the network and the state level.

EVALUATING THE NATIONAL TRANSIT ASSET MANAGEMENT PROGRAM

Mshadoni Smith

The Federal Transit Administration (FTA) and U.S. DOT Volpe Center have undertaken a multi-year, comprehensive evaluation of the FTA Transit Asset Management (TAM) program and rule (49 CFR 625) implementation. The purpose of the evaluation is to understand and analyze how the FTA's development and publication of the TAM final rule has affected transit agencies that receive federal funding in their practice of transit system management and operations, as well as any impacts to the national transit state of good repair backlog. As of October 1, 2018, transit agencies that receive grant funding from FTA are required to develop transit asset management plans that describe the approach to maintaining a state of good repair and establish performance measures for asset condition. This evaluation includes elements looking at both process and outcomes, as initial results will inform recommendations for improvements to the FTA TAM program. The evaluation seeks to understand and monitor impacts and outcomes across three areas: policy change (overall changes to Federal policy and FTA grant making), organizational change (within individual transit agencies), and industry change (changes in practice and operations at transit agencies). The evaluation team collected data using four main sources: FTA-furnished data on grantee interactions; agency-reported data (e.g., National Transit Database [NTD]); web-based and document review and research; and targeted discussions or focus groups with select transit agencies. This research investigates the design and methodology for the evaluation and reviews initial findings related to baseline data collection. The evaluation team provides information on the evaluation approach and initial insights related to data collection, seeking feedback from participants on both the FTA's approach, as well as participant experiences with internal program evaluation.

LIFE CYCLE COST ASSESSMENT OF MAINTENANCE AND REPAIR STRATEGIES FOR BRIDGES

Dena Khatami

Continuous deterioration due to traffic and aging mechanisms over time adversely affects the long-term performance and durability of bridges. To ensure the serviceability and safety of bridges, maintenance and repair actions need to be undertaken periodically. In this regard, identification of cost-efficient maintenance strategies is a high priority for transportation agencies. This research focuses on the main findings and recommendations from a network-level life cycle cost analysis (LCCA) aimed at determining the optimum maintenance treatment for bridges. The best treatment alternatives included the following selection criteria: a) number of treatment actions, b) time and interval of treatment actions, c) effectiveness of treatment actions and d) category of treatment actions including cyclical or condition based. Moreover, the proposed LCCA considers both the direct cost of treatment actions and the indirect costs induced

by the potential losses such as delay and accident. Findings and recommendations provided aim to assist agencies in the development of a systematic plan for the efficient allocation of investments on bridge repair and retrofit to meet the federal transportation performance goals.

WHAT IS A SWING WEIGHT AND WHY DOES IT MATTER?

Bobby Cottam

This research focuses on the best practices from decision analysis for weighting performance measures. Often when thinking about weights, we only consider the importance, but neglect to consider the range of the measure. Without considering range, we cannot accurately assign a weight to our performance measures that captures our stakeholders' preferences. This can lead to misguided investments or selecting sub-optimal alternatives when evaluating a project.

To illustrate this point, this research provides an interactive demonstration that goes through the swing weighting process by using input from audience members. Together, we create ranges, determine the importance, and fill out the swing weight matrix to demonstrate the application of these concepts. We also compare the effect of different perspectives and weights on the project evaluation. This research also investigates the different types of performance measures (proxy versus direct, and natural versus constructed) and objectives that exist (fundamental versus means) within in a project. This helps provide insight into creating the appropriate value measures that we then apply weights too. These fundamental concepts can be applied to decisions across the entire transportation field be it a preferred transit route, asphalt mix, interchange configuration, or anything in between.

THE USE OF PERFORMANCE MEASURES IN TRANSIT FUNDING ALLOCATION: EXPERIENCES ACROSS STATES

Jerry Zhiron Zhao

Since agencies expect limited funding for transit programs in the coming years, states seek new methodologies for funding allocations. Several states have opted to allocate transit funds to different programs based on performance measures. Some argue that this methodology helps states to better allocate the resources to meet the needs, to monitor transit performance, and to ensure efficient use of the funds. Others, however, have concerns over the limitations of performance-based allocation. This research examines the experiences of performance-based transit funding allocation by state DOTs. First, we review the formulas that are used by state DOTs for transit fund allocation across different transit programs. Second, considering only the states that used performance measures for their transit funding allocation, we identify what performance measures are employed, analyze how they are employed, and discuss possible benefits and challenges that can arise from the use of these measures. Finally, we develop multiple case studies of states, including Wisconsin, Iowa, Nebraska, Ohio, North Carolina, and Pennsylvania, to discuss their experiences about using performance measures in transit funding allocation, including the achievements, the drawbacks, and the ongoing discussions. Our research contributes to performance-based budgeting and management, and more specifically, to performance-based management in the transportation sector. The findings assist state agencies in the improvement of their decision making, not only in terms of transit funding allocation but also in other areas of resource allocation.

Chapter 7

Programming and Investment Prioritization

SESSION 1C: STATE OF THE NATION/BALANCING DATA-DRIVEN DECISION-MAKING WITH POLITICAL REALITY

David Jackson, *Cambridge Systematics, presiding*
Tracy Selin, *Cambridge Systematics, recorder*
David Wasserman, *North Carolina Department of Transportation*
Chad Tucker, *Virginia Office of Intermodal Planning and Investment*
Dan Gabiou, *Arizona Department of Transportation*

STATE OF THE NATION

David Jackson

The goal for this session is to understand why and where a process for programming and prioritization originated, how it was implemented and adopted, and how it was navigated through the process with boards and stakeholders. What are the key success factors we should take away from this discussion?

To understand the "State of the Nation" we need to understand our circumstances. There is now more focus on transparency and accountability, with an increasing desire for improvements, and with predictable returns on limited funds. As agencies push earmarks aside, there is a desire for less formulaic approaches and more flexibility. There is a need to inspire confidence, provide a voice, and balance interests, while maintaining flexibility and finding easy victories.

NORTH CAROLINA'S STRATEGIC TRANSPORTATION INVESTMENTS PRIORITIZATION PROCESS

David Wasserman

Background

In 1989, the State Highway Trust Fund (SHTF) provided funds for the development of the Intrastate System, urban loops and secondary road program, and municipal aid. The "Equity Formula" allocated funds based on population (50%), equal share among all the entities competing for funds (25%), and miles to complete the intrastate system (25%). Long-range population projections indicated a large increase between 2000 and 2035. Pressure began to build as North Carolina urbanized, with disincentives associated with the equity formula, and a desire to remove projects from the statute. Changes were also occurring within the legislature. Prior to 2009, the majority of chairs were from rural areas. After 2009, several urban-based chairs declared a desire to update the formula. The General Assembly also expressed interest in

transportation and prioritization strategies. For example, in 2010, they passed a Mobility Fund; in 2011, safety funds were used as a trial for the prioritization process; and in 2012, unpaved secondary roads were prioritized. In 2012, an initial plan was developed. In 2013, there was forward movement with decisions on who would lead and sell the plan. North Carolina Department of Transportation (NCDOT) decided to work with the governor's office. The chief operating officer (COO) presented the plan to the House and Senate leaders, while the DOT staff-led workgroup worked with bill drafters. A number of allocations were evaluated (e.g., 40/30/30 versus 33/33/33). A separate bill, sponsored in the House, flew through committees with only minor changes.

North Carolina has the second largest transportation system in terms of lane miles, second to Texas, with ownership across six modes, requiring a more transparent process in the context of limited revenues. Several large-scale projects that failed caused leadership and decision-makers to pay more attention to developing a more stable and effective prioritization process that helped address the traditional, largely politically driven process. NCDOT has an annual budget of approximately $5 billion and has established a number of key partnerships across the state.

Methods and Measures

The Strategic Transportation Investments (STI) Law prioritizes capital expenditures across all modes (e.g., Mobility/Expansion and Modernization). Decisions are needs based, directly tied to funding to prioritize results, and guided by a workgroup. The STI allocates 40% of the funds for statewide mobility, with a focus to address significant congestion and bottlenecks. For these projects, the selection is based 100% on data, with projects programmed prior to local input rankings. Legislation allocated 30% of the funds to regional impacts, with a focus on improving connectivity within regions. The selection of projects is based 70% on data and 30% on local input, with funding based on populations within each of the seven regions. The final 30% focuses on division needs, particularly their local needs. Project selection is based on 50% data and 50% local inputs. The funding is based on equal shares for each of the fourteen divisions. There are specific STI Law eligible definitions of project types across these three allocation across the six modes. It also has specific scoring instructions across the three allocations with quantitative criteria. For example, statewide mobility requires benefit-cost, reductions in congestion, economic composition, safety, freight, multimodal, pavement condition, lane width, and shoulder width. The non-highway criteria has a separate prioritization process for each mode, with a minimum of four quantitative criteria based on a 0-100 point scale with no bonus points. The STI Law also calls for continual improvement of the prioritization process. Specifically, the legislation states that "<u>The Department shall endeavor to continually improve the methodology and criteria used to score highway and non-highway projects</u> pursuant to this Article, including the use of normalization techniques, and methods to strengthen the data collection process. The Department is directed to continue the use of a workgroup process to develop improvements to the prioritization process."

The Prioritization Workgroup was key for some legislative members. The Prioritization Workshop (P3.0) kicked off with MPO, RPO, local government representatives, NCDOT, and legislative staff. At the same time, legislative leaders wanted feedback. The bill was passed by the House (105-7) and in the Senate (44-2), and then was signed into law on June 26, 2013. The Prioritization Workshop began meeting almost weekly between May through October 2013.

Workshop participants were able to provide recommendations to NCDOT and helped to establish a consensus-based decision-making approach. A set of new projects were submitted by MPOs, RPOs, and 14 state DOT divisions in January of 2014. Projects approved from previous prioritizations received automatic evaluation and was comprised of approximately 3,100 projects. Approximately 17% were funded in the State Transportation Improvement Plan (STIP). The current Strategic Transportation Investment (STI) approach prioritizes capital expenditures across all modes; directly tying funding to prioritizations. The Governor and state legislature cannot usurp the process or the results. North Carolina is perhaps the only state where this is mandated.

Contributions

Implementing STI faces a number of technical challenges, including data availability, cost estimation, new process techniques for several modes, and comparing modal scores. From a statistical perspective, there are challenges with the implementation of scaling and the need for mode-specific recommendations. Moving forward, lessons learned from this experience include the need to start simple, to be sure to involve stakeholders, have champions (internally and externally), to ensure transparency, and to incorporate local priorities (data cannot capture everything). Various metrics defined in state law remove some ambiguity over what to measure. In addition, the legislation embeds the Prioritization Workgroup in law. This action appears to be key. In developing a practical law, leaders and DOT staff became champions of and were actively supportive of this consensus-based approach. Selling the underlying law and concept at executive level, working directly with state legislators, all in step with the Prioritization Workgroup contributed to the success of the legislation. Challenges remain with funding in line with prioritization results and building process across modes

VIRGINIA'S SMART SCALE PROJECT SELECTION PROCESS

Chad Tucker

Background

Following a change in Virginia's administration and legislation, the Commonwealth Transportation Board (CTB) was required to use an objective and quantifiable process to allocate construction funds. The CTB allocates construction funds for the Commonwealth, programming funds for capacity enhancing projects. The intent for the CTB was to select the highest-ranking projects, while maintaining the authority to propose adjustments to the rankings if necessary. The legislature enacted a significant transportation revenue package in 2013. It was the desire by lawmakers to demonstrate to the public the benefits from new taxes. Both lawmakers and stakeholders were concerned that state was not advancing projects that addressed the more urgent needs.

The Governor campaigned on reforming transportation to "pick the right projects, build the best ones." At the time, an opaque decision-making process contributed to a sense that politics drove transportation decisions. For example, concerns of the state and local officials included the following. "All the funds will all go to Northern Virginia." "Rural areas will lose

out in this process." "My region pays taxes and has transportation needs." "Prioritization should be done at a regional level, not a statewide level." "Politics will still drive this process."

It was clear that public engagement was critical. The CTB conducted 27 public hearings across the state, with stakeholder sessions in every construction district, individual meetings with every metropolitan planning organization (MPO), and numerous presentations at stakeholder and association conferences. In 2015, the legislature adopted the administration's recommended revisions to funding formulas for all state and federal construction revenues, excluding specialized programs. The result was that after capital rehabilitation and reconstruction, 50% of the funds are distributed at the statewide level, based on prioritization process, and 50% of funds are set aside for districts, based on formula, and then are distributed within the district, using prioritization process.

Methods and Measures

SMART SCALE is the set of policies and methods used to score and evaluate transportation projects funded in Virginia's Six-Year Improvement Program (SYIP). Projects are scored, based on an objective, outcome-based process that is transparent to the public and allows decision makers to be held accountable to taxpayers. Over the past four years, this process allocated over $3.59 billion in funding for $10.6 billion in operational and capacity transportation improvements (over $7 billion leveraged from regional and local funding sources). SMART SCALE as outlined in state legislation at process level did not include the specific measures. Project evaluation uses key factors including safety, congestion, accessibility, land use, environmental quality, and economic development. The set of measures used for the evaluation process follows guiding principles to ensure the analysis focuses on what matters to people and has a meaningful impact, fair and accurate benefits to cost analysis, transparency, and understandability. The process needs to work for both urban and rural areas, for all modes of transportation, with minimum opportunities for overlaps in measures.

To develop the measures, researchers reviewed the best practices from other state DOTs and MPOs and the Executive Work Group oversaw implementation, with sub-work groups assembled to focus specifically on measures and an online portal. Implementation included a peer exchange workshop, along with outreach meetings with key stakeholders. A pilot project evaluation, reviewed by the CTB, incorporated the following key factors:

- Safety – reduce the number and rate of fatalities and severe injuries;
- Congestion – reduce person hours of delay and increase person throughput;
- Accessibility – increase access to jobs and travel options;
- Economic Development – support economic development and improve goods movement;
- Environmental Quality – improve air quality and avoid impacts to the natural environment; and
- Land Use – support transportation efficient land development patterns.

A key advantage of the approach is the focus on outcomes, and how much a certain project is moving the needle as opposed to just focusing on underlying severity of the problem. In addition, the process uses tailored weighting across different geographic needs

Contributions

Project evaluation within SMART SCALE use a set of quantitative, benefit-focused measures in six factor areas, weighted to reflect the unique priorities of each region. Using scored and prioritized projects, Virginia's CTB has the best information possible to select the right projects for funding. The development and application of the measures emphasized the planning process and linkage to VDOT's needs. It provides for better planning by requiring the calculation of benefits for a project. It points toward the importance of cost with the need to focus the project scope on solving the problem/needs and tries not to let "the perfect get in the way of good." It makes it easier to differentiate between wants and needs by reinforcing the concept of value engineering so that applicants are seeing the importance of lean and focused scope of work. The process also makes it possible to think beyond single occupant vehicles (SOVs) and includes capacity expansion with opportunities for bike and pedestrian, transit, and travel demand management options (e.g., park and ride, and HOV lanes). Non-SOV users used as scaling factor for several measures.

Lessons learned include the need to be open and communicate, to respond directly to feedback and concerns, to be transparent with missteps and issues, to recognize that there is always room for improvement, to consider challenging past practices, to focus on outcome achieved, not size of the problem, and that less "control" may be beneficial. In SMART SCALE, Virginia Department of Transportation (VDOT) and the Virginia Department of Rail and Public Transportation (DRPT) cannot submit projects for evaluation. In addition, CTB only gets two optional applications per round. It is necessary to examine benefits relative to cost. Progress with this program includes $2.4 billion allocated in Rounds 1 and 2, with over 300 projects selected for funding. There was $77 million in cost savings based on construction awards and $75 million re-allocated to cover cost increases. The cost increases represent only 3% of SMART SCALE funds allocated in Rounds 1 and 2. The success is driven by the rescoring policy (e.g., if scope changes such that benefits would be affected or costs increase above a threshold then the project must be rescored). For project change policy see: http://smartscale.org/documents/smart-scale-rescoring-guidance-version.pdf.

SMART SCALE applies for capital projects except for smaller lump sum programs including the Transportation Alternatives Program (TAP), and the Highway Safety Improvement Program (HSIP). Similar to NCDOT, several highly visible projects advancing without any transparency led to leadership focus on transparency around prioritization and funding. It is outcome-based, with a focus on public benefits. Efficiencies driven by the process have enabled the state to leverage local funds in much more significant ways. In addition, unique to SMART SCALE, all selected projects are fully funded within a six-year program. Keys to political support include using a broad-based evaluation, recognizing different parts of state (e.g., urban, rural), being mode-neutral, not affecting fully funded projects, having easy-to-identify transparency, and delivering on funded projects. The approach allows stakeholders to have a voice in development of the process, making it possible for the public to see results on the same day as decision makers (avoid temptation to revise results).

ARIZONA'S P2P PROCESS

Dan Gabiou

Background

Arizona has a population of 7 million, with 22 Indian Tribes, 12 COGs and MPOs, covering 15 counties. The Arizona Department of Transportation (ADOT) is responsible for 9,303 highway centerline miles, 21,531 highway lane miles, with 87 million vehicle miles traveled (VMT) (2017), and only an $.18 state gas tax. Arizona has the largest percentage of tribal lands in the nation—28% of the state. The state last raised gas tax in 1991. Prior to the performance-based planning to programming requirements established in MAP-21 (2012), Arizona already had performance-based planning and programming legislation which passed in 2005, and is still in effect today.

In 2005, the Arizona legislation passed, Arizona Revised Statutes (ARS) Title 28 – Transportation. The legislation requires the development of performance-based planning and programming processes for the department, based on consultation with local, regional, and tribal transportation agencies before developing the processes. In addition, the performance-based processes requires periodic reviews and updating as conditions and system requirements change. A key component is the uniform transportation system performance factors for evaluating existing and potential projects and services established under the law. Applied weights for the performance factors consider and recognize local and regional differences in transportation system performance, for use in all state transportation planning efforts. Systematic forecasts of the anticipated performance outcomes of proposed expenditures, reports, and certification of system performance will integrate with planning, programming, and reporting processes to ensure a sustainable and reliable highway system. ADOT's performance-based planning to programming process (P2P) connects the Recommended Investment Choice (RIC) of the Long Range Transportation Plan (LRTP) to 5-Year Construction Program through performance.

Methods and Measures

Prioritization decisions that are made using four investment categories per the LRTP include pavement preservation, bridge preservation, modernization (safety and technology), and expansion (new lanes or highways). Pavement preservation is allocated at $250 million per year, scored with 35% for technical aspects, 30% by District, 25% for safety, and 10% for policy. Bridge preservation is allocated at $60 million per year, scored with 60% for technical aspects and safety, 30% by district, and 10% policy. Modernization is allocated at $91 million per year, scored with 35% for technical aspects, 30% by district, 25% for safety, and 10% for policy. Finally, no funding is allocated to expansion (although it has scoring of technical aspects of 50%, by district for 25%, safety for 15% and policy for 10%). There is a caveat that expansion can be receive programming up to 5% of the annual budget, but the process requires significant local contributions and an intergovernmental agreement (IGA). The primary focus is on preservation, not expansion at this time. The scoring process breaks down evaluation criteria by factors and weights.

Contributions

P2P is an agency commitment. Time commitments vary, but the data collection, scoring process, and project selection process is currently very labor-intensive. As a point of clarification, the two Transportation Management Areas (TMAs) in Arizona (Mariposa Association of Governments [MAG] and Pima Association of Governments [PAG]) participate in the P2P process, but have the responsibility and authority to complete their own performance-based planning and programming processes. Staffing includes a P2P Manager, responsible for the project prioritization process. The state is striving for continuous improvement via annual lessons learned and tracking of improvements, with ongoing, meaningful engagement and communications around the entire process.

Audience Dialogue

Question: Given the resources involved with developing effective processes, how have agencies managed?

David Wasserman*:* We found that having internal champions was key to our success. Having only a three-person office, the support of internal champions make a difference.

Chad Tucker*:* Finding these champions within leadership means we need to stress a sense of urgency to help leadership focus. Implementation evolves over time as we are increasingly focused on distilling down the number of projects to be evaluated and prioritized to reduce resource constraints and improve project supply over time.

Dan Gabiou: Our initial rounds are typically the most resource-intensive, but our focus on continual improvement has led to process improvements and automation that has reduced burden over time.

Question: Have formalized processes helped with state budgeting and resource allocation?

Dan Gabiou: Yes, they have significantly helped. Data and transparency around investment tradeoffs and project benefits have gone a long way for implementing our program.

David Wasserman: Yes, our data-driven project list helps convey the significance of funding needs. In addition, our data-driven project illustrates where funds are spent.

Chad Tucker: I agree. The process helped to change the political calculus and built trust around revenue allocation.

Dan Gabiou*:* The Virginia governor only serves one term so that has helped force action as well.

Take Aways

While prioritization processes across the nation have developed differently, all emphasize three important factors promoting transparency, using open communication with stakeholders, and being data-driven.

SESSION 2C: DATA-DRIVEN PROJECT SELECTION ACROSS THE STATES

David Wasserman, *North Carolina Department of Transportation, presiding*
Monisha Khurana, *The Goodman Corporation, recorder*
Scott Thomson, *Kentucky Transportation Cabinet*
Bryan Pounds, *Massachusetts Department of Transportation*
Sondra Rosenberg, *Nevada Department of Transportation*
Peter Smith, *Texas Department of Transportation*
Philip Schaffner, *Minnesota Department of Transportation*

KENTUCKY'S SHIFT PROGRAM

Scott Thomson

Background

In 2016, the Strategic Highway Investment Formula for Tomorrow (SHIFT) was enacted to prioritize projects in Kentucky, using a data-driven process. It uses objective data for distributing limited funds. Kentucky looked at other states (e.g., North Carolina) to determine how to bring this process into their state. There are two phases of the SHIFT Kentucky project: statewide and district, which are 100% and 70% data-driven, respectively. The process helps make transportation funding priorities and spending more systematic. Previously, the requests for funding for the Department of Transportation in Kentucky far exceeded the available funds.

Methods and Measures

To accomplish the purpose of SHIFT of prioritizing limited funding, staff categorize projects into five components for project consideration safety, benefit-cost analysis, congestion, economic growth, and asset management. The State is divided into four need zones, each with own goals and priorities. The process requires collecting objective data and prioritizing the requested funding, using the SHIFT formula. The process includes inviting input from stakeholders, including local and district leaders, providing transparency, and a dependable plan for spending.

The focus for eligible projects includes safety and improvements. Excluded projects include rural and municipal aid, maintenance and bridgework, federally dedicated projects, and MPO dedicated projects. The development of the formula uses a variety of data sources. For example, the Kentucky State Police Crash Geo-database is the core source of crash information. The Kentucky Transportation Cabinet (KTC) assisted the efforts by incorporating Highway

Safety Manual (HSM) methods. The Highway Safety Improvement Program (HSIP) group developed new improvement types and Safety Benefit Factors for Kentucky. TREDIS provided refined input improvements for Kentucky's model, KYSTMv18. Bottlenecks for short- and long-haul freight impacts are modeled for freight purposes. The Cabinet for Economic Development (CED) provided updated factors for 120 counties. Using the 2015-2017 HERE Link Level speed data, KTC developed congestion measures, providing a granular assessment of congestion in project areas. The process used the Cabinet's Bridge and Highway Information System Databases (BHISD), in addition to the Pavement Distress Index (PDI) for pavement assessments, making it possible to assess pavement conditions in project areas.

Contributions

This process led to significantly less over programming. For example, reductions were realized (e.g., $3 billion to $200 million in the two-year plan), and less over programming for the six-year plan. Some 91% of projects were able to move forward. In 2018, a number of projects were programmed including 495 projects to address safety and mobility, 85 related to ferry operations and other projects. Of the projects funded, 303 originated from the SHIFT. In addition, the state funds were less over-programmed. The use of the tool demonstrated more flexibility and an improved process from previous efforts. The state is introducing an online decision-making software that is based on multi-criteria decision making to help with the process. This approach will contribute to improved process to look at 1,300 projects and be equitable with different areas and transportation modes.

MassDOT'S PROJECT SELECTION PROCESS

Bryan Pounds

Background

Massachusetts made the decision to move to a Capital Investment Plan (CIP) process for all agencies in Massachusetts Department of Transportation (MassDOT) and the Massachusetts Bay Transportation Authority (MBTA). In the past, there were fragmented silos of planning conducted by each department, and not coordinated across the agency. In 2017, organizational changes were implemented that would allow the CIP to be developed in a coordinated way across priorities, programs, and projects. The priorities are reliability (44% of funds), modernization (28% of funds), and expansion (the remaining funding, of which 60% is dedicated to expansion, including transit expansion). There are more than 60 programs, and the projects then go into the CIP. Previously, MassDOT took an approach that determined the budget and then picked projects, but without any clear sense of what the outcomes may be for the entire transportation system. For 2017–2021 MassDOT CIP and the MBTA jointly developed a new approach to capital planning under the direction of the current administration.

Methods and Measures

The CIP for MassDOT and the MBTA is a written document that contains at least a statement of priorities, financial plan, and a listing of recommended investments. The plan spans five state

fiscal years (currently 2020–2024) and includes all MassDOT Divisions and the MBTA. Both the MassDOT Board of Directors and the MBTA's Financial Management Control Board approved it. MassDOT and the MBTA undertook a number of planning efforts throughout the course of a year, or on a multi-year basis. The planning processes consist of a series of efforts that involve many agencies and stakeholder groups. The planning effort informs not only the multitude of CIP investment programs that have been already been identified through past efforts, but may also lead to the establishment of new investment programs.

The project selection criteria that MassDOT currently uses was derived from an act of legislation that facilitated the creation of the Project Selection Advisory Council (PSAC) in 2014, which ultimately led to a report developed by MassDOT to the legislature on recommendations in 2015. The council defined a set of overarching goals or "criteria" to guide transportation investment decision-making. These goals are as follows: system preservation, mobility, cost effectiveness, economic impacts, safety, social equity, health impacts, and policy support. The 2017 CIP used the PSAC, creating a weighted system in which each division weights their criteria based on these eight sections to equal 100%. Under each weighted system, there are a specific set of criterion relative to each division, with factors and assigned points that add up to each weighted amount. For example, under mobility, the highway division looks at the effects of motor vehicle congestion; bicycle and pedestrian mobility; and transit mobility and overall connectivity. In addition, under connectivity, the scoring factors are whether the project creates new connections, or completes a link between existing facilities.

The CIP is composed of seven modal plans and associated studies (see Figure 30). The efforts to use performance-based planning stems from the work already conducted by setting policy and through our various modal studies, using available tools to set our performance targets by program. MassDOT's uses an annual Performance Tracker that updates across all

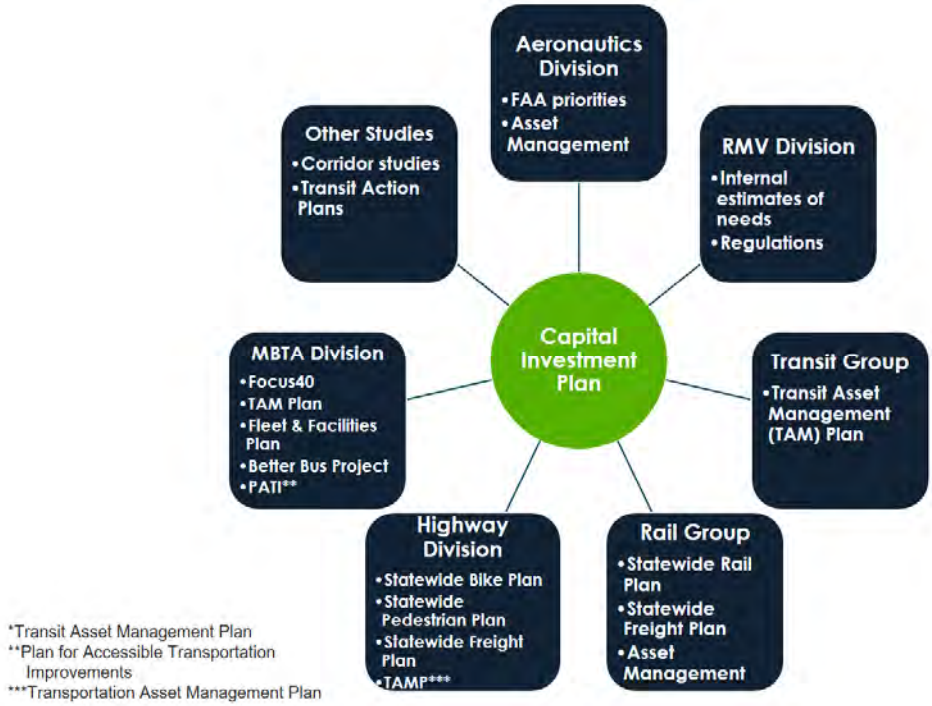


FIGURE 30 MassDOT's modal plans and studies.

divisions. At this stage, analysis with or without financial constraints, illustrates what return we can get on investments to reach our long-term goals. A large part of the capital investment decision-making process is making difficult tradeoffs given the financial constraints (both federal and non-federal) that we have. The CIP and the federally aided State Transportation Improvement Program (STIP), is a perennial exercise with partners at the Executive Office of Administration and Finance (ANF), the Treasury, FHWA and FTA. This effort requires making realistic assumptions about the performance target return-on-investment (ROI) within the five-year forecast and fiscal guidance received. Long-term performance metrics, using an iterative process, assess the performance of projects, based on forecasts, given the financial constraints. Finally, given the performance metrics established and authorizations received, the divisions first size their programs and then select projects through our annual public participation process as part of the CIP development.

The new approach centers upon clear priorities for the capital plan, with distinct investment programs, and then collections of projects that utilize program budgets which were evaluated upon their merits by asset management systems by a new project selection evaluation criteria system. MassDOT currently has three priorities: reliability, modernization, and expansion. Beneath these factors, there are more than 60 programs across the various divisions. Approximately 44% of the $18.3 billion in total investments (both MassDOT and MBTA) identified for the next five years focus on the reliability and resiliency of the core transportation system. Another 28% is devoted to modernizing the system. In 2017, MassDOT needed to transition from their old system and decided to use a better methodology for project proponents (particularly local municipalities) to initiate projects. The process includes setting a course for initiating an electronic project initiation platform through a geographic information database (known as “MaPIT”) to transition our project proponents (namely the municipalities of the Commonwealth) from the archaic paper formats to a GIS-based system. This system contains layers of data with environmental features, right-of-way information, and high crash locations, to inform the project initiation, scoping, scoring, and the selection process. Each department within MassDOT uses a consistent set of criteria for project evaluation, with different programs weighted differently. The process employs the same eight criteria across the board. The Planning for Performance tool (PfP) helps measure what an investment will yield. However, it can only model some categories of investments and not others.

Contributions

Thirteen MPOs in the Commonwealth of Massachusetts score their own projects as well, resulting in some projects receiving a regional score and a PSAC score. An analysis indicated alignment of the two systems. Work continues on efforts to consolidate these two efforts moving forward, as refinements are made on the criteria and factors associated with these weighted goals each year. There are various modal plans conducted over the past few years, and ongoing. The modal plans lead to project initiation either by MassDOT or municipalities in the GeoDOT system, which are then scored, and selected under one of MassDOT’s programs in the CIP and STIP. The process flows from policy to strategic plans, to the perennial CIP program sizing, and project selection. MassDOT then uses the modal plans to assess needs and priorities, which influence the target setting exercises in MassDOT’s annual Performance Tracker. For MassDOT’s annual Performance Tracker, each operating division has selected measures that fall within these goal areas that provide the most accurate picture to legislators, partners, and the

public of performance on core practices. Federally required performance measure setting facilitates the types of factors measured in the Tracker. The Office of Performance Management and Innovation (OPMI) then works with each division to determine plans for performance measure adjustments. From the Tracker, the targets are set in the PfP tool, and scenario planning gauges the return-on-investment (ROI), or "bang for the buck" in moving toward long-term targets. The usefulness of PfP then comes into play when MassDOT is setting program sizing, then reaching out to stakeholders and the public to assist in selecting projects that will encompass the next CIP.

ONE NEVADA TRANSPORTATION PLAN

Sondra Rosenberg

Background

Nevada is one of the fastest growing states in the country and as such, needed to be able to coordinate with local entities in the creation of a policy framework for investment decisions. Nevada regularly updated their Long Range Transportation Plan as required under federal regulations, but needed more to accomplish their goals. Nevada's vision was to have a safe and connected multimodal transportation system that links Nevadans and supports the state's economic vitality. Six critical areas identified for goals encompass the priorities of Nevada's public and transportation partners. The One Nevada Transportation Plan (One NV) was approved by the State Transportation in November of 2018. It provided a strong foundation for a performance-driven process and allowed for buy-in and support from the Nevada Department of Transportation (NDOT) and MPOs. The process yielded a focus on performance and data, even without a prioritized list of projects. The plan is a strategic document that guides future activities of NDOT and transportation planning partners. It provides for a common transportation vision and goals for Nevada and summarizes statewide needs, issues, funding, and trends. It also provides a policy framework to inform future NDOT plans and decisions, providing a roadmap for performance management, project prioritization, and a method for sharing implementation priorities and future actions. It receives support from MPOs as they can align their own goals and benefit from a strong partnership to develop consistent criteria, measures, and processes. The stakeholders recognize this is not just a plan, but also a new way of doing business, with more focus on performance and data, not just major projects.

Methods and Measures

Staff evaluated nearly 400 needs for alignment with One NV goals in order to develop strategies for the next 20 years. Assuming static revenue, the projected shortfall is billions of dollars, resulting in falling further behind in meeting Nevada's transportation needs. The process yielded a common vision and six goals: enhance safety, preserve infrastructure, optimize mobility, transform economies, foster sustainability, and connect communities. This process has allowed a more systematic evaluation and framework to look at projects, as opposed to letting politics drive the process. Transitioning to a performance-based planning framework is not just a plan; it is a culture change that takes time, and incremental changes. In the process, the DOT learned that there is a data shortfall. Although they are data rich, they are information poor. Finding

information on non-traditional metrics (e.g., connecting communities) requires additional information. More information on the project is available at www.onenvplan.com.

Contributions

The process produced a Performance Implementation Roadmap (PIR) to guide decision-making (see Figure 31). Although not everything has yet been accomplished, many lessons were learned along the way. For example, there has been support from all levels in the department that are providing for a more sustainable process, and the support remains as the process moves forward. There is recognition that data is not the same as useful information and just having performance metrics, they aren't the same as prioritization criteria. The process is slower than some would like (but big ships turn slowly or they might capsize). In addition, small adjustments can have a big impact over a long period of time. Taking an incremental approach means you don't try to do it all at once. Finally, communication is a key to success, both internally as well as externally.

TEXAS DOT's PROJECT SELECTION PROCESS

Peter Smith

Background: The Texas Department of Transportation (TxDOT) is developing and implementing a performance-based process with associated tools to support investment decisions at all major stages of its transportation system planning and programming cycle. Major stages include development of the 24-year Statewide Long Range Transportation Plan (SLRTP), the 10-year Unified Transportation Program (UTP) that links anticipated funding to programs and projects, and the four-year Statewide Transportation Improvement Plan (STIP). TxDOT's budget

	PHASE 1 2017 2018 PREPARATION	PHASE 2 2020 2023 PRACTICE	PHASE 3 2024+ EVOLUTION
Communicate and manage agency change	Build support and consensus	Describe roles and responsibilities	Build ownership of process and institutionalize methods
Engage and involve stakeholders	Focus on communication and education with internal agency and external partners	Coordinate activities with internal agency and external partners	Continue collaboration with planning partners
Develop policy and process guidance	Create initial tools, methods, criteria, and resources	Develop policies and guidelines	Develop documentation and user guides
Build out tools, models, and resources	Deploy and test initial tools	Improves tools and analytical capabilities	Build out platforms, tools, and data across divisions, assets, and modes
Improve data quality and coverage	Focus on available data and analytics	Enhance data coverage and sketch planning capabilities	Expand and invest in data

FIGURE 31 Performance Implementation Roadmap.

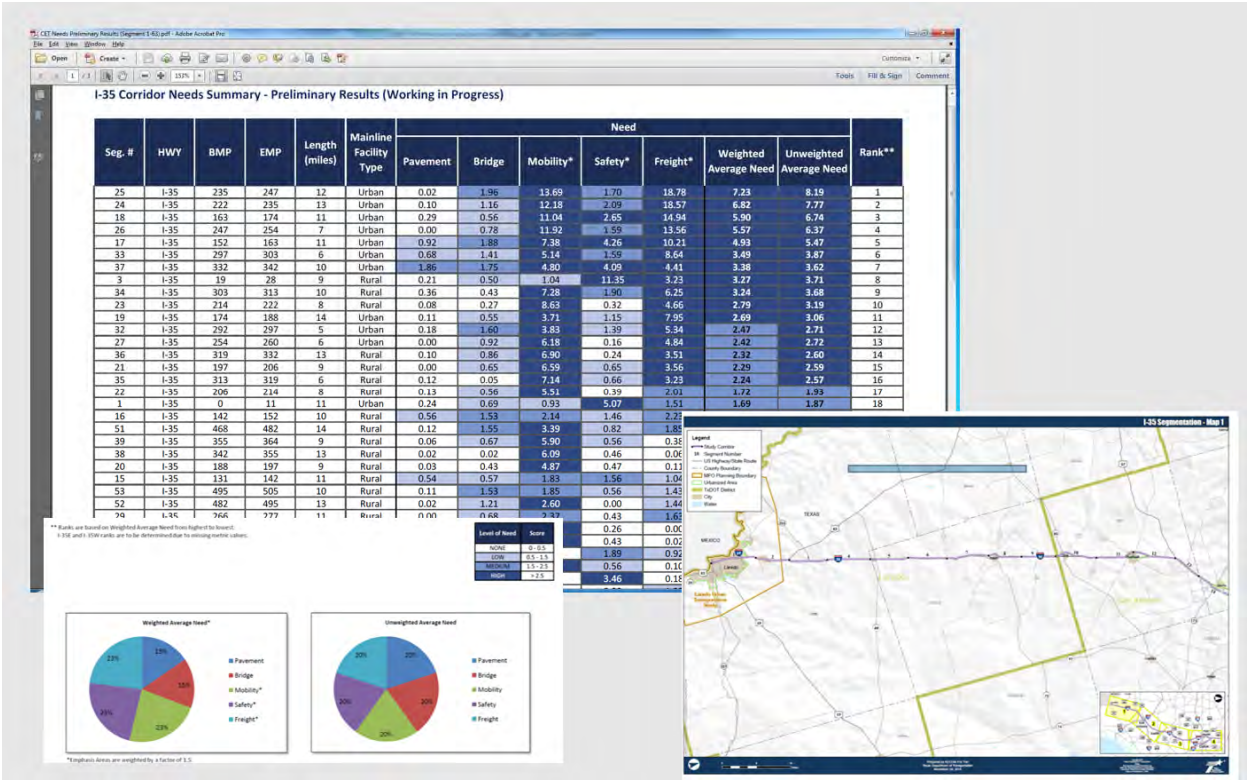
for construction is nearly $77 billion over 10 years. With project development and corridor projects, TxDOT wanted to know the best strategy for developing a prioritized list of projects. TxDOT has a number of tools for various plans and stages of the planning process, from helping evaluate corridors to various investment scenarios. Performance-based planning is useful across the full life cycle, from long-range planning to investment scenarios to project selection. TxDOT recognized the need to establish measures to conform to legislative requirements for performance-based planning and programming (both federal and state). They also needed to develop and implement methodologies to support decisions for investing in transportation programs and projects.

Methods and Measures

TxDOT developed four key performance measure-driven approaches. The first is a corridor prioritization method to evaluate statewide or regional systems by need. This methodology helps identify priorities for the SLTRP, assists the decision-making process for investments in corridor studies, and supports decision making for prioritizing individual projects for funding. Data have been collected and evaluated for 72 corridors of interstate and U.S. highways within Texas. The second approach is a corridor evaluation method that identifies infrastructure deficiencies and needs within a given corridor, considering multiple key performance areas, allowing for prioritization of segments within the corridor for further planning and development of potential projects. TxDOT applied the methodology to the whole of the Texas portion of IH 35 from the Oklahoma to Mexico borders. This method supports decision making for investments in project planning and development. The third is an investment "crosswalk" approach that allows for evaluation of different funding distribution scenarios by estimating key performance outcomes compared to statewide targets for safety, system preservation, and mobility enhancement. This supports decision making for how to distribute anticipated funds among the state's 12 funding categories for development of the UTP. The final approach is a data pre-processing tool and tailored application of hierarchical network analysis software to score and rank portfolios of projects by predicting performance outcomes. This supports decision making for projects as part of the UTP and subsequent STIP. TxDOT has engaged a number of consultants to create tools for this process. There are dashboards and websites to show what happens if money goes into different funding bins (e.g., 2050 Long Range Plan); as well as a corridor tool which shows prioritization of corridors by systematic needs organized by MPOs and districts.

Important elements are a prioritization of corridor studies by system wide need and a system wide performance measure scoring strategy. This approach requires the ability to use automation for corridor prioritization and a Corridor Evaluation Tool with identified data sources and measures. Figure 32 displays the web interface for the Corridor Evaluation Tool. The goal is to have performance-based ten-year Program Investment Scenarios (PIS). TxDOT identified key measures for under a series of factors:

- Safety
  - Total Fatalities – Number of fatalities per year.
  - Fatality Rate – Number of fatalities per year per 100 million vehicle miles traveled (VMT).



I-35 Corridor Needs Summary - Preliminary Results (Working in Progress)

Seg. #	HWY	BMP	EMP	Length (miles)	Mainline Facility Type	Need							Rank**
						Pavement	Bridge	Mobility*	Safety*	Freight*	Weighted Average Need	Unweighted Average Need	
25	I-35	235	247	12	Urban	0.02	1.96	13.69	1.70	18.78	7.23	8.19	1
24	I-35	222	235	13	Urban	0.10	1.16	12.18	2.09	18.57	6.82	7.77	2
18	I-35	163	174	11	Urban	0.29	0.56	11.04	2.65	14.94	5.90	6.74	3
26	I-35	247	254	7	Urban	0.00	0.78	11.92	1.55	13.56	5.57	6.37	4
17	I-35	152	163	11	Urban	0.92	1.88	7.38	4.26	10.21	4.93	5.47	5
33	I-35	297	303	6	Urban	0.68	1.41	5.14	1.59	8.64	3.49	3.87	6
37	I-35	332	342	10	Urban	1.86	1.75	4.80	4.09	4.41	3.38	3.62	7
3	I-35	19	28	9	Rural	0.21	0.50	1.04	11.35	3.23	3.27	3.71	8
34	I-35	303	313	10	Rural	0.36	0.43	7.28	1.90	6.25	3.24	3.68	9
23	I-35	214	222	8	Rural	0.08	0.27	8.63	0.32	4.66	2.79	3.19	10
19	I-35	174	188	14	Urban	0.11	0.55	3.71	1.15	7.95	2.69	3.06	11
32	I-35	292	297	5	Urban	0.18	1.60	3.83	1.39	5.34	2.47	2.71	12
27	I-35	254	260	6	Urban	0.00	0.92	6.18	0.16	4.84	2.42	2.72	13
36	I-35	319	332	13	Rural	0.10	0.86	6.90	0.24	3.51	2.32	2.60	14
21	I-35	197	206	9	Rural	0.00	0.65	6.59	0.65	3.56	2.29	2.59	15
35	I-35	313	319	6	Rural	0.12	0.05	7.14	0.66	3.23	2.24	2.57	16
22	I-35	206	214	8	Rural	0.13	0.56	5.51	0.39	2.01	1.72	1.93	17
1	I-35	0	11	11	Urban	0.24	0.69	0.93	5.07	1.51	1.69	1.87	18
16	I-35	142	152	10	Rural	0.56	1.53	2.14	1.46	2.23			
51	I-35	468	482	14	Rural	0.12	1.55	3.39	0.82	1.85			
39	I-35	355	364	9	Rural	0.06	0.67	5.90	0.56	0.35			
38	I-35	342	355	13	Rural	0.02	0.02	6.09	0.46	0.06			
20	I-35	188	197	9	Rural	0.03	0.43	4.87	0.47	0.11			
15	I-35	131	142	11	Rural	0.54	0.57	1.83	1.56	1.04			
53	I-35	495	505	10	Rural	0.11	1.53	1.85	0.56	1.43			
52	I-35	482	495	13	Rural	0.02	1.21	2.60	0.00	1.44			
29	I-35	266	277	11	Rural	0.00	0.68	2.37	0.26	1.62			
									0.43	0.02			
									1.89	0.92			
									0.56	0.10			
									3.46	0.15			

Level of Need	Score
NONE	0 - 0.5
LOW	0.5 - 1.5
MEDIUM	1.5 - 2.5
HIGH	> 2.5

FIGURE 32 Sample Corridor Evaluation Tool results.

- Preservation:
  - Statewide Pavement Condition – Percent of lane miles of pavement in good or better condition.
  - Statewide Bridge Condition – Overall condition of our bridge inventory.
- Congestion Mitigation:
  - Statewide All Urban Travel Time Index – Ratio of the peak period average travel time to the free flow travel time.
- Enhanced Connectivity:
  - Statewide Rural Reliability Index (SRRI) – Estimates 95th percentile delay on specific routes (during the heaviest traffic days).

TxDOT developed sample scenario investment and performance projections using their performance-based project selection process. Using key data sources, they conducted the scoring using an online decision-making software. Going forward projects will be monitored and tracked.

Contributions

Performance-based planning tools used at investment scenario levels show what happens with funds going into various high-level categories. It is useful at a corridor level with raw data, with performance metrics and weighting factors that allow for varying focus areas and comparison of multiple corridors. At the end of the day, there are performance-based metrics but other factors

come into play (e.g., logistics, politics). Concepts and approaches are at various stages of development and implementation that will support investment decision making at progressive stages of TxDOT's transportation program and project development. More data, time, and experience validate approaches and improve confidence in predictability of performance outcomes. However, there is no exact formula for performance-based planning and programming. Investment decisions will always need to address qualitative considerations as well as quantitative approaches. Challenges remain concerning the accuracy, currency, and availability of input data.

MINNESOTA DOT's NEW PROJECT SELECTION PROCESS

Philip Schaffner

Background

Minnesota has the fifth largest public road system and is ranked 22nd by population. MnDOT is responsible for approximately 10% of the roads in the state. The Minneapolis/St. Paul metropolitan area has more than 50% of the state population. The tranportation commissioner is appointed by the governor, and there is no board or commission as in other states. There are constitutionally dedicated and restricted funding, with set percentages listed in the state constitution to dedicated funds for state highways, county highways, municipal streets, and transit. MnDOT has a long history of using performance-based planning, beginning in 2003.

They have a Twenty-Year Minnesota State Highway Investment Plan (MnSHIP) that is fiscally constrained, risk and performance-based, but not project specific. It sets spending levels for different types of investments with planned and predicted outcomes. There is also a ten-year Capital Highway Investment Plan (CHIP) that is project specific, that explicitly tracks outcomes and investment compared to MnSHIP and is updated annually. How the Minnesota Department of Transportation selects state highway construction projects has been unclear to those both inside and outside the agency for years. A 2016 Legislative Audit found that MnDOT's project selection process was not transparent. MnDOT agreed and made commitments to make the process more understandable.

In 2017, the Minnesota Legislature directed MnDOT to develop and implement a new transparent and objective project selection policy. Minnesota has been doing performance-based planning in the past. The specific requirements include the ability to identify criteria, apply a weight of each criterion, and to follow a process to score each project based on the weighted criteria. The process also requires the identification of both projects selected and not selected. The scores need to be publicized, along with the reasons why projects were not selected.

Methods and Measures

The tasks undertaken from fall 2017 through December 2018 included: reviewing the findings and recommendations of the Legislative Audit; reviewing the project selection scoring practices of other state DOTs; forming an external policy advisory group; conducting multiple rounds of engagement with stakeholders; and working with staff from throughout MnDOT including specialty offices, modal offices, and every district offices. MnDOT developed and tested scoring

processes for every category of project and program. A draft of the plan and scoring criteria was released for stakeholders to review and provide comments prior to adoption.

There were a number of different perspectives. For example, local and regional partners felt that generally speaking, MnDOT selected good projects, but almost no one understood how the decisions were being made. The legislative auditor did not have significant concerns about the decisions themselves, but felt MnDOT was not providing sufficient information about its project selection decisions to the public or interested stakeholders. With insights from the feedback, MnDOT developed a project selection policy and adopted it in November of 2018. The policy applies to almost all state highway construction projects, with the exception of some preventive maintenance and emergency repairs, and projects in the 2019-2022 STIP. Under the new policy, MnDOT will post the criteria and methodology for all project selection processes and the scores for all projects selected and evaluated, but not selected. The score assigned to candidate projects will be a key factor in project selection, but other factors will be considered in addition to the score. When a high scoring project is not selected, or when a lower scoring project is selected, MnDOT will provide a short explanation behind the decision.

The selection categories used for scoring and selecting projects within each district include pavement (NHS, Non-NHS, Urban), non-NHS bridges and culverts, and mobility and capacity expansion, with standalone selection for safety and bicycle and pedestrian projects. The Local Partnership Program (LPP) is scored and selected statewide, with NHS bridges, culverts and pedestrian brides. Specialty and competitive programs include:

- Corridors of Commerce
- Highway Freight Program
- Highway Safety Improvement Program
- Historic Roadside Properties
- ITS
- Railway-Highway Crossings
- Safety Rest Areas
- Standalone Noise Barriers
- Transportation Economic Development
- Weigh Station Capital Improvements

An example of the process for asset management uses the process of integrating asset managment rather than just picking the worst-first. An example of MPO integration is the use of benefit-cost analysis (BCA) to compare across project types, integrating MPO regional prioritization from system studies, exploring opportunities and synergies with other needed investments. For Environmental Justice (EJ), there is a score based on Census data of adjacent tracts for some categories

Contributions

MnDOT is implementing the policy in 2019 with the development of the agency’s 2020-2029 CHIP. What distinguishes Minnesota from other states or entities is the number of different scoring metrics that they have for their projects. Their process includes integration of asset management that MPOs integrated into scoring, BCA, and EJ. The MnDOT website makes it possible to view a project list by type of project, or by district. Shortly, it will contain a project

list with selected projects and the ones not selected with an explanation for each decision outcome. Currently, there are several efforts underway to study equity that may inform revisions and additions. The new policy made two key changes to MnDOT's selection process: the use of scores based on objective criteria and the publication of projects evaluated, but not selected.

Audience Dialogue

Question: How did you develop your project scope and cost estimates?

Nevada*:* From a qualitative perspective, the question is do the needs align with the goals? If so, then there can be some planning level scoping. Prioritization of needs that go to engineering (quantitative) requires finding opportunities to bundle projects for efficiency and may require changing funding allocations.

Kentucky: Agencies sponsor projects. Cost estimates are conducted locally and double-checked to verify costs, timeframe, and scope. These factors are inputs into the Continuous Highway Analysis Framework (CHAF). After scoring, the agency can QA/QC the CHAF.

Minnesota*:* For a 10-year plan, they are generally high-level estimates (with low confidence), with options after review for modification. The advantage of a 10-year plan is that there is time to re-review.

Texas*:* The onus is on the districts. If the costs are out of range, then a project can be de-authorized. However, calculations of need and performance precede cost considerations.

Take Aways

- The Kentucky legislature embraced the DOT's process, with continued support for SHIFT 2020, which is underway right now.
- MassDOT's process has allowed for planning and evaluation to be more consistent and cohesive across modes.
- Although Nevada DOT did not accomplish everything they wanted to, they were able to get support for this new process from internal and external stakeholders. They are moving forward with their new decision-making process.
- MnDOT found their project selection processed produced good projects; they are striving to increase transparency.

SESSION 3C: MODE-NEUTRAL PROJECT EVALUATION

Matthew Carpenter, *Sacramento Area Council of Governments, presiding*
Jason Schronce, *North Carolina Department of Transportation, recorder*
Tracy Selin, *Cambridge Systematics*
Chad Tucker, *Virginia Office of Intermodal Planning and Investment*
Chad Allen, *Vermont Agency of Transportation*

RECAPPING THE SPOKANE PEER EXCHANGE

Tracy Selin

Background

A Peer Exchange was held on July 17, 2018 in Spokane, Washington, and was sponsored by the TRB Statewide Multimodal Committee (ADA10), the TRB Transportation Programming and Investment Decision Making Committee (ADA50), the AASHTO Standing Committee on Planning, and FHWA. The objective of the peer exchange, entitled Multimodal Decision Making at the State, Metropolitan, and Regional Levels, was to share information on best and current practice as it relates to multimodal and cross-modal investment decision making. The focus for the event was to better understand how multimodal goals, measures, evaluation methods are operationalized within prioritization and funding decisions. The event enabled state DOTs, MPOs, and other practitioners to share experiences and lessons learned, to compare approaches, discuss common challenges, and to identify future research needs.

Methods and Measures

The agenda emphasized contributions on the state of the practice, with practitioner presentations. Participants included Minnesota DOT, Virginia DOT, and the Atlanta Regional Commission. Roundtable discussions included the use of mode-neutral measures, collaboration across transportation partners, linking planning to prioritization to funding, building consensus, and communicating results. Two key activities included the ability to define “multimodal” and describe ways to prioritize it. Agencies historically plan, prioritize and program within individual modes, reflecting the traditional budgeting process. To date, federal funding is siloed. At the same time, agencies are facing more pressure to develop multimodal plans to improve movement of people and goods and address multiple other economic and quality of life objectives.

Developing multimodal strategies requires understanding tradeoffs and benefits of investments across modes to assess what best drives performance outcomes. The basic decision-making model uses a traditional top-down process where the first funded modal “buckets” are individual modes (e.g., bridge, rail). The next step prioritizes projects within those mode-specific programs. Almost all agencies have traditionally used this approach. Another approach is to use a bottom-up (mode-neutral process) that prioritizes all projects in one big bucket. This requires the establishment of measures to assist in prioritization decisions. It also requires funding flexibility or creativity to implement, resulting in slowing down implementation. Another mode-neutral process optimizes funds across various investment types and funding sources. Performance measured in context of broader, system wide goals.

Contributions

Project evaluation and prioritization requires careful application of mode-neutral criteria. Performance measures focus on economic and quality of life impacts, and revenue generation associated with multimodal solutions. Using these factors help make the case for integrated investment solutions. Other factors include environmental, land use, and sustainability metrics, all requiring data and the availability of applications. Additionally, there needs to be specific methods for normalizing and weighting within the prioritization process to support fair comparison across project types. Discussions focused on the process, prioritization frameworks, before/after studies (planning, prioritization, funding, and implementation), integrating federal requirements, the data itself, data visualization and communication tools, and predictive tools.

MODE-NEUTRAL PROJECT PRIORITIZATION: AN MPO SUCCESS STORY

Tracy Selin

Background

Chattanooga has a mid-sized MPO. The Chattanooga/Hamilton County/North Georgia Transportation Planning Organization (CHCNGA-TPO) encompasses the Chattanooga Region with 443,000 people with 26% growth by 2040. There are 216,000 jobs with 39% growth by 2040, covering 19 jurisdictions (4 counties and 15 municipalities) and 2,110 lane miles. Their performance-based *2040 Regional Transportation Plan (RTP)* supports transparent decision-making in a competitive funding environment. It provides context and helps organize steps of the plan development. Key metrics are needed to track positive outcomes, ensure investment decisions align with long-term goals, help the agency manage expectations, and be prepared for new requirements under MAP-21. Listening sessions with the public and the analyzed needs assessments established that there were conflicting needs. The needs overall came down to two camps: community versus economic growth of the region. This process established three different frameworks: within community, community to region, and region to region.

Methods and Measures

A performance framework stretched from the community to the region, with three scales, each with a set of goals, objectives, and projects. The Chattanooga 2040 RTP varied goals and objectives by the need and purpose (considered as a scale) of investment, breaking from the traditional, linear approach. The performance measures were limited to a vital few, based on existing data and tools. These easy to understand measures clearly measured progress towards specific goals. The project evaluation assigns projects to a scale, defining the project’s need and purpose. Factors considered are location, proximity to community, and environmental assets. Within each scale, projects are evaluated relative to one another for each of the 12 performance measures. Figure 33 displays the strategy for weighting performance measures. Weights applied for each measure, given the scale of each projects. The process sums points across all measures, producing individual project scores. There is a 100-point score across twelve performance measures.

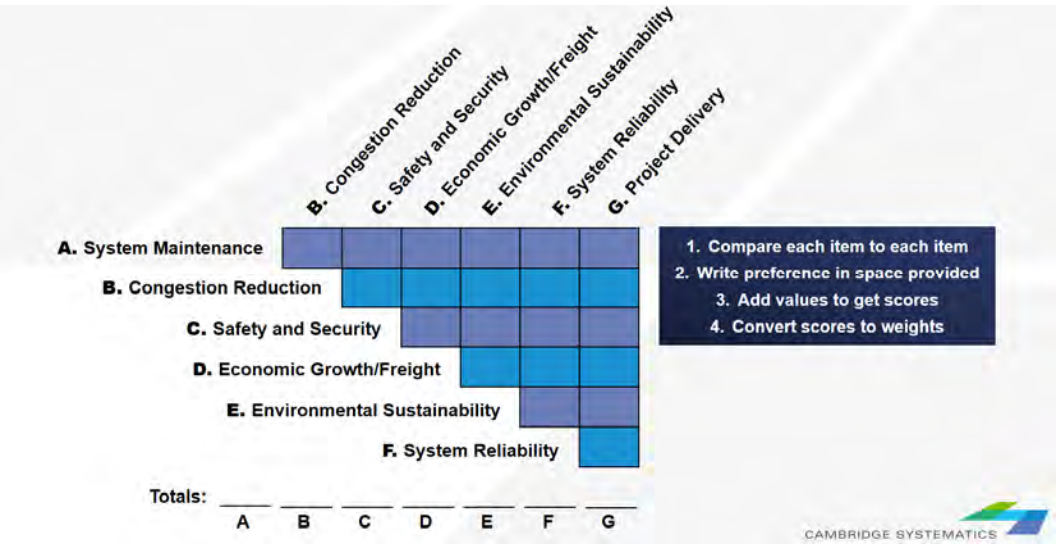


FIGURE 33 Weighting performance measures.

Staff rank projects using a process that yielded three lists sort-ordered by project score, one for each scale. Projects were combined into one list based on individual project scores and grouped into four tiers (Rank 1, Rank 2, etc.) based on groupings of scores. The project evaluation process uses a blend of high-ranking projects (by project type and across geographic scales) for fiscally constrained 2040 RTP. There is objective support for a variety of investments given the mode-neutral performance evaluation, with a focus on performance and priorities. The establishment of priorities occurs before funding sources consideration. All projects ranked 1 and 2 were funded in the 2040 RTP. Successful efforts to double the system preservation funding levels resulted in fully funding long-term needs. Other strategic aspects included the doubling of funding for bicycle and pedestrian improvements, strategic roadway and transit capacity expansion improvements, the identification of two, new major transit capital projects, and the identification of targeted safety and system operations funding set-asides. The three goals had three unique needs, but all three goals used the one set of performance measures with tailored weighting. The method used 12 performance measures that lined up with the federal measures. A full day workshop with stakeholders established the weights and created buy-in to the whole process.

Contributions

Using appropriate weighting is critical as “watering down” this approach will not work. It takes time to understand the context and it requires tools to be in place to evaluate off-model projects. There is a need to keep measures mode-neutral. While a combination of qualitative and quantitative measures is acceptable, both need to reflect objective rankings. Future work includes refinements for the 2045 RTP, with updated versions of several evaluation methods and an augmented performance framework to add a performance monitoring component. The first implementation evaluated two hundred projects. The results yielded the highest scoring multimodal investments with the highest scoring roadway improvements. The response was very positive with only one project’s score officially questioned. With all projects with Ranks 1 and 2 from each goal funded, the process resulted in changing the MPO’s long-term funding decisions.

COMPARING PROJECTS ACROSS MODES IN VIRGINIA

Chad Tucker

Background

Virginia's SMART SCALE process is a mode-neutral method, using particular factors. The goals that guided the measurement development included safety. For example, after identifying several corridors, fatal and injury crash data was assembled for the identification of potential projects over a five-year period. The crashes were converted into Equivalent Property Damage Only (EPDO). The calculations used ridership/volume reduction to calculate reduction in vehicle miles traveled (VMT). The VMT reduction was used to calculate crash reductions. For transit, the fatal and injury frequency were weighted at 100%.

To measure congestion mitigation, the analysis used person hours of delay for existing highway projects. The delay for each segment and intersections were calculated for the peak hour. The delay reduction was summed (up to posted speed limit) and converted to person hours.

The expansion factor was applied to account for the peak period. Transit and travel demand management first identified corridors served. To determine peak period ridership or volume reduction, the previously described process was applied for segments, making it possible to calculate reductions in person-hours. Congestion adjusted the volume to capacity ratio for the congestion score. Staff used these scores for major widening on interstates and for new locations of facilities. Projects that have impacts to regional travel patterns require the use of a travel demand model in congestion evaluation, including major widening of interstates (addition of one or more travel lanes) over two miles in length. For new location facilities, a combination of projects (e.g., widening and new location) were used. The assumptions used included having the vehicle occupancy rate held constant statewide (e.g., 1.2 persons per vehicle, based on the National Household Travel Survey [NHTS]). Peak period from travel demand models indicates 30% of the daily network delay. In addition, throughput increase was based on total delay savings and average trip length (in time) from the no-build condition.

Staff measured accessibility to jobs for all projects using an analysis for congestion measure, using changes in speeds. Also considered was the reduction in travel distances from new facilities and changes in land development patterns. Improvements in speed coded as improvements into an accessibility GIS tool. The tools were used to conduct before and after analyses, making it possible to determine the cumulative change in access to jobs. The transit accessibility measure examined the increase in access to jobs via transit, using a GIS-based model. The analysis at Census block group level used the number of jobs accessible between each block group within 45 minutes (60 minutes for transit). A decay factor was applied based on travel time.

A similar process measured access to jobs for disadvantaged populations. The main difference was the utilization of disadvantaged population data in the calculation. Members of the disadvantaged population included low-income, elderly, minority, and limited English proficiency (LEP) population percentage by Census Block Group. The analysis compared block group and identified block groups in the 75th percentile of the region. The regions involved included Planning District Commission (PDC), Metropolitan Planning Organization (MPO), and Northern Virginia Transportation Authority (NVTA). Projects received points based on features that enhance multimodal access (Max 5 points). Alternative modes included transit, Park and Ride, bike, pedestrian, high-occupancy vehicles or high-occupancy toll lanes (HOV or HOT),

and real-time traveler info or wayfinding. The options were scaled by the number of anticipated non-SOV users.

In addition to transport activity, the process also measured land use with points awarded in the first two rounds, based on promoting walkable bicycle friendly mixed use development, supporting infill development, or having an adopted corridor or access management plan that exceeds VDOT standards. Points were scaled by projected population and employment density (from a MPO-approved travel demand model). The third land use round included non-work accessibility by examining accessibility to key non-work destinations (e.g., grocery, healthcare, education). This approach helps to eliminate subjectivity and captures the degree to which development patterns meet certain criteria.

Contributions

Virginia's SMART SCALE process prioritized projects using mode-neutral measures and methodologies, with the goal of developing mode agnostic measures for scoring. Overall, the challenge is determining if the data is available and scalable. This question becomes a balancing act when developing a prioritization process. The final question to answer is what is reasonable/timeframe to get to the results you desire? Across the various categories, there are specific approaches. The safety measure is converted into a single unit, using five years of data and applying Crash Modification Factors (CMF). Safety for transit looks at a particular corridor and the potential volume reduction due to the project as the reduction in crashes associated with the project. This process is applied to all projects. The congestion measure uses the delta in the number of people moving through corridor. Projects can either reduce the volume, or increase the capacity, creating the ability to conduct before and after analysis. For each round of analysis, new projects arise that challenge the scoring process requiring the need to document process and ensure measures are applied consistently. Accessibility measures the impact on accessibility to jobs based on No-Build and Build scenarios, based on the change in speeds, where groups of jobs located closer count for more. The task is to create an "accessible jobs per person" calculation, including an assessment for job access for disadvantaged populations with multimodal travel options. Finally, the land use measure uses the level of encouragement for mixed use development where people can live closer to jobs and have improved accessibility to non-work destinations.

REVAMPING VERMONT'S PROJECT SELECTION AND PRIORITIZATION PROCESSES

Chad Allen

Background

In Vermont, there was a desire to revamp the project selection process the Vermont Agency for Transportation (VTrans). The traditional approach was broken into four programs: pavement; bridge; roadway; and traffic and safety. For the current system, from 2007 through 2019, the FY08 Capital Program contained too many promises, creating too many projects in the funnel, with unreliable project delivery times. The assumption was that politics was driving the project selection process. There was a need to align projects with the Governor's priorities and line-up

projects to the adopted plans. A new vision focused on a performance-based, data-driven project selection and prioritization framework that maximizes the "transportation value" delivery to Vermont taxpayers. The goals for the new vision included identifying and defining how regional ideas for transportation improvements can become transportation projects, and developing a fair, consistent, reliable and standardized project selection and prioritization framework for use by all regional planning commissions (RPCs). They also include revising current processes to increase transparency, providing "best value" and communicating "transportation" value to customers, developing processes and tools to guide the agency towards holistic corridor management and planning, identifying a process that allows VTrans to remove candidate projects without legislative approval, and incorporating health and resiliency into VTran's project prioritization processes.

Methods and Measures

The process for public engagement included four Stakeholder Workshops to assess the current process and to assist in the development of evaluation criteria. There was a broad cross-section of participants in these events including the RPCs and sister state agencies, special interests (e.g., American Association of Retired Persons (AARP), American Automobile Association [AAA]), and modal interests (e.g., rail council, rail operators, bike and pedestrian, transit providers, Vermont Truck and Bus Association [VTBA]). The aim was to be mode-neutral over the five modes (e.g., highway, walkways/paths/trails (WPT), rail, aviation, transit). The evaluation criteria covered safety, asset condition, community, economic access, resiliency, environment, and health access, each assigned a weight. The previous process used a complex flowchart. The new process followed a three-step process determining how an idea for a transportation improvement becomes a project. To make the point, a visualization assists in understanding the process flow. The feasibility analysis of a project occurs at the idea level. VTrans maps needs in GIS to assist in the establishment of a project scope. The project level includes preliminary engineering (PE), right-of-way (ROW), and construction (funded) costs.

The paradigm shift promotes increased transparency and engagement earlier than in the original process. The result used RPCs input to select the right projects, increasing the value and overall satisfaction instead of just prioritizing backlogged projects. An efficiency frontier that plots project cost against transportation value measure the results. The process also uses web-based communication where data and notifications provided communication between VTrans and the RPCs (e.g., automatic data imports, GIS).

Contributions

The communication provided in the new process provides an opportunity to harmonize activities at the milepost. Next steps include the development of a Responsible, Accountable, Consulted, Informed (RACI) matrix along with a corresponding implementation schedule. The final versions of the documentation will include the process revisions and additions. In addition, it is necessary to draft revisions to the current legislation and supporting policies. Plans are in play to produce a workbook with qualitative and quantitative aspects, beta testing to ensure the communications between VTrans and the RPCs, with additional training and support. The expectation going forward is that VTrans will be better able to invest in the right project at the

right time and that future improvements will use a Transportation Value in mode-neutral benefit-cost evaluation strategy

Take Aways

- At the Spokane Peer Exchange, discussions revealed that prioritization and programming take handholding, time, communication, and engagement with key decision-makers. It is best to not rely on one approach, but instead to understand the local context, starting simple, and evolve the process.
- Chattanooga MPO found that using a combination of qualitative and quantitative measures works best for developing a ranking approach.
- Virginia DOT identified a common theme that scoring focused on outcomes, not the size of the identified problem. Determining the "delta" measures a project's benefit.
- By developing a new process at VTrans, they will be able to accomplish project harmonization. Evaluating each project on its own may not appear to have the needed value for implementation, but when combined with other projects and actions, its benefits elevate the project's significance. The use of a harmonization strategy facilitates the maximization of scheduling.

SESSION 4C: GETTING INTO THE DETAILS OF HIGHWAY AND FREIGHT PROJECT EVALUATION

Joseph Schofer, *Northwestern University, presiding*
Kyle Schroeckenthaler, *EDR, recorder*
Jason Firman, *Michigan Department of Transportation*
Brian Dell, *North Central Texas Council of Governments*
John Orr, *Atlanta Regional Commission*
Jason Schronce, *North Carolina Department of Transportation*

PRIORITIZING PROJECT SELECTIONS FOR OPERATIONS

Jason Firman

Background

Michigan DOT has undergone significant changes in non-freeway and freeway operations. In August of 2018, MDOT went through a minor reorganization and added a Transportation Management Systems and Operations (TMSO) Division. Under the reorganization, TSMO was assigned a set of areas of concern including ITS (including traffic signals), traffic safety area, reliability, management, and maintenance. MDOT uses templates, each with its own program, goals, and strategies, and an allocation of funds for projects. For example, the ITS template includes the construction of ITS devices. There is also an operations set aside designed to operate and maintain the ITS devices. The creation of two new templates covered non-freeway reliability operations ($10 million) and the freeway operations ($40 million). The reorganization improved travel time reliability and safety on existing travel lanes.

Methods and Measures

To meet federal performance regulations, MDOT added tracking reliability and setting targets to their program. Their four-year statewide competitive project process for 2022 through 2025 will allocate $33 million. The 60 submitted projects required some traffic analysis for alternatives. Since only a subset of projects would actually be selected, MDOT wanted to use a pre-screening process to reduce the number of required analyses. The pre-screening process used the Level of Travel Time Reliability (LOTTR), the Travel Time Index (TTI), and the Planning Time Index. LOTTR was only calculated on the National Highway System (NHS) system. Staff needed other measures for the non-NHS projects.

The analysis required a summary of a project, including details of the benefits over a 20-year time period, the severity of the existing travel time reliability, and what the project entails. It also includes information on the safety and reliability that will come from the project, and a determination if a project is to be incorporated in a road, or a bridge project. The scoring process allocates the most points to the benefit to cost ratio, to ensure the most efficient use of the funds. The next evaluation is of the overall benefit, which is a subjective part of the scoring system. This takes into account something that might be unreliable unsystematically (e.g., only for an hour during the day). The next evaluation uses the last time a project was completed in a particular region, known as “pity points” for places with little attention in the recent past. Since this is a statewide competitive process, there is concern that some locations would not be getting projects. Metro areas may get more projects than rural areas (even though rural projects may be less expensive). Safety benefits are based on fatalities and major injury reductions. The following are examples of Non-Freeway Scoring metrics that incorporate a weighting strategy (based on the value of the points) for various factors:

- (30 points) Benefit/Cost Ratio
- (25 points) Overall Benefit
- (20 points) Duration since last awarded project in Region
- (10 points) Safety Benefit based on Time of Return
- (5 points) PTI > 2 or LOTTR > 1.5
- (5 points) Level of Service: E or F, or TTI > 1.5
- (5 points) Combining with an existing Project

The data for the measures is available in the Regional Integrated Transportation Information System (RITIS) from the Center for Advanced Transportation Technology Laboratory (CATT Lab). The metric for LOTTR is accessed by locating the link where a project is proposed and clicking on that link. The Planning Time Index and Travel Time Index are more involved. For example, calculating the Travel Time Index requires using the latest full year of data, typically AM and PM weekday peaks, and selecting the highest values per direction (only one-time period and direction need to be above the threshold) to qualify as unreliable. Non-freeway projects are classified by work types (e.g., center left turn lane, left or right turn lanes, indirect left turn or J-Turns, boulevards, roundabouts, lane extensions or other geometric improvements, signal improvements (must add an operational element and not just modernization), or ITS devices). Items and scoring weights used for Freeway Scoring include:

- (30 points) Benefit/Cost Ratio
- (30 points) Overall Benefit
- (15 points) Safety Benefit based on Time of Return
- (10 points) Combining with an existing Project
- (7.5 points) PTI > 2 or LOTTR > 1.5
- (7.5 points) TTI > 1.5

The eligible freeway work types include ramp improvements, interchange improvement (Diversion Diamond Interchange (DDI), Single-Point Urban Interchange (SPUI), loop ramps, fly overs, etc.), ramp metering, adding auxiliary/weave/merge lanes, crash investigation sites, reversible lanes, Hard Shoulder Running, and Active Traffic Management Strategies.

Contributions

Michigan has only used this approach for one selection process. Over time, the process will be evaluating the various thresholds and exploring possible adjustments. The before and after analysis of a flex route on U.S. 23 indicates a 50% increase in reliability. Every project receives a before and after evaluation to ensure the results anticipated are achieved.

HOW TRAVEL TIME DATA IS USED IN NCTCOG's PROJECT SELECTION

Brian Dell

Background

Texas House Bill (HB) 20 mandates that Metropolitan Planning Organizations (MPOs) develop 10-year plans using performance-based planning and project selection methods. The North Central Texas Council of Governments (NCTCOG) reviewed the first 10 years of the Metropolitan Transportation Plans (MTPs) to identify candidate projects using a series of performance measures to select projects. NCTCOG financially constrained the lists and solicited input from the public, their technical committee, and the policy board for their review and approval. While plans of this nature only recently became legislatively mandated, NCTCOG has been conducting this type of planning for many years. Projects start from the Long Range Transportation Plan (LRTP). NCTCOG receives project requests throughout the year and does not have annual calls for projects. They needed a good screening metric.

Methods and Measures

The National Performance Management Research Dataset (NPMRDS) that provides travel times in five-minute increments for each day, served as the core of the analysis for screening purposes. The NPMRDS is available for the NHS system (freeways and major arterials). The historical data is available from July 2013. NCTCOG staff utilize "heat charts" based on this data as a visual representation of congestion. The process has three tracks including existing facility (under construction or needing its next phase), new freeways, and new arterials. Figure 34 displays a before and after analysis of conditions on SH 161. While only one of many selection

criteria, it can be a high-level screen (e.g., can filter out corridors that do not have a significant congestion issue).

Contributions

There are a number of benefits of using the travel time data. The congestion heat charts are intuitive and suitable for sharing with elected officials and the public. These charts allow staff to identify issues with both recurring and non-recurring congestion along a corridor. In addition, the data is useful for assisting regional partners. Only one project in the 10-year plan exhibited no congestion, and was not advanced.

Audience Dialogue

Question: Do you do these in-house (RITIS has these capabilities now)?

Response: We use SQL and TransCad with output extracted in Excel. Requests can be analyzed rapidly (e.g., in a couple of days). NCTCOG also produces heat charts for other parts of the state.

Question: Is before and after analysis routine?

Response: Most of the analyzed projects are not yet constructed, or are not yet completed. It is not clear if the process will be used for before and after analysis.

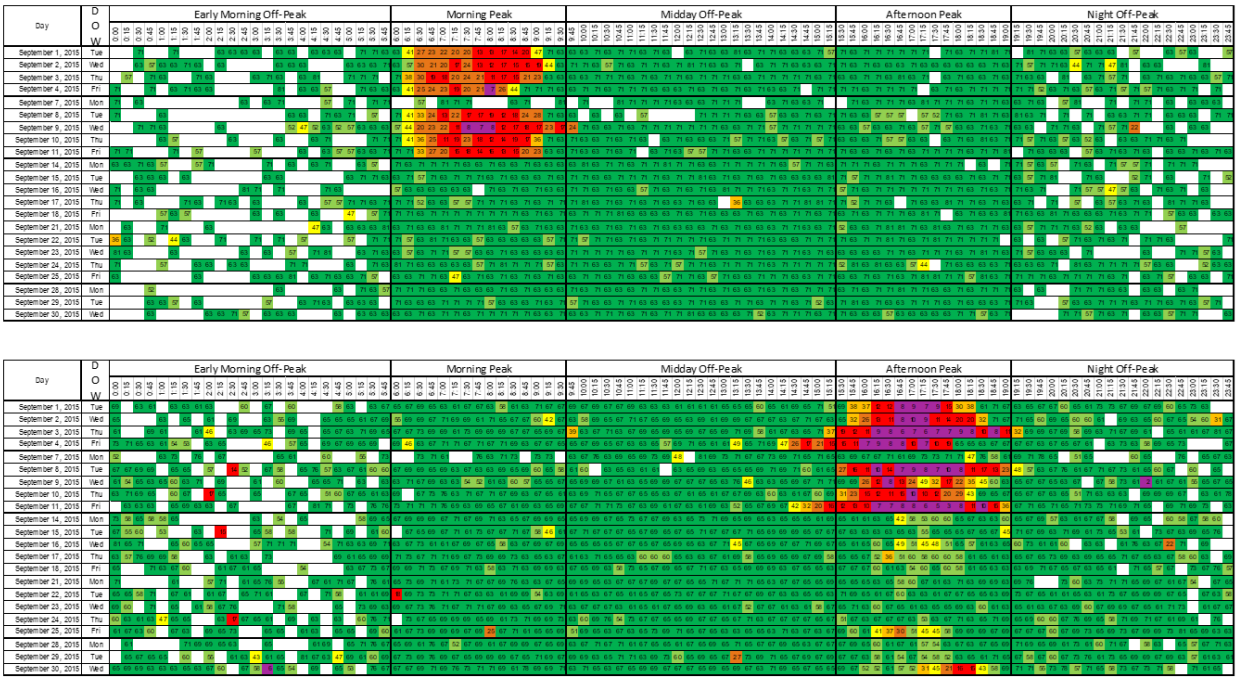


FIGURE 34 Example of before and after conditions on SH 161.

HOW ARC EVALUATES HIGHWAY PROJECTS

John Orr

Background

The Atlanta Regional Council (ARC) is composed of twenty counties, with a population of 5.8 million and has added nearly 90,000 more people in 2018. The population is forecasted to be 8 million by 2040. Transportation planners are responsible for producing desired transportation outcomes (improving safety, responding to congestion, improving air quality, etc.) and need to ask if projects promote these goals. In addition, they need to determine if analyses are conducted in a fair and equitable manner. ARC focuses on creating and maintaining livable communities, with 25 planners on staff. Key issues are roadway capacity and freight projects. ARC is responsible for a very large area with a great deal of variation in geographic range and community types. To adequately address the region, ARC needs to employ a technically sound process that leads to desired outcomes and is fair and equitable (especially geographically). This is a problem for many other geographically large MPOs and most states. For example, rural communities often feel neglected compared to other areas.

Methods and Measures

The concept that ARC employs to meet the transportation needs of their region is simple and built around key decision points (KDPs). It begins with a universal Transportation Improvement Program (TIP) project call, followed by a review against KDP1, a policy filter. The next step is KDP2, project evaluation, followed by KDP3, final factors. The last step is the decision to fund a project in one of three programs: Surface Transportation Block Grant (STBG), Congestion Management & Air Quality (CMAQ), or Transportation Alternatives Program (TAP). Throughout the decision-making process, it is critical to connect performance criteria to the desired planning visions. Criteria are applied using three goals from ARC's Vision: world-class infrastructure, healthy livable cities, and competitive economy. Different project types use different criteria.

ARC has moved away from use of travel demand models in favor of probe data (e.g., National Performance Management Research Dataset (NPMRDS) or INRIX data). However, these new data sources are not helpful for forecasting impacts, making it necessary to still use modeling for congestion, although less so, for reliability. The application of the first screening filters assist in evaluating qualitative readiness and policy compliance screening criteria to ensure projects truly have support from multiple directions and program eligibility. Each project type group has detailed weighting across criteria (see Figure 35). Projects are prioritized within each project type. Attempts to use cross-modal and mode-neutral methods have not been successful. Technical performance and cost effectiveness are key considerations. High cost effectiveness is more important than high total benefits of a project. Some projects (e.g., safety issues) will never perform well in a large multi-criteria ranking.

Criteria	Bike/Ped/Trail	Roadway Asset Management	Roadway Expansion & TSM&O	Transit Expansion	Transit Asset Management & System Upgrades[14]
Asset Management & Resiliency	-	14.9 %	-	-	24.4 % / 22.1 %
Mobility & Congestion	13.7 %	13.8 %	13.0 %	13.5 %	21.6 % / 19.6 %
Safety	14.5 %	14.4 %	13.4 %	8.5 %	13.6 % / 12.3 %
Network Connectivity	14.4 %	12.9 %	12.4 %	13.5 %	-
Reliability	-	-	12.1 %	12.0 %	-
Multimodalism	12.6 %	11.8 %	11.3 %	10.2 %	-
Employment Accessibility	10.4 %	10.2 %	10.3 %	11.6 %	18.6 % / 16.8 %
Land Use Compatibility	11.5 %	-	-	10.5 %	-
Social Equity	9.7 %	8.3 %	7.0 %	9.5 %	15.2 % / 13.8 %
Air Quality & Climate Change	6.3 %	-	7.3 %	6.5 %	0.0 % / 9.4 %
Goods Movement	-	8.1 %	7.8 %	-	-
Cultural & Environmental Sensitivity	6.8 %	5.5 %	5.3 %	4.1 %	6.6 % / 6.0 %

FIGURE 35 Weights assigned based on public and policymaker input.

Contributions

Most officials and the public in the region have been wary of technocratic processes that appear to be black boxes. The technical processes need to inform the process, but not be the process. To add clarity to the entire process, projects are categorized in four tiers. Tier I has high performance and high cost effectiveness. Tier 2 has low performance and high cost effectiveness. Tier 3 has high performance, but low cost effectiveness. Finally, Tier 4 classifications are both low performance and low cost effectiveness.

Audience Dialogue

Question: How did you develop the scoring weights?

Response: We started with staff developed weights. They presented the score weighting to various committees, who provided feedback. There was a 60-day public process, along with a workshop that included disadvantaged populations. Much of the process took advantage of an online surveying effort.

Question: What was the cost effectiveness measure?

Response: Our cost effectiveness measure is a benefit-cost ratio for valve of time, safety, emissions, and other factors.

Question: What is the impact of having many different categories with similar, small weights? They rarely register over 15%.

Response: Yes, we do lose projects that address specific pain points.

Question: To what extent do you look at safety? There are data challenges with police reporting of crashes and geocoding.

Response: Fortunately, this has improved over the last few years.

Question: Has this affected local process?

Response: Most of our partnership relationships are between the state and MPOs. Some local governments are starting to get involved as well.

BALANCING URBAN AND RURAL PROJECT SCORING IN A RAPIDLY URBANIZING STATE

Jason Schronce

Background

North Carolina DOT (NCDOT) has nineteen MPOs and eight RPOs, overlapping with fourteen Divisions. NCDOT funds six modes, including the largest state ferry system in the U.S. Their annual budget is approximately $4.8 billion, of which $2.8 billion is for Strategic Transportation Investments (STIs). All of the critical budgetary decisions use quantitative analysis. The STI is broken into three buckets. The first is for statewide mobility (receives 40% of the funds and addresses significant congestion and bottlenecks using 100% quantitative analysis). The second is for regional impacts where 30% of the funds address connectivity improvements within the regions. The selection of projects for these funds is based on data analysis (70%) and local inputs (30%), with the final distribution of these funds based on the populations within the seven regions. The third is for division needs (received 30% of the funds and addresses local needs, with selection based on 50% data analysis and 50% local input and distributions of the funds based on equal shares for each of the fourteen Divisions). At this time, there are counties with declining populations, while the urban areas are growing rapidly. The planning division is currently working on a 2050 plan and envisions increasing congestion. NCDOT anticipates needing 10 or 11 future intrastates.

Methods and Measures

The State has a Transportation Investment Strategy Formula process that directs NCDOT to "continually improve the methodology and criteria used to score highway and non-highway projects…. Including the use of normalization, techniques and methods to strengthen the data collection profess. The Department is directed to continue the use of a workgroup process to develop improvements to the prioritization process." Currently the Workgroup is composed of four MPO representatives, four RPO representatives, five advocacy groups (urban and rural interests), and 13 NCDOT representatives, including four Division Engineers, and some additional advisory representatives and technical experts. The Workgroup has just completed the P5.0 scoring for the 2020-2025 Statewide Transportation Improvement Program (STIP). In the process, statewide economic competitiveness must be balanced against accessibility and connectivity for regional and divisional points.

The congestion measures use volume to capacity (V/C) with some weight towards higher volume facilities in higher tiers. The analysis for the Peak Average Daily Traffic (PADT) uses the highest month Average Daily Traffic (ADT), including weekends. A factor is applied to AADT, using defaults for county and SR routes and route specific for U.S. routes and up. The data employed has at least four counts per year and the lower the volume, the higher the variability across the seasons. The process applies safety benefit factors, largely developed and updated by the Institute for Transportation Research and Education (ITRE). The current question is whether there is any safety benefit of urban widening. Rural widening does get a benefit.

Contributions

Moving forward, P6.0 is moving towards trading off mobility and modernization. Mobility will focus on adding capacity, new locations, access management and ITS, while modernization will include modernizing the roadway, and upgrading freeways to interstate standards (see Figure 36).

Future interstate status is of concern for rural areas and this concern is included in the freight measure. Safety benefits are actually double counted through the BCA and the dedicated safety category. Economic competitiveness measures use the percentage change in the economic forecast, using TREDIS, and only for statewide projects. Regional and divisional projects use measures for accessibility and connectivity including county economic distress indicators and travel time savings per user (e.g., saving 100 users 10 minutes is better than saving 10,000 users 10 seconds).

Audience Dialogue

Question: Has anyone suggested adding Hazard Mitigation projects (flooding) in order to get proactive FEMA funds?

Response: The detour during Florence was literally to go around the state. During P6.0 consideration was given to including resiliency, but there was no consensus reached on how to measure it. It is very difficult to fit into the STI Law requirements.

Question: How do you deal with projects that deal with negative travel time savings?

Response: Politically, we do not want to show a negative travel time savings; instead, we show that they do not save time by adjusting them to zero. All projects use a zero to 100% scale so our scoring procedure can account for negatives. Sometimes safety benefits are large enough to carry projects.

Question: Have you looked at interactions between categories?

Response: We conducted substantial statistical analysis during P3.0. Overall, interactions are project specific. Positive correlation between measures is much higher in non-highway scoring. All that data leads to the same project types. We are not too concerned about correlation.

Question: Is there a decision tree for splitting Mobility and Modernization?

Response: We are accepting project submittals in the categories.

Funding Category	QUANTITATIVE		LOCAL INPUT	
	Data		Division	MPO/RPO
Statewide Mobility	Congestion = 10% Safety = 25% Freight = 25% Lane Width = 10% Shoulder Width = 20% Pavement Condition = 10%	100%	--	--
Regional Impact	Congestion = 5% Safety = 25% Freight = 10% Lane Width = 10% Shoulder Width = 10% Pavement Condition = 10%	70%	15%	15%
Division Needs	Safety = 20% Freight = 5% Lane Width = 5% Shoulder Width = 10% Pavement Condition = 10%	50%	25%	25%

FIGURE 36 P6.0 Highway criteria and weights with modernization default.

SESSION 5C: GETTING INTO THE DETAILS OF MULTIMODAL (TRANSIT/BIKE AND PEDESTRIAN) PROJECT EVALUATION

Jason Schronce, *North Carolina Department of Transportation, presiding*
Matthew Carpenter, *Sacramento Area Council of Governments, recorder*
Lori Sand, *Atlanta-Region Transit Link Authority*
Mark Yamarone, *Los Angeles County Metropolitan Transportation Organization*
Michael Snavely, *Cambridge Systematics*
Elise Barrella, *Wake Forest University*
Eric Sundquist, *State Smart Transportation Initiative*
Dave Vautin, *Metropolitan Transportation Commission*

THE ATLANTA-REGION TRANSIT LINK AUTHORITY PROJECT SELECTION PROJECT

Lori Sand

Background

The *Atlanta Regional Transit Plan (ARTP)* uses a six-year and 20-year time horizon, in consultation with MPO. It includes all projects funded through a HB930 sales tax and all the transit projects that meet the definition of a "regionally significant" project, regardless of funding source. The ARTP is the primary source for projects considered for inclusion in the Transportation Improvement Plan (TIP) or Regional Transportation Plans (RTP) and includes a prioritization process.

Methods and Measures

The governing principles for the prioritization process cover six primary areas:

- Economic development and land use (creates or enhances connectivity and access to job centers, activity centers and economic centers in line with the Unified Growth Policy (UGP));
- Environmental sustainability (offers new or enhanced services as alternatives to SOV travel, and promoting the use of alternative fuels to build environmentally sustainable communities);
- Equity (provides new or expanded service to and from low and moderate income areas to improve connectivity and focusing on investments that better enable people to meet their day-to-day needs);
- Innovation (uses innovative solutions to improve rider experience, fare collection, cost savings, integration with transit alternatives);
- Mobility and access (connects population centers, employment, recreation, using cross-jurisdictional services to create regional connectivity); and
- Return-on-investment (ROI).

In addition, economic development and land use ensures that project financing plans are feasible and sound and promotes cost-efficient alternatives for new or enhanced service that enable regional economic opportunity and growth.

The schedule for the process extended from December to May and included a review of the existing methods, developing a performance framework, and communicating and documenting the process. The prioritization criteria has three categories. The first is market potential which consists of existing and projected population density, existing population and communities of interest, existing employment density, existing low wage employment density, and existing and planned land use mix (+/- community impacts); and (re)development potential. The second is deliverability which includes a financial plan, documented project support, project readiness (e.g., schedule and environmental impacts), and regional integration. The third factor is performance impacts that includes transit trips, transit reliability, increased useful life, and elements to improve (e.g., safety, security, environmental). At the intersection of these three factors is cost effectiveness measured as the cost per point based on the analysis of the three factors. A Four-Quadrant Matrix Model is used to correlate the total scores against the cost per point, producing four tiers based on the high score/high cost per point, high score/low cost per point, low score/high cost per point, and finally, low score/low cost per point.

The next phase includes the prioritization process and testing. After compiling, processing and reviewing, some clear indications are revealed about using data. The data advances prioritization goals/objectives, is readily available, is consistent across 13 counties, is stable, yields discrete, relative distribution across projects, and can be efficiently processed for scoring and ranking purposes. It is necessary to build a GIS-based platform to evaluate quantitative metrics. ATL developed project application to support qualitative metrics and built a scoring and ranking calculator. Figure 37 displays the components of the ARTP evaluation process.

Contributions

To date, 195 projects have been submitted and 192 have been run through the evaluation framework. Median scores are used to set tiers. The next step is to present the results to the ATL Board. The Plan is currently on schedule for a December adoption. The process will be revisited and updated on an annual basis.

LA METRO'S PROJECT SELECTION PROCESS

Mark Yamarone and Michael Snavely

Background

Los Angeles County Metropolitan Transportation Authority (LA Metro) oversees the operations of four subways, two LRT and two BRT lines, serving 93 stations. There are 165 bus routes, 450 million annual riders, serving 10 million LA county residents. Another 2.3 million residents are anticipated over the next 40 years. Recent system expansions include the Gold Line Extension to Azusa and the Expo Line Extension to Santa Monica, which both opened in 2016. The Downtown Regional Connector, the Crenshaw/LAX and Purple Line Extension are all currently under construction.

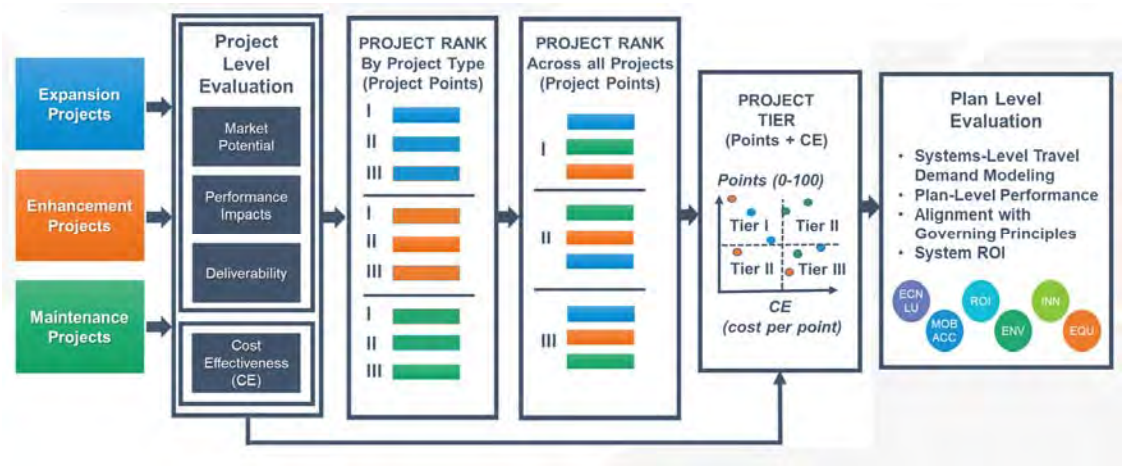


FIGURE 37 ARTP Project Evaluation and Prioritization Process.

The expansion was funded with Proposition A, a $.005 sales tax passed in 1980; Proposition C, an additional $.005 passed in 1990; Measure R, an additional $.005 with a 30-year sunset, passed in 2008; and Measure M, which eliminates the Measure R sunset, and adds an additional $.005, passed in 2016. In total, these measures have provided $120 billion over 40 years. In fact, after educating poll respondents about ballot Measure R, 72% voted for the "no sunset" measure.

The potential benefits that resonate the most with the voters include keeping fares affordable for seniors, students, and persons with disabilities; creating jobs; repairing potholes; retrofitting bridges as earthquake mitigation; and improving freeway traffic flow. LA Metro held 11 public meetings across the county, one virtual online public meeting, 14 telephone town halls, and 84 meetings attended by Metro staff.

A number of general themes emerged from the public comments including a desire for accelerating projects, especially rail, providing more reliable bus service and BRT lines. Some member of the public wanted increases in funding for active transportation. It also includes increases in funding for senior, disabled and student programs, a desire to build in funding for safety, security and technology, and a desire to continue part of the tax to keep the system in good working condition.

The Project M details include three years of preparation engaging regional partners to identify projects for consideration, engage stakeholders on performance metric selection, maintain an open dialogue with stakeholders throughout the process, and frequent, direct coordination with board staff. To move projects forward, the first step required board approval of the weighting framework, applying the scores and ranking the projects, consideration of other sequencing factors including the acceleration of high-performing existing projects, geographic equity, cash flow availability, cost of projects, and the status of environment processes.

Methods and Measures

The board established a set of goal areas with scoring weights: mobility (45%), accessibility (17.5%), economy (12.5%), safety (12.5%), and sustainability and quality of life (12%). These same goals also had transit prioritization metrics including mobility (number of riders), person

throughput, travel time reliability, and service frequency; accessibility (population served by frequent transit), and number of transit dependent households served. It also included improved system connectivity, and access to parks and acres of open space, economy (number of potential transit-oriented developments [TODs]), access to jobs, and dollars invested in disadvantaged communities), safety (number of fatal or severe injury collision area addressed and transit system safety addressed); and sustainability and quality of life (amount of Green House Gases [GHG] emissions, heat island effect and storm water runoff potential; habitat and open space preservation, and clean option in environmentally sensitive community).

To conduct the analysis, the data sources included:

- Metro Travel Demand Model
- Socioeconomic data (U.S. Census)
- Socioeconomic forecasts (SCAG)
- CalEnviroScreen (CalEPA)
- Statewide collisions database (SWITRS)
- EMFAC emissions model (CARB)
- Regional GIS data library

The qualitative characteristics for each project included:

- Project description and details
- Project studies and reports
- Draft/Final environmental documents

Contributions

The scoring approach calculates raw metric scores; both quantitative and qualitative measures are evaluated side-by-side. The scores are normalized by distance or number of stations, with 0.0 as the lowest score to 1.0 as the highest. The average metric scores are identified within each goal area. Weights applied were board-approved and combined goal area scores. A spatial analysis demonstrated the increased coverage available with the passage of Measure M. Early and frequent stakeholder and board collaboration was critical. Using a bottom-up approach for project identification and establishing early consensus on goals, measures, and weights helped with the success of the approach. Finally, using a transparent and data-driven process bolstered support for final project list.

APPLICATION OF ACTIVETRANS PRIORITIZATION BY CITY OF HARRISONBURG, VIRGINIA

Elise Barrella

Background

The City of Harrisonburg is heralded as “The Friendly City”, with approximately 50,000 residents, making it the 12th largest city in Virginia. It is located in Rockingham County and

governed by a council-manager. According to the Vision Statement for City of Harrisonburg's Bicycle and Pedestrian Master Plan, 2017, the City of Harrisonburg "will be a place where pedestrians and cyclists can access a connected network of bicycle and pedestrian infrastructure to safely and conveniently reach all areas of the city for school, work, play, and other daily needs." The Harrisonburg Planning Process began in March of 2015. In April of 2017, the City Council adopted the updated plan. The ActiveTrans Tool systematically uses data to inform priorities in order to be more competitive for state and federal funds.

Transportation Alternatives Program (TAP) funds and Virginia's own Smart Scale prioritization process both required more, and higher quality data, to support funding requests. For example, there are metrics needed for safety (number of fatal and severe injury crashes, rate of fatal severe injury crashes), congestion mitigation (person throughput, person hours of delay), and accessibility (access to jobs, and access to jobs for disadvantaged populations, access to multimodal choices). Additional metrics address environmental quality (air quality and energy environmental effect, impact to natural and cultural resources), economic development (project support for economic development, intermodal access and efficiency, travel time reliability), and land use (only required for MPOs with populations of more than 200,000, land use policy consistency). The bike and pedestrian planning process required mapping the existing bike and pedestrian infrastructure network. Staff logged project needs from prior plans and other planning documents and made efforts to collect project needs from public workshops, focus groups, MPO wiki maps, public comment, etc.

Methods and Measures

Staff can prioritize potential projects using the ActiveTrans Tool (*NCHRP Report 803: Pedestrian and Bicycle Transportation Along Existing Roads—ActiveTrans Priority Tool Guidebook*, http://www.pedbikeinfo.org/topics/tools_apt.cfm). The process is divided into two phases. In the first phase, there are six steps including: defining the purpose, selecting factors, establishing factor weights, selecting variables, assessing data, and assessing technical resources. The second phase provides a strategy for prioritizing projects by setting up a prioritization tool, measuring and inputting data, scaling the variables, and creating a ranked list of projects.

Planners decided to customize the ATP process by using a local process that identifies projects to be funded by a variety of funding sources, including state and federal programs. The potential factors for prioritization included: stakeholder input, constraints, existing conditions, connectivity, and equity. Some additional factors were examined and considered for inclusion. For example, opportunities, both financial and political, could provide resources that support the implementation of a project. Another factor would be safety, defined as risk for pedestrians and bicyclists. This factor would be a priority for all projects, although it lacked quality local data for all projects. Demand was to be included as an estimate of activity levels; however, both bicycle and pedestrian counts were on hold with the need for better methodologies, making it difficult to be confident in data for this factor. Finally, compliance was offered to address issues with existing infrastructure, particularly where it was not meeting bicycle and pedestrian standards and guidelines. Efforts finalized variables for each of the factors and modes, with consideration given to four different types of facilities including bicycle segments, pedestrian segments, intersections, and shared-use paths.

Contributions

The process of compiling available data at the appropriate scale presents a challenge, as well as arriving at the factor weightings. The variables are matching the community's values. Throughout the process, it is important to integrate the prioritization procedures with the public engagement process. Lessons learned during the process include the recognition that different weighting scenarios produced shifts in priorities. There are gaps in local data, and qualitative data sources as important as quantitative. It is important to make the process easily customizable to different locales and different modes and scalable to different sized communities.

INTEGRATING EQUITY AND RESILIENCE INTO THE METROPOLITAN TRANSPORTATION COMMISSION PROJECT EVALUATION PROCESS

Dave Vautin

Background

The Metropolitan Transportation Commission (MTC), located in the Bay Area of California, has been leveraging project level performance assessment for the past decade to identify effective investments. The Bay Area has a long history of facing challenges including the earthquake of 1906, the growth of the urban core, issues with homelessness, and increasing traffic. Even with this trajectory, equity and resilience had not been deeply woven into the methodology and approach for planning until now. The Horizon Plan focuses on "preparing for an uncertain future by identifying resilient and equitable strategies." The previous effort, Plan Bay Area 2040, covering spring 2015 through July 2017, was the foundation for the Horizon Plan (February 2018 to November 2019). Now Plan Bay Area 2050 (September 2019 to June 2021) will build on a better foundation for the next plan, with a focus on outreach, perspective papers, futures, and project evaluation. The reality is that even though a plan envisions a smooth trajectory into the future, in reality, a number of unexpected challenges are more likely. What external forces might influence the future of the world and the United States (e.g., changes affecting the political, environmental, economic, land use, and transportation sectors)?

Methods and Measures

Being prepared for the future requires a focus on what areas might have substantial impacts. MTC looked at three key areas: Clean and Green (*What if*... new technologies and a national carbon tax enabled greater telecommuting and distributed job centers?); Rising Tides, Falling Fortunes (What if... the federal government cuts spending and reduces regulations, leaving more policy decisions to states and regions?); or Back to the Future (What if... an economic boom and new transportation options spur a new wave of development?). These futures were set into a matrix to examine a set of external factors: immigration and trade; national taxes and funding; national growth; land use preferences; national environmental policy; new technologies; and natural disasters (e.g., a 7.0 earthquake). The impacts were shaded from lower values to higher values.

A request for transformative transportation projects produced over 500 big ideas to improve Bay Area transportation. The top 100 projects were stress tested against the three

possible futures. The first test used a benefit-cost assessment that featured benefits (e.g., accessibility in terms of travel time in vehicle, vehicle operating costs, mode choice availability, travel time out-of-vehicle, travel costs, transit crowding, travel time reliability, emissions, natural lands, health, safety and noise). Costs for the public sector included capital costs (e.g., initial investment, residential value), and gross operating and maintenance costs. The process used external factors including, a Regional Economic Models Inc. (REMI) Regional Forecast model, UrbanSim for land use impacts, and Travel Model 1.5 for long-term and daily travel choices, to determine project benefits.

Equity assessments traditionally use a spatial analysis, using Census tract values. A new approach made it possible to evaluate the equity implications of the three futures. The new approach creates an equity score using the average annual accessibility benefits per person applied to household income quartiles (2018 dollars). The benefits per person of lower income groups is divided by the benefits per person for all groups to calculate the equity score. Each project is assigned an equity score over the three futures. Scores were categorized into three groups: less than 40% impede equity, scores between 40% and 60% exhibit an even distribution of benefits, and scores greater than 60% advance equity.

Another consideration focused on assessing projects against a set of defined Guiding Principles that reflect the public's priorities. The Guiding Principles described a desired outcomes and factors for achieving the outcomes in areas that included affordability *(*all Bay Area residents and workers have sufficient affordable housing options they can afford ensuring households are economically secure for residents and employees), connected (an expanded, well-functioning transportation system connects the Bay Area that is fast, frequent, and efficient intercity trips are complemented by a suite of local transportation options, connecting communities and creating a cohesive region*)*, and diverse *(*the Bay Area is an inclusive region where people from all backgrounds, abilities, and ages can remain in place with access to the region's assets and resources). They also included healthy (the region's natural resources, open space, clean water and clean air are conserved and the region actively reduces its environmental footprint and protects residents from environmental impacts*)*, and vibrant *(*the Bay Area region is an innovation leader, creating quality job opportunities for all and ample fiscal resources for communities*)*. These Guiding Principles flagged adverse impacts from any particular project. For example, does the project increase travel costs for lower income residents, affecting affordability. Does the project impact travel times or eliminate travel options affecting connectivity? Does the project displace lower income residents or divide communities affecting diversity? Does the project significantly increase collisions or emissions affecting health? Does the project eliminate jobs affecting vibrancy?

After more than 300 model runs, researchers assembled the draft results in a matrix (see Figure 38) making it possible to identify project overall rating, compared to other potential projects.

Contributions

Almost all 100 projects have been run through Travel Model 1.5. The next step is publishing draft results and working with elected officials and stakeholders to use all seven scores to rate projects as high, medium, and low performing. Changing the status quo is never easy. It requires

Project (Names Redacted)	Benefit-Cost Ratio			Equity Score			Guiding Principles Rating	*Potential* Overall Rating
	RTFF	CAG	BTFF	RTFF	CAG	BTFF		
Project #1	>5	>5	>5	Advances Equity	Advances Equity	Advances Equity	Supports Principles	VERY HIGH
Project #2	1	2	3	Even	Even	Even	Supports Principles	HIGH
Project #3	0.6	1	1	Even	Even	Even	Supports Principles	MEDIUM
Project #4	0.3	0.8	0.6	Impedes Equity	Even	Impedes Equity	Supports Principles	LOW
Project #5	0.3	1	0.9	Even	Even	Even	Does Not Support	LOW

FIGURE 38 Sample draft results using the methodology highlighting equity and resilience.

methodological upgrades and a willingness to change. The transition from a "linear" or fixed-forecast planning approach to one that focuses on uncertainty can be a bit jarring to long-time planners and modelers. Conducting such a robust project evaluation process, while incredibly valuable to better inform decision-making, is time-intensive and resource-intensive.

Challenges, including integrating equity into the project evaluation framework, allows for a better understanding of "who benefits" so targeted investments can address long-standing racial and economic disparities. Integrating resilience provides an opportunity to "stress test" long-standing project proposals to ensure they will be effective under a wide range of conditions. This type of planning process helps address big-picture questions from elected officials outside of the traditional state and federal requirements for a long range plan.

SESSION 6C: SPEED DATA[ING] (DATA AND TOOLS USED IN PROJECT EVALUATION THAT FEEDS THE TIP/STIP)

Penelope Weinberger, *American Association of State Highway and Transportation Officials, presiding*
David Wasserman, *North Carolina Department of Transportation, recorder*
Mark Egge, *High Street Consulting*
Jason Schronce, *North Carolina Department of Transportation*
Chris Hamby, *New York City Department of Transportation*
Dave Adams, *Georgia Department of Transportation*
Ben Lempke, *Georgia Department of Transportation*
Thomas Chase, *Institute for Transportation Research and Education*
Peter Smith, *Texas Department of Transportation*

KENTUCKY'S SHIFT TOOLS

Mark Egge

The Kentucky Transportation Cabinet (KTC) created the Strategic Highway Investment Formula For Tomorrow (SHIFT), a data-driven methodology for prioritizing their capital improvement projects. The formulas used to score candidate projects were created through a collaboration of technical experts within the Kentucky Cabinet and are based on project data points (e.g., AADT, crash history, vehicle hours of delay), and other data points for a candidate project. These data generate scores with respect to their various goal areas, and then an online decision-making software ranks and prioritizes projects. The process required an intermediary to take the scores and translate them, using a script, into the online software, as a one-time process. However, there was the issue over time that required more than attempting to simply update the scripts. Users wanted to have more autonomy and control over the process of making adjustments to accommodate changes. Staff made the decision to create a calculator capable of allowing users to create their own transformations on an ongoing basis.

The solution was to build an online web-graphing calculator that allows users to upload inputs of candidate projects with their data points and then define formulas that translate their input data points into output scores. The necessary formulas can be relatively simple, complex, or conditional on a number of different conditions (e.g., scaling with minimums and maximums). Basically, all the formulas found in a calculator are built into the application. After defining the formulas, the input data points for projects are uploaded and processed, using the formulas and delivers score for each of projects. The scores are ingested into the online software where they can adjust their criteria weights and see the recommended prioritization of those projects with respect to the project scores and the goals that they have identified.

NORTH CAROLINA DOT's "SPOT ONLINE"

Jason Schronce

North Carolina needed a method for capturing project data from transportation and other agency partners. To accomplish this, they developed SPOT Online, a Geographic Information Systems (GIS), web-based app, specifically designed to capture all the necessary information for a project and submit projects to North Carolina DOT (NCDOT) for scoring. The three main components of the tool are a user-friendly interface, a scoring management app, and a cost estimation tool. The software includes a map with an integrated list (see Figure 39). The scoring management allows the user to examine criteria, weights, local inputs, and measures. The project entry wizard provides buttons and selection menu for ease of use, along with geoprocessing. The cost estimation tool includes costs of construction, right-of-way (ROW), and utilities for each of the highway projects. The software includes inputs from the user, and then generates detailed reports (e.g., cross-sections two-lane highway, 12-lane cross-sections with managed lanes in both directions). The software incorporates sidewalks, bicycle lanes, shared-use paths, and multi-use paths in the cross-sections.

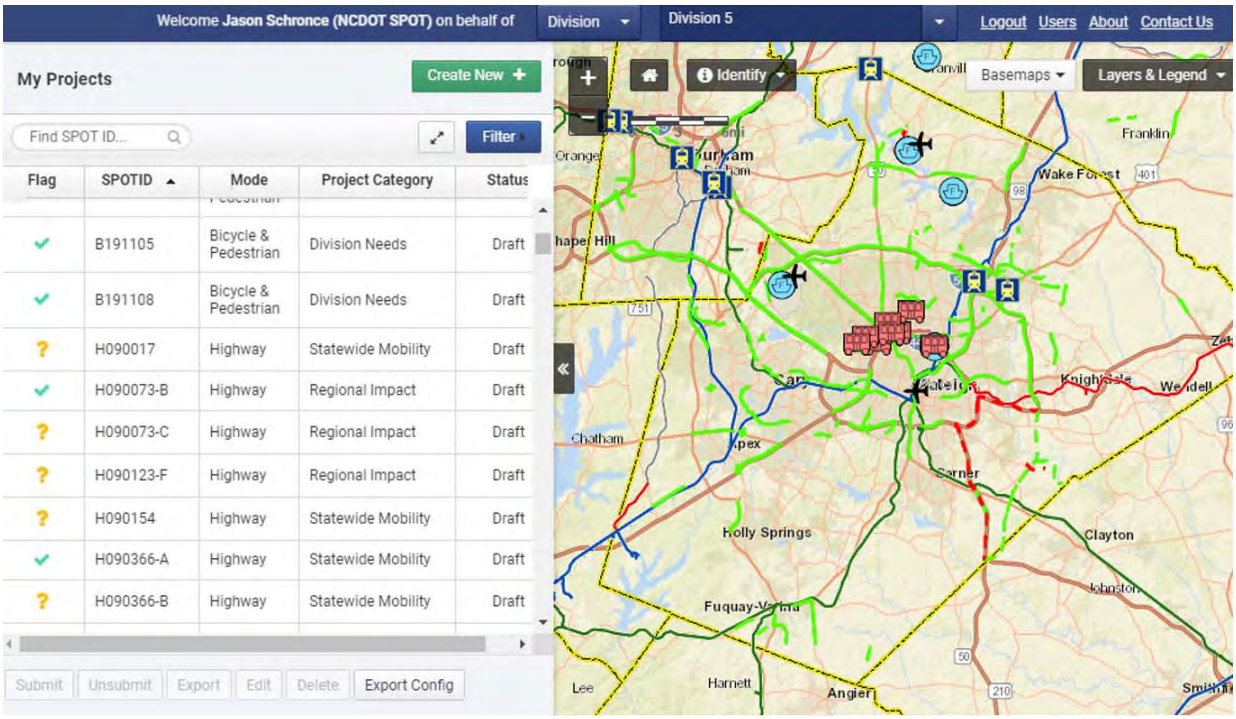


FIGURE 39 NCDOT Project Prioritization Tool.

NEW YORK CITY STRATEGIC PLAN SCORING SYSTEM

Chris Hamby

New York City Department of Transportation (NYCDOT) oversees 6,000 miles of streets, 12,000 miles of sidewalk, 794 bridges, 13,000 signalized intersections, 300,000 streetlights, and 69 million linear feet of street markings. They regularly solicit local, state, and federal funding for projects. The key is to have a balanced plan and to prioritize citywide programs, community requests, and other needs. Capital planning is a complex and opaque process, and with limited funding, an organization often has to make difficult decisions about which programs and projects to prioritize. In light of the need to prioritize, NYCDOT needed a methodology to more clearly align its more than $3 billion street reconstruction program with the agency and the city strategic plans, using simple tools and public data to support more transparent, value-driven decision-making. The project's tracking system was more than 10 years old and posed significant constraints, making it difficult to track and report on projects.

A new prioritization system was developed and updated, using Excel spreadsheets. Even so, version management and distribution remained difficult. The next improvement was to migrate the Excel tables to Microsoft Access. To prioritize the many competing projects, NYCDOT put the focus on quantitative and clear capital prioritization in its administration. New strategies were used to develop models in ArcGIS to replace the previous manual geospatial process. The new system has the ability to automate data importing and update data sources using Access macros. The research team created a new front-end for project managers.

The Access database provided guidance for eventual long-term solutions. The core project data is now managed in a modern, shareable, reportable system, while the prioritization framework remains in Access. Throughout the process as NYCDOT developed its tools, they cultivated institutional support for the creation of a data-driven prioritization system that interacts with real-world considerations, and the shifts in agency planning culture that occurred after the system was implemented. Staff are now in the process of moving to modernize with a completely new application for NYCDOT. When staff worked with IT, they could clearly see what was needed (based on previous work). The prioritization system is still in Access, rather than in a dedicated system, to allow the prioritization process to continue to use a proven method for updates. Staff were unwilling to rely on IT for changes or updates.

The NYCStreets Pavementworks Tool (see Figure 40) provides a mapping interface with attributes for the project. For example, Project ID HWK1155 is located in Downtown Brooklyn and is a traffic calming strategy. The process extracts the relevant data from the Capital Planning Database (CPD). The context data makes it possible to understand the spatial aspects of the project.

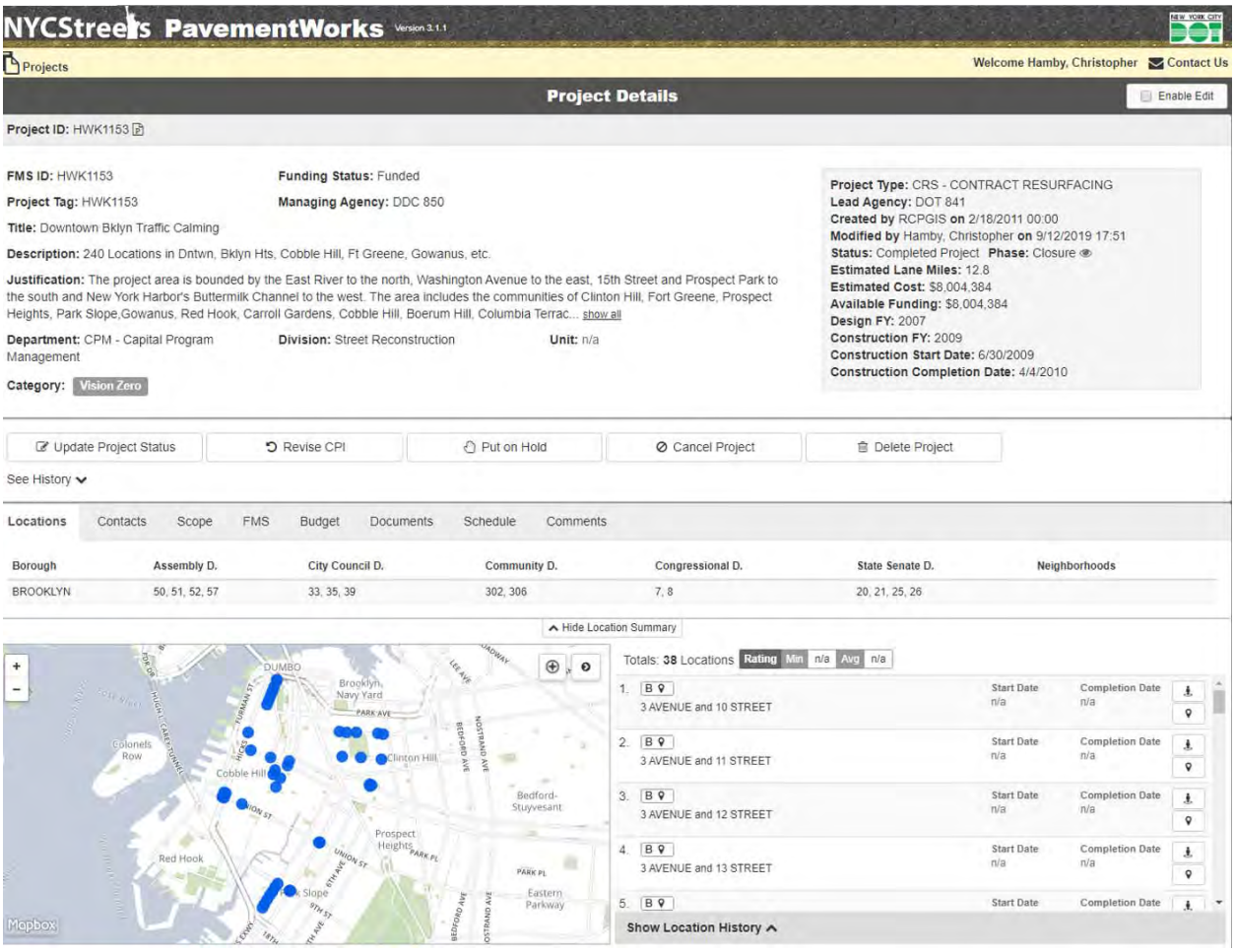


FIGURE 40 NYCStreets PavementWorks interface.

NEWMETRIC'S SAFETY SOFTWARE

David Adams

At Georgia Department of Transportation (GDOT), crash data, attributes, and road centerline data were analyzed using Geographic Information Systems (GIS). A decision was made to reach out and work with an external partner, NewMetrics. Their tool provides quick look-ups, an easy to understand interface, is very reliable and able to provide general crash information. The tool has two purposes to fulfill customer requests and to drive decision-making. As part of the tool, copious graphic data provides basic trends. The tool provides an interface to download the raw crash data and then put the latitude and longitude points into another GIS project. The key is pulling all these data pieces together in a GIS to facilitate problem solving, to help drive the safety program, and to make better decisions where we want to go next with our next safety projects.

GEORGIA'S MARK1

Ben Lempke

The Measurement, Accuracy, and Reliability Kit (MARK1) is a web-based, open source, software accessed on the web. It provides a monthly report with operational performance metrics displayed as trends over a monthly period. These metrics include throughput, spillback, travel time indices, and more. In addition to performance and operational metrics, MARK1 also displays agency equipment updates (e.g., vehicle detection, closed-circuit televisions [CCTVs]), and communications to signal cabinets. MARK1 makes it possible to manage a large transportation network by providing all the data graphically and numerically, allowing users to see trends that are trailing off or underperforming. It displays where to further investigation, or locate more resources. Users can use the functions remotely, including remote investigation using the different tools and graphics available. Users can view that data on a programmatic level, on a district level, or even by corridors.

PERFORMANCE-BASED PRIORITIZATION OF NCDOT STATEWIDE SIGNAL SYSTEM RETIMING PROGRAM

Thomas Chase

NCDOT maintains more than 380 closed loop signal systems, including more than 2,300 controllers, with an annual retiming program used to ensure the signal plans are current and effective. Traditionally, this retiming program centered on a three-year update cycle for signal systems as well as collecting input from the 14 divisions across the state. Two years ago, the Central Office System Timing (COST) section began testing probe travel time data for identification of systems in need of retiming with initial internal work showing consistent results with field collected travel times.

The Institute for Transportation Research and Education (ITRE), with assistance from others, developed a performance-based prioritization tool with similarities to the prioritization framework used for NCDOT's (State Transportation Improvement Program [STIP]). The web-based prioritization tool incorporates travel times, reliability, trends, safety performance. It also

provides Annual Average Daily Traffic (AADT), visualizations and standard reports that COST and the NCDOT Divisions can use to inform the selection process. Travel time performance measures include average and reliability metrics by time of day as well as the FHWA's Level of Travel Time Reliability (LOTTR) metric, enabling the program to identify signal systems on the NHS are targeted for improving the statewide MAP-21 reliability performance measure. Safety data include critical crash rates, crash densities, and severities, while AADT data provide information on the number of vehicles served by each system. NCDOT has utilized the tool for prioritizing the FY2019 program, and plans to update the datasets for continued use in future years.

TEXAS CORRIDOR PRIORITIZATION TOOL

Peter Smith

Texas let $9 billion worth of projects, along with $1.8 billion per year invested in projects to get them ready for construction. The need is to transition from long-range ideas to moving the right projects through the process. To address this need, the Texas corridor prioritization tool uses multiple data sources, and categorizes projects into six key performance areas that can score the whole Texas network, or at smaller geographies for evaluation. Staff used GIS to preprocess data for the creation of the 21 key performance metrics. The process establishes scores using current conditions, or in some cases, future conditions, using the volume to capacity (V/C) ratios. A score is developed for each link in the system. First, the process uses fixed weights for key performance measures, and then it uses flexible, adjustable weights in the key performance areas to score the elements in the system. In Texas, all projects are ranked and scored. They are subdivided into key performance areas to see how they rank in each of the performance areas. Finding the projects that rank the highest (e.g., I-695) should be the next level of focus. It is possible to break down the data into a number of different elements, with high, medium, and low ratings for a particular performance area.

SESSION 7C: COMMUNICATING PROJECT SELECTION RESULTS

Hannah Twaddell, *ICF, presiding*
Mark Seaman, *New York City Department of Transportation, recorder*
David Wasserman, *North Carolina Department of Transportation*
Chad Tucker, *Virginia Office of Intermodal Planning and Investment*
Dan Gabiou, *Arizona Department of Transportation*

ARIZONA DOT

Dan Gabiou

Planners have both internal and external stakeholders, including engineers and other planners, management staff, board and committee members, agency staff, and the public. It is important to consider the target audience, depending on where in the planning process a particular activity is located at a particular time. To get the best outcomes from any communications, it is important

to first build consensus on the process, criteria, and the weights that are being developed. There are also a set of practices that can help ensure success. For example, agenices should always be ready to share data and report on progress.

Staff need to formalize communication channels and make sure to get to the bottom of issues as early as possible to reduce delays, and without building prioritization strategies within silos. It is important to provide any stakeholder (e.g., local Councils of Government (COGs), Metropolitan Planning Organizations (MPOs), tribes, and districts) with a solid foundation for criteria options from technical experts. The information needs to be based on federal, state, or MPO performance measures, including for project nominations, through required approvals by the designated Transportation Board.

Figure 41 illustrates the path for project prioritization, beginning with the project nominations process and ending with the ADOT Five-Year Program. The district workshops provide the opportunity to check whether prioritization makes sense. During the process, it is worth keeping an eye on opportunities for continuous improvement of the Planning to Programming (P2P) process. At the same time, it is important to make sure participants remain involved to avoid surprises, or problems managing expectations. For example, in many cases, not all issues with the process are fixed in one cycle, just as not all projects can be programmed in a single cycle. As issues arise, they need to be documented and assigned for follow-up with a

FIGURE 41 Project prioritization path.

deadline for a response. As the process goes forward and lessons learned are identified, it is useful to have a technical steering committee to oversee the process, including for consultation and approvals from external executive parties, to reassure participants that progress is being made. Transparency can be demonstrated if everyone's involvement in the process is laid out for all stakeholders to review via a checklist. Communicating the process to all involved includes explaining the reason why the process exists (e.g., state-mandated requirement for this prioritization). In communicating with stakeholders, be cognizant of their individual communication styles (e.g., provide the appropriate amount of detail).

Audience Dialogue

Question: How are you presenting prioritization to the public?

Response: The team has yet to present the prioritizations to the public, but we are aiming to post in on the web by the end of FY 21.

Question: Who is involved in determining criteria and weights?

Response: Criteria and weights are developed internally, but we provide opportunities for input from external stakeholders.

VIRGINIA OFFICE OF INTERMODAL

Chad Tucker

Virginia's SMART SCALE is the set of policies and methods used to score and evaluate transportation projects that fund in the Virginia's Six-Year Improvement Program (SYIP). The projects are scored based on an objective, outcome-based process that is transparent to the public and allows decision-makers to be held accountable to taxpayers. SMART SCALE has been used over the past four years to allocate over $3.25 billion in funding for operational and capacity transportation improvements.

The first rule of communication practices for the SMART SCALE program is that all parties see the scoring results at the same time. Decision-makers are presented the results and the staff recommended funding scenario the same day the results are released to the public. This important policy helps to maintain the integrity and transparency of the process. Another feature in the communication strategy is to produce and distribute a PDF version of each scorecard (see Figure 42). The documents are also posted online and included projects that are screened out and the reasons for screening out. For example, some projects do not meet eligibility criteria (e.g., maintenance projects), others do not meet objectives or a project is not ready (e.g., no signal warrant analysis prepared). The SMART Portal is open for communicating review of submitted applications. Statewide public hearings also provide opportunities to educate and share general and specific details of the process. After projects are selected for funding, SMART SCALE provides information on their dashboard. Staff provide the legislative body with a full document of the results.

A second rule is to the extent possible, provide full information by showing underlying analysis. The SMART SCALE provides all the calculations on their website. During the scoring

process, there is blind scoring of the applications. In addition,10% of projects go through a second independent process by another analyst, independent verifications, and validation by an outside auditor. An external peer review group composed of the Virginia Association of Counties, the Virginia Muncipal League, the Virginia Transit Association, along with other non-governmental groups, oversee the process. It should be noted that VDOT cannot itself apply for funding through this process, except for two statewide projects each round.

Although no one wants to make a mistake, if one occurs, the third rule directs an agency to own up to the mistake. Transparency includes explaining why it happened and how it will be fixed or prevented in the future. While there may be those who would prefer to sweep failure "under the rug," that only makes it harder to learn from it. SMART SCALE has had a few failures (e.g., I-95 being assigned zero freight tonnage during one of the rounds of analysis). Another failure occurred when a project was mis-scored due to a travel model limitation. The Commissioner identified the error the morning after the public release and staff immediately corrected the error and was transparent about the situation with the oversight board.

The fourth rule is to always strive for improvement. For example, after the scoring process is completed, a productive step is to conduct reviews and document lessons learned. The External Review Group is responsible for conducting reviews of the process for the development of measures and scores. For example, the External Review Group deploy internal and external stakeholder surveys on the application in-take process, screening, and validation. Implementation team workshops focused on all aspects of the process. These types of follow-up tasks help to inform the work plan for the next round. To foster continuous improvements, post mortem analysis are conducted to assist in the determination of how to improve any aspect of the process, including feedback from applicants, staff, and the external peer review group.

The fifth rule is to not stop communicating when a project is funded, but rather to continue to communicate through tracking and implementation, including reporting the metrics associated with the outcomes of the completed project.

The SMART SCALE Dashboard was launched in January 2017. Having the dashboard has changed how Virginia tracks project development. For example, now, the 10 milestones are scheduled in project development as opposed to the previous practice of just reporting the advertisement date. Projects are tracked through the project award to close the gap between the time of the advertisement and the award. The rules developed for this part of the process were designed to encourage early starts and early finishes. Reviewing the new practices, revealed that overall, milestones are being completed earlier and localities are struggling to meet their targets. For example, the milestones completed prior to SMART SCALE were compared to those milestones completed on SMART SCALE Projects (February 2017–May 2018), and (June 2018–May 2019). The results show that the percent of milestones completed late have been cut in half, while the percent of milestones completed early have almost tripled. While the milestones are being completed earlier, but challenges to meet established targets exist. Localities awarded 48% of projects on-time (33% of award dollar value), while VDOT awarded 80% of projects on-time (89% of the award dollar value). With respect to milestones for project completion, localities completed 57% of projects on-time (13% of dollar value scheduled for completion) and VDOT has completed 87% of projects on-time (79% of the dollar value scheduled for completion).

SMART SCALE — Funding the Right Transportation Projects in Virginia

VDOT · DRPT · Office of INTERMODAL Planning and Investment

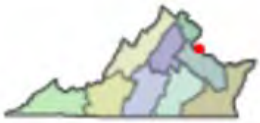
PROJECT SCORECARD

For more information on how to read a scorecard, click here.

Route 301 University Drive/Market Ctr Double RCUT — Project Id: 3488

Reconfigure intersections of University Drive at US 301 and Market Center at US 301 respectively to Restricted Crossing U-Turn intersections & install marked pedestrian crossings.

Submitting Entity: King George County
Preliminary Engineering: Not Started
Right of Way: Not Started
Construction: Not Started
Eligible Fund Program: District Grant
VTRANS Need: Urban Development Area (click here for details)



10.5 SMART SCALE SCORE			
	#32	OF 433 STATEWIDE	SMART SCALE Requested Funds..... $3,500,000
	#1	OF 32 DISTRICTWIDE	Total Project Cost..... $3,500,000
			Project Benefit..... 3.7
			Project Benefit / Total Cost..... 10.5

SMART SCALE Area Type D

Factor	Congestion Mitigation		Safety		Accessibility			Economic Development			Environment		Land Use	
Measure	Increase in Peak Period Person Throughput	Reduction in Peak Period Delay	Reduction in Fatal and Injury Crashes	Reduction in Fatal and Injury Crash Rate	Increase in Access to Jobs	Increase in Access to Jobs for Disadvantaged Populations	Increase in Access to Multimodal Travel Choices	Square Feet of Commercial/Industrial Development Supported	Tons of Goods Impacted	Improvement to Travel Time Reliability	Potential to Improve Air Quality	Other Factor Values Scaled by Potential Acreage Impacted	Support of Transportation-Effident Land Use	Increase Transportation-Efficient Land Use
Measure Value	6.8 persons	6.0 person hrs.	38.5 EPDO	1,108.1 EPDO / 100M VMT	10.5 jobs per resident	17.2 jobs per resident	10.2 adjusted score	1,935,264.3 thousand adj. sq. ft.	43,777.2 thousand adj. daily tons	11,370,600.0 adj. buffer time index	13.6 adjusted points	2.9 scaled points	access * pop/emp density ∆	access * pop/emp density change
Normalized Measure Value (0-100)	0.0	0.1	11.0	2.3	0.2	0.3	0.0	5.2	0.9	0.4	0.1	8.8		
Measure Weight (% of Factor)	0.5	0.5	0.5	0.5	0.6	0.2	0.2	0.6	0.2	0.2	0.5	0.5		
Factor Value	0.1		6.7		0.2			3.4			4.5			
Factor Weight (% of Project Score)	10%		30%		15%			35%			10%		N/A	
Weighted Factor Value	0.0		2.0		0.0			1.2			0.4			
Project Benefit	3.7													
SMART SCALE Cost	$3,500,000													
SMART SCALE Score (Project Benefit per $10M SMART SCALE Cost)	**10.5**													

FIGURE 42 VDOT SMART SCALE report card.

Audience Dialogue

Question: Priorities are different between localities and states. How do you resolve these differences?

Response: Projects funded by VTrans have to meet VTrans needs. There can be issues. For example, localities may not be interested in advancing an interstate upgrade, but VTrans would like to advance that project for the betterment of the State.

Question: How often are statewide plans updated?

Response: A comprehensive effort is made every four years, with plan updates every two years.

Comment*:* It is much easier to prioritize projects using data, instead of just starting from a qualitative place. Having to use data is more painful for planners. However, previously, without using data, all projects were declared "important" because "congestion is really bad" was an argument for every project.

Question: How do you deal with political sacred cows (e.g., I was promised this project)?

Response: Sometimes the data will justify the project. Biggest problem is economic development projects. These tend to fall to the bottom of the ranking. However, politicians are grateful because they have something substantive (the objective scoring) that they can take back to their constituents.

Question: How did localities respond to the presentation of project implementation status on the dashboard?

Response: This issue has not really been a concern.

Question: Some MPOs have put in place penalties for localities that do not hit milestones. How is this dealt with?

Response: VDOT can track performance by locality and provides assistance for localities that are having trouble delivering on time.

Question: Does VDOT require public input be part of the process?

Response: Yes, but that process is associated with going to the board and making a case is public.

Question: How do you communicate to local residents about a project that is rejected?

Response: It is important to communicate scoring and then listen to the public response (e.g., the public provided input that weekend congestion was an issue and was not accounted for in the process. Based on input, there was another look at the project).

NORTH CAROLINA DOT

David Wasserman

North Carolina's General Statutes, Chapter 136 requires compliance with Article 14B. Strategic Prioritization Funding Plan for Transportation Investments, which lays out a process for prioritizing projects, with three identified funding priorities and percentages: Mobility (40%), Regional Impact (30%), and Division Needs (30%). The priority analysis is incorporated in the State Transportation Improvement Program (STIP). The 2019 STIP provides direction for 2020 through 2029. The revenues come from a variety of sources including auto registrations, gas taxes, and federal funding. After meeting the various category-funding requirements, the remaining funds are available for 22 buckets of projects from a prioritization process. Some funds are taken off the top for committed projects and mandated programs. Previously, the allocations were made using an equity formula. The new Strategic Transportation Investment Program is producing new outcomes for Virginia.

The prioritization process was applied to 3,100 proposed projects, with 530 receiving funding (17%). A key strategy is to provide as much transparency as possible by making all the data available for review by the public. When projects are not selected, VDOT provides an explanation. In the new strategy, MPOs and RPOs have greater input on the project funding decision. This is a new responsibility for RPOs. The public input phase occurs with the MPOs, RPOs, and divisions. This practice moves the politics of project selection to the local level, with an emphasis on project submittal and point assignment. This change increases public participation and reduces the amount of lobbying of NCDOT board members. The Board of Transportation (BOT) now focuses on department policy, not on project selection. In the process, there is an increased emphasis on data, making accuracy and the need for a thorough review of data necessary. As previously noted, NCDOT allows localities to review all data used in the scoring process before the results are published. Overall, the strategic investment approach has received positive feedback. Legislative leadership is pleased with the STI process. The use of STI has prevented loss of funding with motor fuels tax changes, increases in the Department of Motor Vehicles (DMV) fees (revenue reform), and stopped $205 million in annual transfers outside DOT. The transition to the STI process required recognizing the need for balance when moving to the new system with existing projects in the pipeline. The original plan was for a longer transition timeframe. Some 85% of the projects from P3.0 are new, which led to a build-up of cash.

Challenges exist for cost estimations with the need to obtain reasonable costs for hundreds of projects. Costs for some projects have grown dramatically. VDOT has a process whereby if costs or scope change, that project is rescored. This has forced project sponsors to be more careful up front when defining scope and estimating cost. Increased oversight and scopes that are more detailed reduces cost under-estimations. In addition, if cost increases by more than a certain threshold, a project may get re-prioritized. Engineers review some projects themselves and use tools for others. There are cost increases for most projects, which affect the availability of funds for future STIPs. The improvements are using express designs, with corridor development engineers available to improve project scopes when submitting projects. There is a policy for reprioritization of committed projects. Another challenge was the tension between urban and rural needs. There was a backlog of projects in the urban areas. The large number of new projects meant that cash accumulated because selected projects were not ready to implement. A longer transition phase would have been helpful. Under the STI, the majority of

projects selected in P3.0 and P4.0 in urban areas were based on the data. There was a strong desire for a better balance. The Workgroup tasked with addressing issues made adjustments in P5.0, resulting in a better balance.

The STI process has increased project stability and reliability for all partners, while still allowing for some adjustments of priorities. For example, if new opportunities or projects arise, NCDOT needs to be responsive. Projects programmed for right-of-way (ROW) or construction within the first six years of the STIP are committed, while other projects can re-compete in the next prioritization cycle. Combining stability with changes in policies and partnerships has substantially reduced project delivery. The new process identifies projects cut due to a funding shortfall, and help make the case for increasing overall funding levels. Project stability has also improved since the rotation of elected officials no longer affects project funding.

Audience Dialogue

Question: Do you see localities re-designing projects so they meet criteria?

Response: Yes. Rejected applicants ask VTrans how they can improve their project for next round. It has resulted in applicants narrowing down a project to focus on where the real needs are.

Question: Can applicants get a pre-score for the project, to see how it will eventually do?

Response: Yes, with no guarantee that score will be the same. It is harder to do at VTrans, because the scores are scaled, based on all of the projects submitted. It is also important to note the importance of scrutinizing the scores for politically sensitive projects, to be prepared for defending the results.

Chapter 8

Special Guest Speaker

Patricia Hendren, *I-95 Corridor Coalition presiding*
Hannah Twaddell, *ICF, recorder*
Mohammed Chaara, *Director of Machine Learning and Data Science, UPS*

THE LINK BETWEEN TRANSPORTATION PERFORMANCE AND ECONOMIC VITALITY

Mohammed Chaara

My role is to help UPS become a better learning organization, getting as much learning as possible out of data. I do this by enabling capabilities, moving UPS to become a data-driven decision-making organization. Although UPS has always been at the forefront of applying data in their business, we have also been at the forefront of operations research with our Orion Program. While data has been used to improve transportation, we are now thinking about expanding the scope of data-driven decision-making to all the aspects of the business, being more innovative and entrepreneurial in the process.

There has been massive digitization and disruption in logistics. Consumers are behaving differently with E-commerce and other types of gig-economy driven services. Businesses are expecting different types of services because they are reacting to changes in consumer technology and innovation, changing the way we transport goods. For example, as we move objects from A to B, we want to know more about how we interact with different objects, or even people, as we move them from A to B. It is a new renaissance in the logistics industry. Data is being generated in many aspects of our business. For example, imagine interacting with a customer, then taking responsibility for an asset that customer wants, tracking that asset throughout our network and interacting with a co-signee. The entire process generates a number of events, movements, liability, and responsibility, using numerous technologies. The result is large volumes of complex data, all part of a logistics organizations, especially at the scale of UPS.

With data, innovation is a never-ending journey. Previously, we looked at data as static. Now data is being viewed as an “asset” capable of providing value through a variety of new applications. As an organization, either in the public domain, or as a business enterprise like ours, data is important and requires governing principles so it can be managed. A classic approach to data claims it should be accurate, complete, consistent, timely, and compliant. However, in real life, data is never completely accurate. We all have bad data and we all know that. Data is created not just by machines, but also by humans, and humans are not perfect, so data is never accurate. Data is never complete. There will always be missing variables in a dataset. In addition, it is never really consistent because the world changes around us and data now becomes the representative of that environment. I propose we look at data in a different way. Data as an asset for future insights with multiple dimensions to consider. Every organization dependent on the industry space where they operate needs to deal with different attributes, or categorizations of ways to manage and govern your data. Any data collection, or

data management strategy, needs to be focused on the end user, the end customer, and goal, or citizen, or resident, depending on who is your ultimate person entity that you want to model or manage. Instead of accurate and complete, I would like to use the word trusted. Trusted, in this situation, means you know the behavior of that data. For example, you know things that are wrong with your data. You know where incompleteness is, and you take that as a conditional statement, making decisions knowing this. The key is figuring out how to deal with the data you have and the questions you want to answer.

Data needs to be agile, open, and available. As a resource, data needs to be mined to get the full value from it. The best method for mining is to have many people looking at it in a governed, dynamic and safe way. There are ways to keep it safe, secure, governed with new technologies and tools, without hurting the speed to gain value. In general, open, freely available data provides the most benefits.

Data is used for key performance indicators (KPI) and often, people have KPIs for the sake of KPIs. It is critical to determine the purpose of the data. For UPS, the purpose is to take objects from A to B. For example, we have introduced drone delivery. We are the first ones to go to market with a commercial viable drone service in the health care space and we have taken that lead based on research data analysis and modeling. We extract as much value as possible out of our asset. We perform similar analysis to get the most use from our vehicles. It is all about asset utilization as an important metric for us at UPS.

Learning is finding new insights, new observations. At UPS, we are speeding up the process to capture information, apply hypothesis testing model analysis, and provide insights to an organization. We use an innovation theater, a cutting edge, cloud-based environment with access to structured and unstructured data. We then allow data scientists to apply their science in a very quick manner. We discover, analyze and develop insights. During discovery, we tend to seize the opportunity. Most importantly, what we do in discovery is translate what the internal state order thinks the problem is, into what truly the problem is. For example, we look at symptoms as they come in, filter them and make them into a diagnosis, similar to an actual doctor. A symptom of the problem in hand. Then we move into the actual analysis so we can know what the mathematical representation is, what modeling is required, or the approach needed to come to an answer. When we have accuracy, relevance, and feasibility studies completed, we move it inside, and push it into production.

Consider a use case around predicting jams in automated facilities. Some very senior leaders in our organization went to one of our automated facilities, visited the control tower to view the camera screens and saw this amazing thing happening in real time. The engineers have access to a large number of screens, providing vast amounts of information. However, it is almost impossible to have an awareness of every item that is happening in an automated facility. The challenge for us was to leverage the cameras that are installed inside the facility for security purposes, and the videos that are coming out of those cameras, with the application of artificial intelligence (AI) machine learning (ML), to automatically detect events (e.g., jams on the conveyor belts, similar to a traffic jam). We are looking at jams and boxes that are moving throughout the sorting belt. We started with the discovery, to define the problem, and then moved into processing our data so we took that video feeds. With the actual data moving into analysis, the hypothesis was that as the number of boxes increasing to a specific level is a predictor of the possibility of a jam. While that was not sufficient, we moved into a different hypothesis as we learned more and iterated very quickly through the exercise. We even did a

third solution with a third different model so we had three different solutions to come up with our final solution (still underway).

AI is able to see a “box” and count it. Unfortunately, when the boxes get too close to each other, the computer cannot really tell the difference between them. Another strategy looked at the green space on the belt and counted that space. As the green space gets smaller, up to a certain point, the event is highlighted. When there is quite a bit of green space, and then less green space, it begins predicting there is a jam. However, this is not a perfect solution, because if you have a consist flow of boxes, even if in the belt, you still have a flow and you do not have a jam. Our goal is to predict a jam, not to predict flows. A third approach, a flow indicator, detects box activity and flow in specific locations and collectively detects whether there is good movement, or a jam.

We devised a method with test scenarios using green, yellow, and red lines. These indicators describe the state of the belt. Guiding principles for data-driven culture, including protecting the company, or protecting the customer being served. There is a responsibility to use appropriate governance and to apply ethical security and safe practices with data. It is critical, especially at UPS to pay attention to security and the safety of customers’ data. The next principle is to question everything, followed by thinking in multi-dimensional ways. It is too easy to get too geeky and too focused on technology and a science-orientation. Instead, we need to be focusing on making money in order to stay in business. The final principle is to dream big, but do it in small steps.

Audience Dialogue

Question: What can UPS do to share more with public sector?

Response: I cannot speak on behalf of UPS. However, I can speak on behalf of my team. My leadership has always tried to support research. To this end, we have partnerships with institutions for data sharing, appropriation of research and intellectual property. Logistics faces a highly competitive marketspace. We face significant transformations and challenges of data and the logistics space. As a result, protecting intellectual property is critical for my team. We have had multiple brainstorming sessions where we were thinking about partnering with local municipalities to get different data sharing from an IoT perspective to see if we can create an ecosystem of learning together. Such ideas that are definitely going on around at UPS.

Chapter 9

Communications and Stakeholder Engagement

SESSION 1D: ENGAGING THE PUBLIC AND LOCAL OFFICIALS IN DATA-DRIVEN DECISION MAKING

Claudia Bilotto, *WSP, presiding*
Hannah Twaddell, *ICF, recorder*
Allan Fye, *Northern Virginia Transportation Commission*
Ben Owen, *Northern Virginia Transportation Commission*
Beth Alden, *Hillsborough County City-County Planning Commission*
Trey Wadsworth, *Northwestern Indiana Regional Planning Commission*

PROJECT PRIORITIZATION MADE SIMPLE

Allan Fye and Ben Owen

Background

North Virginia Transportation Commission (NVTC) regional transit commission reports to 21 elected officials in the Virginia jurisdictions of the Washington D.C. metropolitan region. NVTC works across jurisdictional boundaries to coordinate transit service, considered the voice of transit for Northern Virginia, with responsibilities for funding and stewardship of WMATA and Virginia Railway Express. In addition, they are managing state and regional funding for six local bus systems, and administering the Commuter Choice program (I-66 inside the Beltway and I-395/I-95). The Commuter Choice program is the first in the country to competitively fund transit and transportation demand management (TDM) projects and programs with toll revenues. The benefits of the program and projects to the toll payers (by the law that defined the program) requires documentation. The requirements present a challenge to getting the database information to this audience of elected officials within the period required. NVTC needs to get projects approved and funded so that the construction is underway by the time the tolls start being collected (Tolling Day One). They must meet requirements set forth by memorandum of understanding (MOU) among the localities involved in the program, and by the Meeks Virginia Supreme Court decision that specifically required the allocation of program funds to transit and TDM, not exclusively, but guaranteeing that the toll revenues would not fund only roadway expansion projects.

Methods and Measures

The ability of an application to move people through the corridor, reduce congestion, and address diversion, drives the scoring process. Annual Program Funding includes I-395/95 ($15 million per year, escalated 2.5%) and I-66 ($12 million to $20 million per year, based on annual revenue

estimates). NVTC needs to communicate with a large audience, making sure they are imparting information in understandable and accessible ways. Key questions important to communication are:

- Who is the audience?
  - How much time to they have to absorb the information?
  - Are they really interested in the topic?
- What are you trying to convey?
  - Communications aimed at the right comprehension level for an audience still require data to back up facts.
  - What is the process for identifying and deciding upon projects?
  - What are the decision making criteria?
- Why is your message important?
  - What are the interests and concerns of the politicians or decision-makers?
  - How can you keep them focused on the topic at hand?
- How are you communicating complex information to your audience?
  - Techniques matter – tell them a story that is consistent and compounds in subsequent meetings.
  - Remind the audience at each meeting of what they talked about and decided upon in previous meetings.
  - Where are they at this moment?
  - What decisions move the audience forward?

For the Commuter Choice Program, there have been three rounds of funding for the I-66 corridor. The first round for I-66 and the first round for I-395/95 used a compressed schedule to ensure Toll Day One could implement projects. The scoring approach was undertaken in-house by NVTC staff, with assistance from consultant technical support. The goal was to start from scratch to meet the identified requirements. Modifications to criteria and approach in the first few rounds responded to lessons learned and feedback from Commissioners and applicant staff. Just as important, an ongoing feedback loop improves the process going forward.

Contributions

During the development and application of the NTVC methodology, a number of lessons were learned. First, each project should have only one score. If projects are scored on several factors (e.g., benefits and costs), it is possible for the benefit score to be from zero to one hundred with five weighted elements and a cost effectiveness based on a formula calculation (total benefit score x 1,000,000/funding request), with scores ranging from 8 to 788. Trying to apply this strategy raises the question of which score is more important, how to rank a particular project, and how to respond if one score is high and the other is low. It is far more effective to address differences systematically in the development of the single score. This approach keeps data from becoming a distraction is an important lesson. Situations can arise where a number of data points are zero, all of the data are low, or even the highest point is too low for consideration. In these cases, the data causing the concerns may not be relevant to the question. When all the projects have single score, is it easier to communicate the overall project score, even if it is composed of

multiple elements, with data that supports the technical analysis, with a total capped at 100 points. Figure 43 illustrates the ease of use for a single score metric, located in the third column of the table.

To make a communication regarding prioritization effective, it is important to know your audience. There is only a limited amount of time available to communicate with many stakeholders and this task is only one of many priorities for their time. The presentation needs to be deliberate and easy to understand. The information conveyed should be simplified, but focused without losing the integrity of the data. Clearly convey any discussion regarding weights. Most importantly, presentations need to be visually engaging and understood by audiences from different backgrounds. The commission should be able to easily compare and contrast each project's score in order to rank the list of proposed project. They can ask "gut-check" questions (e.g., why a project received higher or lower score than expected) without needing technical expertise on the scoring methodology.

Applicant	FY2020 I-66 Commuter Choice Application Title	Application Score (Max 100 Points)	Funding Request
NVTC	Program Administration/Oversight, Marketing/Outreach	-	$ 800,000
Arlington County	Enhanced Bus Service on Metrobus 3Y: Lee Highway-Farragut Square	95	$ 1,040,000
Fairfax County	Enhanced Bus Service from Government Center to D.C.	95	$ 1,939,500
Loudoun County	Enhanced Bus Service from Stone Ridge to D.C.	94	$ 532,031
PRTC (OmniRide)	Enhanced Bus Service from Gainesville to D.C.	85	$ 1,519,100
PRTC (OmniRide)	Enhanced Bus Service from Gainesville to Pentagon	84	$ 4,671,700
PRTC (OmniRide)	New Bus Service from Haymarket to Rosslyn	78	$ 776,700
Prince William County	New TDM Outreach to the I-66 Corridor	76	$ 200,000
Fairfax County	New Bus Service from Stringfellow to Constitution Center	73	$ 4,326,000
PRTC (OmniRide)	I-66 Slug Line Campaign	73	$ 287,800
Loudoun County	New Bus Service from Stone Ridge to Pentagon	72	$ 1,257,226
Loudoun County	New Bus Service from Purcellville to D.C.	69	$ 949,482
Arlington County	Expanded TDM Outreach to the I-66 Corridor	64	$ 1,350,000
Arlington County	Lee Highway HOV & Bus-Only Lane in Rosslyn	58	$ 1,500,000
Town of Vienna	Bike Share Implementation	56	$ 550,000
Arlington County	Vehicle Presence Detection Enhancements on Lee Highway	51	$ 300,000
City of Fairfax	Bike Share Implementation	51	$ 1,085,000
Arlington County	Lee Hwy and Washington Blvd Intersection Improvements	48	$ 400,000
Fairfax County	Trail Access to Vienna Metrorail Station	47	$ 3,000,000
City of Falls Church	N Washington St & Gresham Pl Intersection Improvements	42	$ 1,500,000
Prince William County	Residency Road Trail Access to VRE Broad Run Station	41	$ 4,882,800
TOTAL FUNDING REQUEST			$32,867,339

FIGURE 43 Illustration of the use of single score metrics.

#FLORIDAMAN MAKES RATIONAL CHOICES USING PBPP

Beth Alden

Background

Tampa Bay, Florida, located in Hillsborough County is the 13th largest television market in the U.S., has the 19th largest population, is in the top 20 regions for congestion (according to the Texas Transportation Institute (TTI) congestion index), in the top 10 for severe and fatal crashes (based on several metrics), and has no rapid transit system. Florida has a reputation for being a low tax state. The Hillsborough system performance metrics were reviewed prior to the last long range plan update. The review revealed a number of facts including: roads are resurfaced every 50 years, on average; traffic deaths are 50% higher than peer cities per capital; and traffic signal controls must be adjusted manually. In addition, some of the technologies being used are no longer supported by manufacturers, and frequent bus service is only available to one sixth of population and job locations.

Even though the 2010 Referendum on Sales Tax for Transportation failed, exit polls indicated that 72% of the voters thought traffic still needed attention. Discussion with local community members found that traffic congestion was equated with a failure to plan ahead, where developers and government were at fault. Popular strategies addressed frustration with intersections, bicycling and walking are unsafe, and an incremental approach was preferred for major investments (e.g., rail projects). The experience revealed a misalignment between the MPO's stated priorities and the public's priorities—if not in reality, at least in public perception. The proposed MPO transit investment in the failed referendum was intended to align with the public's clearly stated desire for more transit, but it was not perceived that way, at least not strongly enough to support the passage of the referendum. There was a pressing need for the public and decision makers to make educated, thoughtful decisions about how to allocate transportation funds more effectively, aligning the public's stated desires with the MPO long-range plan funding program.

Methods and Measures

In November of 2018, the voters of the greater Tampa area approved a one-penny sales tax to fund multimodal transportation improvements: 29% for bus service and other transit, 16% for transit in exclusive ROW, 15% for safe streets, 14% for congestion management, 11% for maintenance, 6% for walk/bike network, and 8% for other road improvements. Funds were allocated based on the Hillsborough MPO's Imagine 2040 Transportation Plan that used a performance-based planning process to inform public engagement and leadership decision-making.

For each category of multimodal transportation improvements, the Imagine 2040 Plan provided information on future performance outcomes at low, medium, and high levels of spending. The forecasted performance measures included vehicle travel time reliability, crash rates, pavement condition, access to transit and walk and bike facilities at various levels of service, recovery time from a major storm, and other metrics. Citizens could choose their preferred spending level for each category (low, medium, or high), and create their own balanced budget using existing and potential new funding sources. More than 80% of the 2,500 or so survey respondents chose to increase performance outcomes over current levels, and raise taxes

or fees. This informed community decision-making process laid the groundwork for a grassroots citizen-petition initiative, Today, the Hillsborough MPO is building new data-sharing and predictive analytics tools to help the implementing agencies target the dollars for best impact on performance, and will be preparing annual reports on performance and resource use for the public.

Focus groups identified the reasons people did not vote to raise funds for transit in the previous referendum. In addition, planners held public opinion polls on people's priorities for transportation dollars, revealing priorities for basic maintenance and operations. However, discussions on these types of investments are not normally held at the MPO level. Online surveying software enabled the public to visualize the implications of proposed transportation funding budgets, to see for themselves where more money might be needed than was available, and to see how different amounts of allocated dollars would improve system performance. The results of the combined engagement enabled staff to prepare compelling, data-driven information to elected officials on their board about the types of improvements the public clearly wanted, and the estimated benefits of those improvements.

The "Trend Plus Sales Tax scenario" referendum passed, which legally required staff to change the funding program in the long-range plan. One of the commissioners was angry about having to adopt the plan required by the referendum and is suing his/her own government, so the plan is not quite adopted. In the meantime, the MPO is continuing to publish public briefings and highlights about system performance results of the preferred Trend Plus Sales Tax funding scenario.

Contributions

As part of State of Good Repair report, pavement condition is a major focus. The Trend Investment Scenario only allows 60% of roads to achieve the goal. Trend plus Sales Tax Investment Scenario will achieve 100%. For transit, the Trend Scenario provides for a fleet of 202 buses, with 10% of the buses older than twelve years, with an average bus fleet age of nine years. The transit service has 2,071 road-calls per year, or eight road-calls each weekend. With the Trend plus Sales Tax Scenario, the fleet expands to 283 buses, with 100% replacements on time. The average bus fleet is seven years old, and half as many road-calls (breakdowns) per bus is expected.

Currently, funding for storm water improvements is $45 million year. There are local government Capital Improvement Programs (CIPs) and FDOT work programs. There is a need for additional funding for resilience, including additional storm water drainage that would require investment of $22 million per year, and pavement, profile, wave attenuation that would require investment of $72 million per year. The Trend Scenario uses for $364 million or $18 million per year for the 130 miles of the highest-crash roads to be retrofitted as Complete Streets as a Vision Zero project. There should be more than a 15% reduction in bike and pedestrian crashes, fatal and injury crashes, and total crashes on major roads. With the Trend + Sales Tax Scenario, there would be $1.24 billion or $62 million per year for 350 miles of the highest-crash roads to be retrofitted as Complete Streets, and greater than a 35% reduction in fatal and injury crashes an total crashes on major roads and greater than a 30% reduction in bike and pedestrian crashes.

For Smart Cities, without improvements by the year 2045, vehicle hours of delay could increase more than 2.8 times. The Trend Scenario would produce $1.2 billion or $60 million per

year for more than 130 miles of major roads improved. The Trend Scenario also produces a 40% reduction in total delay on major roads from 2045 conditions, and more than a 10% improvement in mean travel time. The Trend plus Sales Tax Scenario produces $2 billion or $100 million per year for more than 220 miles of major roads improved. It also produces an 80% reduction in total delay on major roads from 2045 conditions, and more than a 30% improvement in mean travel time.

Access to trails and side paths would produce $2million per year under the Trend Scenario, with more than 600,000 people served, nearly one-third of the county, with 50 new miles of trails and side paths. The Trend plus Sales Tax would produce $6 million per year and would serve more than 1,000,000, nearly half the county, with 150 new miles of trails and side paths.

Finally, access to transit under the Trend Scenario would accommodate approximately 300 miles of roads with somewhat frequent service or better, covering nearly one-third of the populations and jobs with freight service. The Trend plus Sales Tax Scenario would cover nearly 800 miles of roads with somewhat frequent service or better, with nearly half of the population and jobs near frequent service within the existing Urban Service Boundary.

CONNECTING NORTHWESTERN INDIANA'S VISION FOR 2050 TO THE TRANSPORTATION IMPROVEMENT PROGRAM

Trey Wadsworth

Background

The Northwestern Indiana Regional Planning Commission (NIRPC) adopted its first, and nationally award winning comprehensive regional plan in 2011, focusing on the environment, economic development, governance, and transportation. The plan was broad in scope, but succinct in its vision for Northwestern Indiana (NWI) in 2040: an accessible, revitalized, united, and vibrant NWI. In the eight years since that plan, regional leaders have supported the implementation of the plan, but there was never a strong link to the projects programmed in subsequent Transportation Investment Programs in 2011. The commission adopted the 2040 plan, that included four simple vision statements: connected, renewed (economically as a rust belt region), united (in response to race and environmental justice issues), and vibrant. However, as the years went on, it became clear that these inspiring vision statements were not being fully addressed in the plan and program. The real goal was to allocate available monies to Transportation Improvement Plan (TIP) funding programs in a way that clearly lines up with the vision and priorities of the 2050 plan before making criteria-based decisions on projects proposed by localities in response to the MPO's Notice of Funding Availability (NOFA).

Methods and Measures

NIRPC has been developing its next long range plan, the NWI 2050 Plan, for adoption in May 2019. After public participation, NIRPC confirmed continued support for the vision for the NWI from the 2040 Plan. The development has placed a strong emphasis on building a clear link between the vision for NWI with the programming process for both the Plan and the 2020-2024 TIP in concurrent development. Staff used the four vision words and the plan focus areas to identify sixteen clear critical paths to achieve the vision. Staff then evaluated all federally

eligible transportation project types for their impact on addressing the 16 critical paths using an in-house tool. Staff targeted projects for funding after ranking them by project types and assembling them by investment program. The NWI 2050 Plan is now aligned with the 2020-2024 TIP. The new 2050 plan maintained the vision statement and identified clearly defined focus areas for implementation: people, leaders, economy in place, and environment. They came up with a matrix that connected the four planning focus areas to the four elements of the vision statement. The results produced sixteen critical paths for achieving the vision. They developed the 2050 plan and the TIP update concurrently.

In the new process, they first set targets for each of the thirteen funding programs in a systematic fashion. They evaluated the potential for each program to advance the critical paths identified in the plan, its impact on future economic and transportation goals, and the difficulty involved in implementing the program (funding and institutional capacity). Three possible future program allocation scenarios included New Changes for a New Frontier, Sharp and in Focus, and Stay in Your Lane. More than 80 project types (e.g., roadway expansion, active transportation project, Complete Street project) were evaluated against their potential to advance the sixteen critical paths and the future scenarios.

The outcome of the efforts resulted in annual targets for funding in a few clusters of project types: transit, active transportation and Complete Streets, air quality and environment, quality of place and planning, and roadway improvements. Communities were then able to submit proposed projects associated with the allocated funds for each program and scored based on criteria associated with the program purpose.

Contributions

The improved decision making process is justified by systematic thought and criteria. Although it was not perfect, it was much better than the previous process. Prior to this approach, staff routinely over-programmed the TIP, with allocations greater than the funds available in order to get major highway projects programmed all at once. This new approach is challenging for roadway program staff. They were used to being able to get $20 million allocated all at once, but that is not actually possible because $20 million in any given year would constitute all of the TIP funds. The roadway programmers are now facing the same challenge that the transit programmers have always faced, allocating their funds on a yearly basis, not able to guarantee exactly how much they will have to work with more than a year or two out.

Staff used a three-step process to set funding targets: impacts on critical paths, impacts on the future, and difficulty. Project types may be low in difficulty if no factors are identified that would make implementation difficult. The decision tool assists in the analysis of programmatic breakdown and evaluating individual projects while striving for continuous improvement. In the short-term, efforts are aimed at the next NOFA for 2022–2026 TIP. There will be a surveying effort to gather information from municipal officials and transit operators on prior NOFA experiences to improve the approach and reach desired outcomes, as not everyone was happy with previous efforts. One possible improvement would be to consolidate project types and programs and adjust funding targets prior to moving it forward for approval. There is a need to identify strategies for investment, particularly transformative investments for roadway projects. In the long-term, the next long-range plan update is in 2023. Being able to measure outcomes and make adjusts will facilitate the transition from qualitative to quantitative evaluations.

Take Aways

- Invest time and effort (e.g., focus groups, public polls, and thoughtful staff consideration) to identify the interests, concerns, and perceptions among the public and elected officials about whatever the transportation agency is putting forth, whether it is technical information about project impacts or policy questions about funding priorities. The MPO would not make much headway by focusing all its communications efforts on a big rapid transit project with community members and elected officials whose primary concerns are about basic roadway maintenance. Acknowledge the concerns of the audience first, and describe and discuss additional topics with that perspective in mind.
- Use data points and evaluation criteria that speak to the interests and concerns of officials and the public, even if they are not ones that the agency has used before. Evaluate and convey things that may be hard to quantify (e.g., the potential for transportation demand management marketing programs to reduce peak hour traffic congestion). Include reflections on sensitive issues and hot-button topics (e.g., the equity impact of transportation investments in a community where racial injustice is a serious concern).
- Changing the way that funding decisions are made is going to make some stakeholders (e.g. agency staff and elected officials) uncomfortable, or even angry. Expect pushback, and consider what to do if a new decision-making approach or method stalls out due to these kinds of struggles. For example, an elected official in Tampa is suing the local government for adopting an MPO budget that aligns with the public referendum results instead of the original MPO plan. Another example is the roadway programming staff in northwest Indiana whose regular, predictable practice of budgeting project funds in large chunks across multiple years has to change in order to program funds in smaller chunks annually.

SESSION 2D: FOSTERING LOCAL ACCOUNTABILITY FOR REGIONAL AND STATEWIDE SYSTEM PERFORMANCE

Michael Grant, *ICF, presiding*
Mark Wilkes, *Coastal Region MPO, recorder*
Gareth McKay, *WSP*
Theresa Romell, *Metropolitan Transportation Commission*

PERFORMANCE-BASED MAINTENANCE AT MICHIGAN DOT

Garth McKay

Background

In 2018, the Michigan Department of Transportation (MDOT) implemented a performance-based approach for highway maintenance operations across the state. This research is the result of a multi-year organization-wide effort to understand current performance and define measures to improve future decision-making. The Michigan DOT performance-based highway maintenance initiative was created to manage risk, level-of-service (LOS), and cost to inform

decision-making, while better understanding the diversity of the state and improving transparency.

Methods and Measures

MDOT wanted to reduce subjective decision-making with goals of including more consistent levels of service, enhanced transparency and accountability from both MDOT andits highway maintenance service providers, with more visible value-for-money through time and cost savings. In setting performance measures for highway maintenance, MDOT wanted to shift to an outcome focus for its maintenance delivery to take the key elements of performance-based contracted highway maintenance services and apply them to work undertaken by a combination of internal MDOT and counties delivering maintenance, as well as contracted services for specific activities. The process took 3.5– 4 years to complete. Phases included discovery (data, challenges), definition (which maintenance activities to include, and how to measure), pilot (to confirm levels of effort and work out any kinks), implement (training, support, data analytics and reporting), optimize (set expectations and future roadmap balancing risks and LOS with cost). Figure 44 displays the use of ratings (low, medium, and high) for each of the factors.

Contributions

The most important part of the approach is to involve people throughout the organization throughout the process, fostering ownership. Regions are using the data informally to plan work activities more proactively. Maps of locations not meeting measures (targets) are proving useful for maintenance teams. Currently staff are looking at targets again, and looking to expand to all maintenance activities. Winter maintenance and graffiti removal are difficult to measure.

	Roadway							Safety				Roadside				
	Cracking	*Potholes*	*Flexible / Rigid Pavement Patching*	*Shoulders*	Catch Basins	Curb & Gutter	Debris	Sweeping	*Barrier (Conc., Cable, Guardrail, & Impact Att.)*	*Signs*	Delineators	*Ditches & Culverts*	Vegetation	Mowing	Litter Removal	Animal Carcass Removal
Safety	L	H	H	H	M	M	M	M	H	M	M	H	L	L	-	M
Reliability	H	H	H	-	M	-	L	-	M	L	L	H	-	-	-	M
Economic Benefit & Quality of Life	*H*	*H*	*H*	*L*	*M*	*L*	*M*	*M*	*M*	*M*	-	-	*H*	*H*	*H*	*M*

FIGURE 44 Performance measures contributing to objectives with ratings (low, medium, and high).

DEVELOPMENT OF A PERFORMANCE-BASED APPROACH TO REVENUE DISTRIBUTION IN THE SAN FRANCISCO BAY AREA: A CASE STUDY IN STAKEHOLDER ENGAGEMENT

Theresa Romell

Background

The San Francisco Bay Region includes nine counties, 100 cities, nine county transportation authorities, and 25 transit agencies. There are 43,300 lane miles of local roads with an average pavement condition index (PCI) of 68. Since 1984, the Metropolitan Transportation Commission (MTC), San Francisco Bay Area's Metropolitan Planning Organization (MPO), had concerns about what the regional maintenance needs would be for local streets and roads, and if they could not fix everything, what should they fix first?

Methods and Measures

MTC developed its first pavement management software with only six jurisdictions. Today, all jurisdictions use the same software to monitor conditions, funding needs, and to develop maintenance strategies. MTC continues to work with local jurisdictions to improve the functionality of its pavement maintenance software and maintenance practices in the region. As the region's MPO, MTC is also responsible for the distribution of funding for capital maintenance. Instead of using previous distribution policies based on population or funding needs, MTC used its relationship with local jurisdictions to develop a performance-based distribution policy. Under MTC leadership, a committee of local public works staff developed criteria for the performance measure. MTC's Local Street and Road Working Group reviewed existing practices of engaging stakeholders in policy. Stakeholders desired to justify increased levels of funding and recognized the advocacy benefit from performance-based conditions. Using bottom-up policy development leads to stronger "buy-in". The group found it was difficult to find a one-size-fits-all solution and decided that stakeholder criteria would make measurement a must. Using a measurable approach meant that the process would be as objective as possible, could be fairly applied, and would need to utilize data that was widely available. To be meaningful, the effort would need to improve pavement management. The options considered included pavement condition improvement, local investment level, backlog reduction, and preventive maintenance performance.

A preventive maintenance performance (PMP) approach required defining the performance measure. In this case, the recommended investment was compared to the actual percentage of the budget spent on preventive maintenance. For example, a 10-year maintenance practice scenario comparison could use lane miles by condition, by year over four levels of pavement (poor, fair, good excellent), current practice, previous maintenance, or worst-first. Using the previous maintenance produced the largest rating of excellent compared to the other two approaches. The pavement preservation index (PPI) used the actual preventive maintenance percent (PM%) divided by the recommended PM%.

For the PMP program, the stakeholder criteria were measurable; objective (e.g., condition is met or not met); fairly applied (measure does not discriminate based on budget size or existing pavement conditions); and able to utilize data widely available (data available in StreetSaver used by all Bay Area jurisdictions). It also included providing a meaningful approach that

improves pavement management, based on the notion that improved preventive maintenance would improve pavement conditions with existing budgets. The recommended allocation formula included 25% population, 25% lane miles, 25% shortfall and 25% PM Performance. The proposed measure had to be 1) measureable, 2) objective, 3) fairly applied, 4) utilize available data, and 5) be meaningful (promote pavement management objectives). This “ground up” approach not only produced an agreed-upon performance-based distribution policy, but it achieved measurable results that would not have been possible with an alternative, “top-down” approach. With engagement and collaboration, MTC navigated issues with revenue distribution and achieved improvement in the state of good repair of its local roadway infrastructure through the regional promotion of best practices. For example, what behaviors should planners expect to affect, and how much stakeholder involvement is most effective? MTC wanted to maximize available funding and improve the quality of the region’s pavement. A bottom-up approach was preferred to foster stronger buy-in. Figure 45 illustrates the progress made on the Pavement Program.

Contributions

Policies change when the priorities change. A performance-based approach significantly improves pavement condition over time. The process changed the funding distribution to incentivize better policies and practices. Between 2013 and 2018, the performance-based process saved $12 billion in asset value versus the old approach. The new approach did have consequences with a change in the winners and losers. The transition was slow as buy-in takes time to implement. The “why” for the change needed to be convincing, with, again, the recognition that policies change when priorities change. The positive aspects of the change included an improved understanding of best practices and pavement management system recommendations, increased budget expenditures on preventive maintenance, less reliance on “worst-first” and improvements in pavement conditions over time.

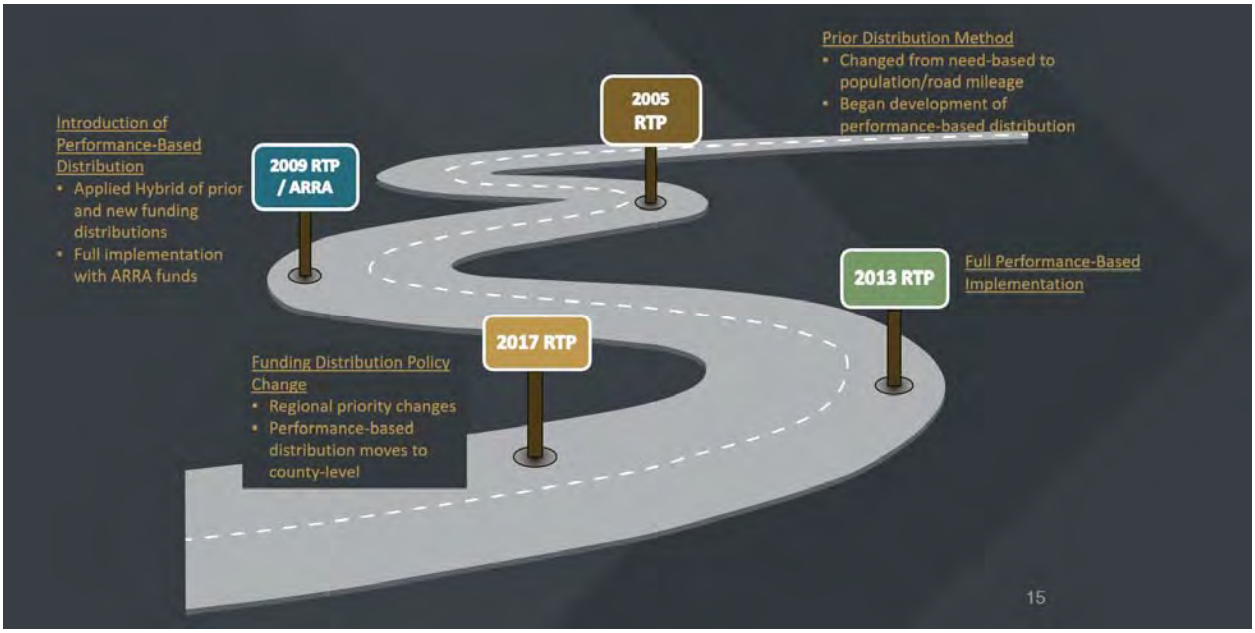


FIGURE 45 Trajectory of progress on Pavement Program.

At the same time, the drawbacks included the additional work explaining changes, tracking performance, and developing distributions. Lesson learned in the MTC experience include: when time permits, the "bottom-up" approach is more enduring; establish clear guiding principles and have goal(s) to set the state for success; availability of consistent quality data is critical; buy-in takes time, but is worthwhile; evaluation of results is critical; and good policies often become best practices.

SESSION 3D: FOSTERING EMPLOYEE ACCOUNTABILITY FOR AGENCY PERFORMANCE—WMATA CASE STUDY

Jordon Holt, *Washington Metropolitan Area Transit Authority, presiding*
Matthew Wilson, *Cambridge Systematics, recorder*
Elissa McDade, *Washington Metropolitan Area Transit Authority*
Mark Irvine, *Washington Metropolitan Area Transit Authority*
Laura Moeini, *Washington Metropolitan Area Transit Authority*

I NEED TRACK RIGHTS: USING DATA TO SUPPORT AND SUSTAIN DEVELOPMENT OF STANDARDIZED PROCESSES

Elissa McDade

Background

At the Washington Metropolitan Area Transit Authority (WMATA), maintenance division supervisors were deeply frustrated with the planning process for work conducted on the rail right-of-way (ROW). Chief among their complaints was that the system allowed an office to cancel others' planned work if that office had an emergency. It appeared that maintenance departments had begun a problematic cycle of overusing "emergency requests" when it was not a "true emergency." This caused dozens of work cancellations each week and ultimately rewarded offices who did not plan far in advance. WMATA formed the Strategic Initiatives Team to work with the Chief of Operations to improve safety and operations. WMATA needed to cut operating costs to deliver consistent service and manage their subsidy rate.

Methods and Measures

The Strategic Initiatives Team worked with several other offices to address the challenges. This team pulled the ROW work requests data, and analysis revealed that Emergency Requests represented approximately 9% of all monthly ROW work requests. This data was used to justify the implementation of a three-week pilot process that added a level of justification and senior management oversight to the approval of the emergency rights. As a result, total emergency requests dropped to an average of less than 4% per month. The success of this pilot validated an initiative to work with all parties involved in the ROW work planning process to re-develop the Standard Operating Procedure (SOP) that governed planned work on the ROW. The new SOP has presentations for users and a monthly training course for new and existing users. In addition

to continuing to track Emergency Rights, an additional metric measures the success of the SOP: piggyback requests (other approved work groups share existing track rights). After the release, and continued training of the SOP, piggyback requests increased from a monthly average of 13% to 16% of all requests.

Contributions

The effort produced a 30-page track rights procedure document and recorded a 50% reduction in emergency track events. There was internal pushback, but executive buy-in supported the pilot and led to implementation. Training is a key part of the success of the implementation.

WASHINGTON METRO'S 3% CHALLENGE: MOBILIZING AN AGENCY-WIDE EFFICIENCY TRANSFORMATION PROGRAM

Elissa McDade

Background

WMATA developed a 3% challenge to mobilizing an agency-wide efficiency transformation program after several negative events and issues occurred. In 2018, WMATA made a commitment to improvement and is now required to establish a new $500M dedicated capital funding stream, capping its budget subsidy growth at 3% per year. As subsidy growth has averaged 5 to 6% per year over the past decade, making good on this commitment will require big revenue gains and operating budget cost savings. During Fiscal Year 2019, WMATA began a way forward to reach the goal of a 3% operating subsidy cap with a dedicated 10 year $300 million in capital funding commitment with a new accountability system and tools to restore ridership growth.

Methods and Measures

WMATA's approach has a number of components. First, there is a need to mobilize to meet the challenge by changing the conversation and cultivating a shared responsibility to change business practices and embrace a focus on efficiency. The second is to identify opportunities, making projects work by actively identifying short- and long-term opportunities to achieve positive operating budget impact and execute projects effectively. The third component is to measure progress by jointly tracking progress with shared visibility across the organization.

One of the key changes required for success was the appreciation for the development of a culture of data. A small program team steered the effort, putting resources in place to build, approve, and implement projects that reduce costs or increase revenues. WMATA used data to drive change in the following ways:

- Created an original and innovative budget data assessment and forecasting tool to quantify a project's impact on the operating budget;
- Built a multi-layered dashboard for executives, budget holders, and project managers to track project progress, forecasted operating budget impact, and realized savings or revenue secured by successful projects;

- Set and tracked project performance goals to proactively manage and drive forward projects;
- Created an executive management decision cycle driven by financial data analysis; and
- Deliver broad, data-driven internal communications and stakeholder engagement, holding budget owners to account and infusing corporate conversations with operating budget databased facts and testimonials.

Contributions

Because of the efforts to move to a data-centric organization, WMATA developed 25 portfolio projects and 10 queue projects from over three hundred ideas that were submitted.

Audience Dialogue

Question: To meet the 3% Challenge you have to address revenue vehicles, what is the strategy and costs associated related to those vehicles?

Response: Revenue vehicles are being completely replaced (e.g., 7000 series) and are now going to be more reliable. We are also looking at WMATA's supply chain and parts replacement to address procurement issues.

Question: How were non-revenue vehicles and track rights issue selected for the 3% Challenge?

Response: Track rights was selected to solve the issue of overnight track work problem and the emergency track rights issue was a way to improve it. There were also many internal issues with who would have access to track ahead of others and this would help equalize the playing field and focused on the problem. For the non-revenue vehicles, it centered on efficiency and effectiveness issue with so many offices and people at WMATA involved. The project also provided a test for "dashboarding" data at WMATA.

WMATA'S NON-REVENUE FLEET DASHBOARD

Laura Moeini

Background

Since 2017, WMATA offices have worked together to rewrite non-revenue fleet (NRF) policies, install vehicle telematics, and refine fleet oversight roles. These initiatives set the foundation for stronger fleet management and substantial cost savings (e.g., retiring unused vehicles from one office or moving them to an office that needs them). The missing link was a tool that could easily track program performance to ensure efforts do not go to waste. The challenge was to make smarter decisions about of NRF to satisfy WMATA's needs and priorities. Better fleet management would help WMATA manage costs and became a part of the 3% Challenge.

Methods and Measures

WMATA developed a three-step approach for a set of accountability tools. First, policies clarifying responsibilities across the many parties involved in NFR activities needed to be developed. Second, there needed to be a good training program to ensure the necessary changes would take place and continue over time. The third is the use of telematics to monitor vehicle usage. These three steps were designed to improve the accountability with non-revenue NRF. In addition to providing the data, there needs to be a methodology for visualizing and analyzing it. Web-based dashboards provide the necessary capabilities.

At its simplest, a dashboard allows leadership to monitor vehicle assignments and make decisions based on vehicle usage. It also gives individual offices across WMATA information on NRF vehicles. Using the dashboard assisted in the ability to tell stories. To do this, the NRF team tracked down useful datasets across the agency, eventually piecing together fields that could tell a story and justify choices. For this effort, the dashboard pulls data from the agency's asset management dataset, two external fleet management programs, and tickets from local jurisdictions. The success of the dashboard effort relied upon an outcomes-based mindset. It is not enough to release a new policy or add tracking systems to 1,000-plus vehicles. The dashboard allows WMATA to move beyond surface-level outputs and measure the value of these changes, including calculating dollars saved. Improving the data quality is critical as numerous offices depend on accurate NRF data and seamless sharing. Building the NRF dashboard highlighted data quality issues that WMATA now has the tools to address

Contributions

WMATA is able to share results of the dashboard building efforts widely with senior leaders in monthly services reports. For example, internal WMATA policy ties to these reports. The service vehicle office are able to allocate vehicles more efficiently. Staff are now able to estimate and recommend budget reductions based on accountability tools. In addition, it has allowed WMATA to set targets for unused vehicles to increase efficiency and effectiveness.

Audience Dialogue

Question: Is it a publicly accessible dashboard?

Response: No, the dashboard is only available for WMATA internally.

Question: Do you look at break-even mileage?

Response: Return-on-Investment (ROI) and cost-benefit analysis are elements throughout the process. For example, should WMATA shift to personal vehicle use, or invest in a separate fleet? There were several costly take-home vehicles. WMATA reduced that number by half to provide savings and allowed those people other options.

Question: Is there an executive dashboard, or separate dashboard for senior management, to provide feedback?

Response: There is only one dashboard. Key elements from the dashboard are included in the monthly reports for executive staff. Feedback is not from one specific group. The 3% Challenge Dashboard has three levels for senior executives.

SESSION 4D: STATEWIDE FRAMEWORKS FOR COLLABORATIVE PERFORMANCE MANAGEMENT

Peter Plumeau, *Economic Development Research Group, presiding*
Nilesh Deshpande, *WSP, recorder*
Carl Mikyska, *Florida Metropolitan Planning Organization Advisory Council*
John Kaliski, *Cambridge Systematics*
Gehan Elsayed, *West Virginia Department of Transportation*
David Jackson, *Cambridge Systematics*

FLORIDA DOT/MPO COLLABORATION FOR TRANSPORTATION PLANNING AND PERFORMANCE MANAGEMENT

Carl Mikyska

Background

Florida has one of the largest and most multimodal transportation systems in the nation, including: 12,100 centerline miles of state highways and more than 110,000 miles of local roads, 31 urban and 23 rural transit systems, extensive bicycle and pedestrian networks; more than 2,700 miles of rail; 15 public seaports; 20 commercial service airports, and two spaceports. Florida has 27 MPOs, more than any other state. They range in size from one county to six counties, with a wide diversity in terms of structure and staff capacity. Florida has 22 million residents and 126 million visitors. Ninety-six percent of the state's population live in the planning area. The state is growing by 1,000 new residents per day. The State currently receives $2.5billion in federal aid per year and can expand to about $10.8 billion by overmatching federal aid. Performance measures make it possible to show that the investments are moving the state forward. In addition, it is important to be able to demonstrate that FHWA, FTA, and FDOT are all working together. Florida faces the challenge of how to implement the Transportation Performance Management (TPM) requirements in a coordinated manner that reflects the differences among the MPOs.

Performance management is not new in Florida. The Florida Transportation Commission (FTC) has been conducting an annual performance review of Florida Department of Transportation (FDOT) since the 1990s, as well as for the major expressway and transit authorities in statute. FDOT has been developing an annual performance report tied directly to the Florida Transportation Plan (FTP), the state's long-range transportation plan. For the past few decades, FDOT has had statutory targets to meet for bridge and pavement condition, as well as requirements for annual performance reporting to the Governor. Many of the MPOs already

were identifying performance measures and publishing periodic state of the system or indicators reports.

Through MAP-21 and the FAST Act, the Federal government established seven national goals for the federal aid highway program, as well as general purposes for public transportation investments. For the most part, these align with Florida goals through the FTP. The federal government now requires FDOT to report on specific performance measures aligned with the national goals. The intent is to guide decision-making including policies, investment decisions, and project selection, to focus on the national goals. As mentioned, FDOT already had been tracking progress in most of these areas and are just moving everyone to the same measures and enhancing coordination among FDOT, the MPOs, and our transit providers, to move toward them. The national goals for the Federal-Aid Highway Program include safety, infrastructure condition, congestion reduction, system reliability, freight movement and economic vitality, environmental sustainability, and reduced project delivery delays. FTP goals include safety and security; agile, resilient and quality infrastructure; mobility; economic competitiveness; and environment and energy. Florida's performance management includes highway safety, pavement condition, bridge condition, system performance, freight, congestion mitigation, and air quality. Performance management specifically for public transportation includes transit safety and transit asset management. Figure 46 provides a comparison among the national goals, FDOT's transportation plan goals, and the performance management metrics. Communication within, across and throughout the many agencies involved in the performance measurement process is key to the success of these efforts.

FIGURE 46 Comparison among national goals, Florida transportation plan goals, and performance measures.

Methods and Measures

FDOT/Metropolitan Planning Organization Advisory Council (MPOAC) TPM implementation approach emphasizes communication, collaboration, the use of pilot projects, the development of consensus planning documents, data sharing, target setting, and providing technical support resources. To promote communication and collaboration, FDOT has several standing agenda items. These items include the MPOAC Leadership Team, the MPOAC Policy & Technical Subcommittee, and the MPOAC Governing Board. The Florida Metropolitan Planning Partnership encourages FDOT MPO liaisons. For example, every two years FDOT, the MPOs, consultants, FHWA, and FTA hold a workshop. The Florida Transportation Plan Steering Committee held more than 100 meetings, webinars, and workshops, since completion of the MAP-21 rules.

The MPO Pilot Project began prior to the completion of the MAP-21 rules. It consisted of four MPOs: Broward, Hillsborough, Gainesville, and Indian River. The pilot project focused on reviewing MPO level performance results for FHWA measures in comparison with the statewide trends to examine the nature of local data, its variability and context. Additional details explain whether particular improvements affect the performance measures. The project added data for four MPOs to FDOT annual National Measures report for the Florida Congressional Delegation. FDOT and MPOAC cooperatively produced a consensus planning document, updated in April 2019. The document addresses federal requirements for data sharing, target setting, and performance reporting. It outlines roles of FDOT, MPOs, and transit providers for inclusion in the TIP.

With respect to data sharing, FDOT collects and maintains data for federal measures, performs calculations of performance metrics and measures, and provides each MPO calculations to be used to develop statewide targets as well as for each MPO planning area and each county within each MPO planning area. The MPOs share supplemental data that MPOs can use to develop their own targets for any measure. Transit providers collect performance data for transit asset management and transit safety measures and share the data with FDOT and appropriate MPO(s). As an example of data sharing for the system performance measures, FDOT analyzes and provides all required measures for the state as a whole, and for each MPO, to report required metrics for interstate and non-interstate roads, highways, urbanized areas, MPO planning areas, counties, and broader regions, as needed. Collectively, this helps meet multiple planning needs at the same time and align both federal and state required processes.

The major focus of collaboration has been on target setting. The target setting process included reviewing existing baseline data and trends, ensuring statutory guidance for safety, bridge, and pavement are met, linking to existing and new statewide plans such as the Florida Transportation Plan, Strategic Highway Safety Plan, and Transportation Asset Management Plan, and coordinating among all partners. The first round of targets were produced just in time to meet the federal guidelines; moving forward, staff plan to align their schedule with MPOAC meetings to facilitate coordination among all partners. For safety, FDOT set the targets for all measures at zero, reflecting the department's belief that every life matters. Twenty of the MPOs have supported FDOT's target; the remaining MPOs have set their own targets but support the concept of Vision Zero. This has led to a productive dialogue among FDOT and the MPOs about how they can achieve zero deaths, recognizing that it will take more than a strong safety program, but really aligning all of their activities, including decision about preservation, design, and operations to accomplish zero deaths. For infrastructure condition and mobility, FDOT set

conservative targets recognizing that the data and processes are new. All twenty MPOs have adopted this same set of targets in their plans. Transit providers have adopted transit asset management targets, supported by relevant MPOs.

Contributions

Resources developed during the process include model language and relevant examples from actual TIPs. This document is a starting point for each MPO for their TIPs. Additional resources include factsheets for all measures, timelines for FDOT, MPOs, transit providers, a methodology and data sources report, an MPO program management handbook, guidance memos, best practice sharing and on-call assistance from FDOT staff, and consultants. FDOT established a document portal to facilitate the submission of the TIPs, Unified Planning Work Programs (UPWPs), Long Range Transportation Plans (LRTPs), and the existing Statewide Transportation Improvement Program (STIP). MPO staff can directly upload these files. Next steps include adding the highway safety target updates, the public transportation safety targets, and the mid-period performance report for PM2 and PM3, in coordination with FDOT, MPOs, and transit providers. Additionally, the enhanced long-range plans and STIP/TIPs with clear linkage between performance goals, policies, and project selection need to be completed.

WEST VIRGINIA DOT PLANNING AND COMMUNICATING FOR PERFORMANCE: ALIGNING DATA, COMMUNICATION, AND MANAGEMENT TOOLS TO INSTITUTIONALIZE PERFORMANCE-BASED DECISION-MAKING

Gehan Elsayed and David Jackson

Background

In 2017, West Virginia's population was 1.82 million. Despite its relatively small size, West Virginia is home to approximately 3,100 cities, towns and small communities. Linking them are approximately 38,770 miles of public roads, of which about 89% are owned and operated by the West Virginia Division of Highways (WVDOH), making it the sixth largest state maintained highway network in the country. The WVDOH maintained system includes 7,124 bridges, exclusive of the WV Turnpike, which operates an 87-mile toll facility with 97 bridges. The roadway miles within the State cross a variety of terrain, support a freight system that facilitates the state’s unique economy, provides connections to tourism and recreation, and provides mobility and access to jobs and opportunities for West Virginia citizens. With this ownership model, and the complexities that WV geography and weather creates, asset management is a critical activity within WVDOH. WVDOH does not maintain federal or municipal system streets, but is one of only a few states (including Alaska, Delaware, North Carolina, Virginia) in the nation to manage virtually all other public road mileage.

TPM process framework began in 2016, with a small group in the planning division integrating planning processes by organizing data, communication and management tool to engage all stakeholders to meet federal requirements. Two SHRP 2 grants, as part of the Planning Works grants, funded the process. These funds helped states develop a performance-based planning approach in addition to meet federal requirements. The safety plan, the asset management plan, transit plans all fed into performance reporting which informs the LRTP and

the STIP. In the first phase, staff established a data collection and management framework for performance-based planning. They compiled baseline information and reoriented the existing state process to the federal TPM process. It was an effort to change the culture into a performance-based approach, particularly since WVDOT did not have an office related to performance-based planning at the time. The stakeholders for the process included eight MPOs, with five sharing a border with another state, management, division directors, and FHWA local division staff.

The second phase focused on supporting initial target setting. The system for performance-based planning requires an understanding of the measures and target setting processes, establishing data-driven target setting, evaluating trends, and setting targets and justifications. It also includes communicating measures, target setting, and understanding external and internal factors affecting trends. The process uses extensive outreach (e.g., workshops, webinars, USDOT and WVDOT teams, consultants). The process relied upon collaboration and awareness within WVDOT and outreach to MPOs.

Methods and Measures

WVDOT used communication strategies and best practices in a three-step process during the two phases. In the first step, a working group met to ensure awareness of the requirements and establish staff responsibilities. Staff then reviewed data requirements and available resources within WVDOT's data systems and identified data gaps. They established an action plan to address and identify process improvements for sharing data within WVDOT and to the MPO community to facilitate targets setting and meeting their MPO 3C planning agreements. The second step focused on trend analysis and visualization, data development and review, and communications with leadership group to deliver a consensus-based targets setting process. WVDOT best practices for facilitating the process used fact sheets including data profiles, context, trends, and investments, leadership group workshops to review information and trends, review workshops with stakeholders to confirm targets setting conclusions, and peer exchanges. These experiences set a path for the third step, where WVDOT will institutionalize performance-based planning.

WVDOT developed decision support tools to assist their processes. PROVIS is an online planning tool that tracks STIP/TIP and LRTP projects and performance trends, using automated measure calculations and GIS. It incorporates the National Bridge Inventory (NBI), pavement, the National Performance Management Research Dataset (NPMRDS), the Highway Performance Monitoring System (HPMS), and the National Highway System (NHS) pavement. The tool also streamlines the process for data exchange between the WVDOT and MPOs. The Planning for Performance Trade-off Tool is a spreadsheet-based tool enabling program level investment and performance trade-off analysis. The Bridge and Pavement Management Systems (BPMS), is a sophisticated performance and investment planning tools to support WVDOT investment decisions for managing the bridge and pavement systems.

Contributions

The success of the efforts relied upon coordination among WVDOT (e.g., breaking down silos, working with pavement, maintenance, bridge, and safety). The effort also required a change of culture, which is continuing to make further advances. To deal with data challenges, the

approach is to develop an action item to tighten QA/QC procedures, and to deploy dedicated staff on communication of the data management system. There were negative impacts from staff turnover, particularly the loss of key staff. There were additional challenges due to changes in state leadership. The original strategy was called the Roads to Prosperity program, with $3 billion for over 600 projects, over 1,200 miles of facilities, spread across all 50 counties, that will provide new roads and bridges while at the same time fixing aging infrastructure. The new administration came with a different vision, an evolution into maintenance first. It is unclear how this change will affect the system and the performance management program. Without having a formal entity responsible for performance management, it was also a challenge to convince other departments and entities to share their data. Some challenges remain due to a small number of staff, but having clear roles and responsibilities helped, as does retaining and recruiting experienced staff. In addition, it is important to have top management included in the performance management strategies.

Going forward, plans are underway to streamline the approaches used to meet the 2020 milestones, with better integration with safety and transit. A new division is being formed to support the strategic performance management operations, including using decision support tools. There are plans to promote consistency with LRTP and future STIPs. In addition, there are limitations in some of the data sets. The transition from a static programming process to the new dynamic strategy requires thinking about programming of data and performance-based approaches.

Audience Dialogue

Question: With respect to the Vision Zero targets, what is your philosophy for pushing for a target of zero deaths? Is this an overwhelming goal, even though it is what we need?

FDOT*:* With a reality of 10% fatalities, we are trying to reduce bike and pedestrian crashes, including trying to accomplish a Vision Zero policy on our trail system.

Question: With the revolution towards the use of performance measures and management and the role of data, has there been change in any skillset you will need in the next 5–10 year term?

FDOT*:* There will be a need for expertise in GIS as there are so many uses of spatial data. We have a challenge to get product out the door due to the mounting costs. We are looking to hire an individual to provide services for multiple MPOs. We see the need for more skills, but have to deal with the fiscal impacts. Another skill that is needed is the ability to advocate and communicate to leadership, particularly elected officials. It is critical that they are able to defend our budget and explain how we compete nationally. MPO leadership needs to be able to convey these matters to their boards.

WVDOT: We are moving towards different trends. For example, we want to upgrade our geographic skills with more expertise in GIS. We also see the importance of data governance (DG). We also see our bridge management system now working together to gain improvements.

Question: If targets are not met for safety performance measures, could penalties be levied? There is a need to create safety implementation plans, with apportionments equal to the year

prior to the one with targets that are shown to not be met. In addition, there will be a loss in the ability to transfer funds between sources (e.g., National Highway Performance Program (NHPP), bridge, pavement, CMAQ). Are you prepared to address penalties?

FDOT*:* We have tried to program above those levels as a cushion. We have the luxury of generating three-quarters of our funds locally. If we were just matching, then federal funds would be more of a concern. In addition, it would be difficult if our financial picture were different.

Question Does the agreement in the Transportation Improvement Program (TIP) go beyond Transportation Performance Management (TPM) staff, or is it just focused on performance measures? Are the transit agencies party to it?

FDOT: For the TIP, the MPO can have a separate board action. They can develop a consensus document that is exclusive to keep elements modular. Using a modular approach makes it much easier to make revisions. We discussed the various processes with transit organizations and look forward to increasing regular communications between MPOs and transit agencies.

Question: Do you have formal agreements about data sharing?

FDOT: We have no master agreement, but do have a number of individual agreements.

Question: With respect to the safety pavement performance measures, how are you addressing the baseline for areas with delivered projects?

WVDOT: Our governor's office and FDOT have been successful in providing transparency with their delivery of projects. We have yet to conduct the analysis on the impacts for today and tomorrow. For example, we need to know the outcome of having all of the projects in the pipeline completed.

FDOT*:* We have a mix of projects and are concerned with multimodal aspects through our Strategic Intermodal System (SIS), which predate the TPM. We pay attention to the highest use and mandate minimum level of condition on these facilities. No less than 50% of capacity expansion occurs on the SIS.

Question: Was your trade-off tool developed in-house, or purchased off the shelf? Are there gaps in the program broadly that technology can address?

Response: With respect to the trade-off tool, Cambridge Systematics developed it in Microsoft. They deconstructed it from Southern West Virginia version to focus on federal requirements. The spreadsheet-based structure is completely open and shareable. The intent is to share simple aspects of the tool, as it is part of the SHRP 2 program.

WVDOT: We see gaps in not having QA/QC procedures. We are focusing on this aspect now, with help from some of the tools and other options.

FDOT: We have seen gaps in the Transportation Systems Management and Operations (TSMO) as the technologies are private sector advancements (e.g., auto options with new technologies). We are attempting to improve mobility on existing facilities for what the future will bring, particularly as we move into automated vehicle deployments.

SESSION 5D: DASHBOARD DEMO

Penelope Weinberger, *American Association of State Highway and Transportation Officials, presiding*
Amy Van Doren, *Marin Transit, recorder*
Jay Styles, *Virginia Department of Transportation*
Laura Moeini, *Washington Metropolitan Area Transit Authority*
Monica Zhong, *Florida Department of Transportation*
Praveen Pasumarthy, *Cambridge Systematics*
Tyrone Scorsone, *Kittelson Associates*
Shichen Fan, *Atlanta Regional Commission*
Kyung-Hwa Kim, *Atlanta Regional Commission*
Abigail Marinelli, Guy Rousseau, and Kyeil Kim, *Atlanta Regional Commission*
Deanna Belden, *Minnesota Department of Transportation*
Hyeeun Tortora, *Chicago Transit Authority*

VDOT'S NEW DASHBOARD

Jay Styles

In 2018, Virginia Department of Transportation (VDOT) launched its new dashboard to supersede their original dashboard, launched in 2003. The new version uses modern technologies and updated business rules designed to increase performance. The project focused on improving the metrics, introducing predictives, and exploring leading indicators of performance. Using performance management can lead to better business as well, making it possible to deliver more closely to the available budget, rather than just providing an estimate. The information quickens the pace of the program, demonstrating that projects can be delivered more quickly if there are no breaks in the funding stream. It can also promote earlier starts and earlier completion of projects.

VDOT's Dashboard is a performance reporting system for projects and programs, providing a tool to identify strengths and weaknesses in project management and administration (available at www.virginiadot.org). Clicking on the Dashboard icon opens a set of project dials, that open into deeper and deeper levels of information on each project (see Figure 47). Having this interface provides heightened attention to project schedules and budgets throughout the development process. It also promotes increased attention to project scoping. Scoping locks in the schedule, and the budget for non-SMART SCALE projects. Tools promote better communications between VDOT and localities. A recognized benefit is being able to see activities finishing earlier. Another feature is the visualization of the impact of business rule changes using the SMART SCALE Dashboard.

FIGURE 47 VDOT Dashboard Projects dial.

The Dashboard maintains an on-time and on-budget focus, making better use of leading indicators to anticipate performance, and allowing time for necessary adjustments. The team developed a system that looks at 10 key activities in the project development phase. Previously, only project advertisements were tracked. Under the new rules, a project turns yellow if any one of the key activities get within 30 or 60 days of the due date. This "warning track" acts as an alert that a key due date is coming up. If an activity is completed late, then the project will turn red, but only until the next activity is completed on time. Since implementing the new rules and dashboard, twice the number of projects are being completed early or on time compared with projects completed and tracked using the old system. In order to undertake this alert system, a huge QA/QC effort took place to validate the necessary data was correct and complete for each project. While this was a time-consuming effort, it exposed the need for several process improvements from both a business as well as a data handling perspective.

Focusing attention on project performance maintains data quality. As Dashboard 4.0 moves away from a custom-coded applications and leverages Microsoft's Power BI, it has changed how VDOT approaches Dashboard work. It now acts as business analysts, rather than an IT developer, when designing and building visualizations. Business and IT staff work closely to mine the data from the data warehouse and prepare it for consumption by the Dashboard. The tools make it possible to drill down to project delivery, or project development, using Power BI. For example, it is now possible to use project engineer's data for ongoing project management, based on fixed dates for completions. The process includes a number of templates based on project types.

THE NON-REVENUE FLEET DASHBOARD

Laura Moeini

WMATA is turning their databases into an actionable, user-friendly tool. The two-year effort focuses on the utilization of vehicles that support official business or transport tools (non-

revenue generating vehicles). The necessary data to understand non-revenue vehicles was located in different departments, making it difficult to get a complete picture or to analyze the data. Previously, there was almost no effective method for tracking these activities.

Easy to understand visualizations are made with the data and used for analysis. The first version of the tools used Tableau; however, the most recent version uses Power BI. The tool also ingests asset data and citation data. The tool now acts as a one-stop location for data. The tool makes it possible to share the analysis widely, and tie evidence-based analysis to policy for the front line to pay attention to important factors or activities. By pulling the various flat files together in a single tool, it is easier to manage the use of the fleet, lower idling and costs, and make the vehicles available, when needed. The tool also helps staff to clarify roles and responsibilities, and identify training needs. By installing telematics on the vehicles, the use of the smart GPS informs operations.

ARC DASHes THROUGH THE DATA

Shichen Fan and Kyung-Hwa Kim

The Atlanta Regional Commission (ARC) created an online, interactive dashboard—DASH—to understand where they are exceling, and where they are falling short. DASH is organized according to MPO impact areas (e.g., project, program, or regional performance). Users can navigate to a specific topic including congestion reduction, safety, and equity. The tool provides short compelling narratives, visualizes trends, and allows users to delve into regional performance measures. Users can also interact with charts and maps, download data, and share findings. ARC's goal is to turn data into information. Staff developed the tools in-house, across several functions. The information connects to multiple geographies, with data on multimodal activities. The tools assist with performance-based planning and functions as a one-stop shop for analysis. The data is processed, visualized, and is downloadable for the site. The in-house team relied on staff knowledge and interest in R (open source software), GIS analysis, and technical aspects of planning, to design storytelling to decision-makers.

There is a variety of data available to assist in building stories around the calculated measures. These data include Georgia Department of Transportation (GDOT) crash reports, Longitudinal Employer-Household Dynamics (LEHD), INRIX, local governments, transit operators and sketch model software, activity-based models, project performance and delivery, and Census data. Housing performance data in one location gives ARC staff and its partners greater accessibility to data. Local governments and the public in particular can look to DASH to understand current and historic conditions, and create better projects in the future. Sharing this information in an approachable way helps ARC reach a broader, less technical audience while satisfying federal requirements. Figure 48 illustrates the interface with mapping capabilities, tables of information, and spatial analyses of numerous factors. Visual storytelling also helps impact ARC's regional policies and goals by tying salient data points to recommendations and actionable policy objectives. The tool is useful for asset management in the future. Staff were fortunate to have time to research best practices, experiment with design and functions, establish a design vision, and collaborate with other ARC staff to understand their needs during the construction phase of the dashboard.

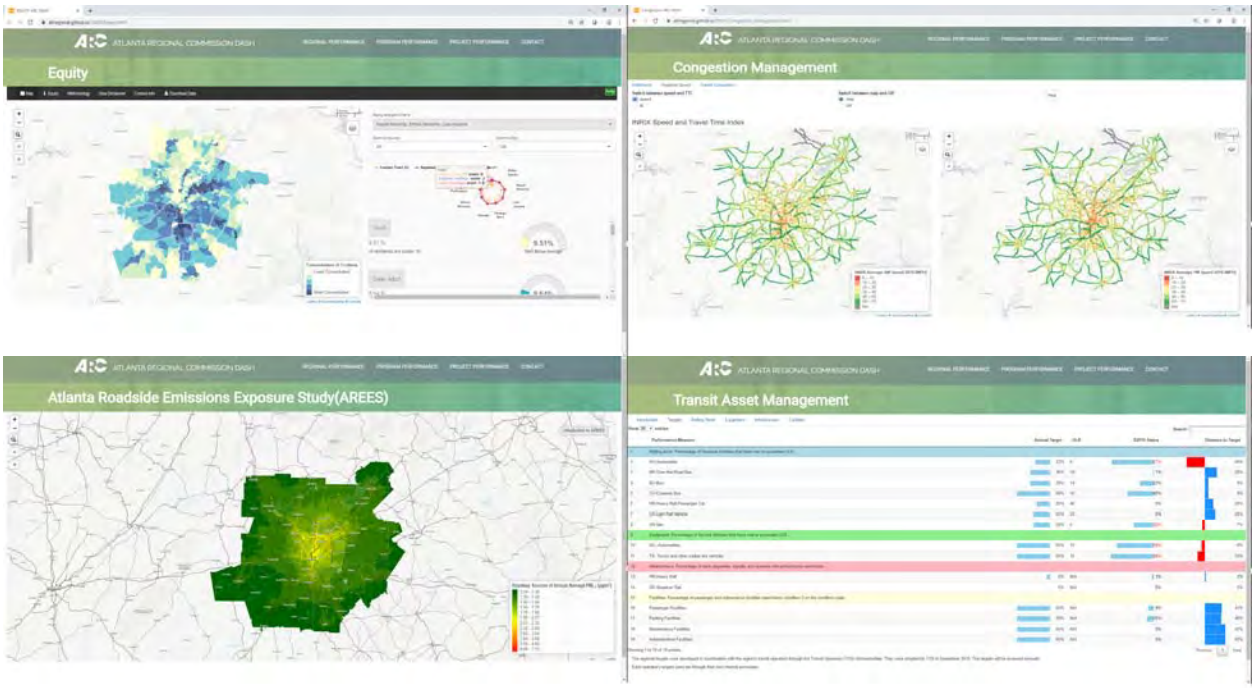


FIGURE 48 Examples of ARC DASH analyses.

To ensure staff have the right competencies, ARC supported external technical trainings, including self-guided trainings. The structure of the tool makes it possible to connect federal performance measures to local street level data. The consensus process to involve all the stakeholders took over two years. Now jurisdictions use and can understand the performance management process.

ARC ACTIVITY-BASED MODEL VISUALIZATION PLATFORM (ABMVIZ)

Abigail Marinelli, Guy Rousseau, and Kyeil Kim

ARC needed to know how best to leverage and visualize model data to inform meaningful performance measures for transportation investment decisions and policymaking analysis. Atlanta's Activity-Based Model Visualization Platform (ABMVIZ) transforms the regional activity-based travel demand model output into easy to understand graphics that address key questions for future scenario years. The Atlanta Regional Commission (ARC) needed to read and visualize data from the travel demand model and to validate it. The ABM provides forecasts for transportation and now the ABMVIZ site displays easy to understand visuals of the forecasts. ABMVIZ is web-based, hosted in GitHub, and formatted as .csv files. The tool allows for public and private control over the data. The graphics include charts to show modal split, daily activity patterns, performance measures by activity center, maps to show O/D pairs, transit ridership by stop, and travel time sheds among other performance metrics. The graphics are manipulatable, with adjustable visual features (e.g., color and size), and filterable data features (e.g., time of day or mode type). The graphics have hover-over features to provide specific data points if the user

needs them. The software displays individual scenario years and comparisons across various scenario years.

The software creates graphics that accept data as .csv files or other open source file types, allowing the graphic generating with data from any region. ARC is currently working with a consortium of MPOs to standardize the code enabling the sharing of graphics, using local data on local visualization platforms. The visual nature of ABMVIZ aids decision and policy makers who may be less-than-fluent with travel demand modeling and the complex outputs that modeling can produce. Being able to view the outcome of a 30-year transportation plan on a manipulatable map is helpful for understanding the true impact of infrastructure investments. As a web-based tool, ABMVIZ outputs are accessible and sharable. The tool utilizes output from model to identify outliers. CUBE software planners use the tool to visual model output. While it was relatively expensive to build, it provides a wide range of services to a broad group of users.

MnDOT PERFORMANCE DASHBOARD

Deanna Belden

Since 2007, MnDOT produced a performance report in printed format, typically released in the fall, including data for the prior year. They now have transitioned to the performance reporting website. MnDOT wanted a public facing performance website designed to tell our story to the public and legislators, as well as internal users. A consultant created the website, along with templates for ease of use, making the information more dynamic, flexible, and current. The software produces a printable scorecard displaying the aggregated performance metrics, similar to the previous scorecards. Moving forward, one of the desired features is the ability to communicate enterprise risk, including the risks associated with performance measure, where applicable. The purpose will be to create a risk-based scorecard that will automatically aggregate all the performance measures associated with goals (available at performance.minnesotago.org). Figure 49 displays the variety of analyses produced to assist in understanding trends and telling

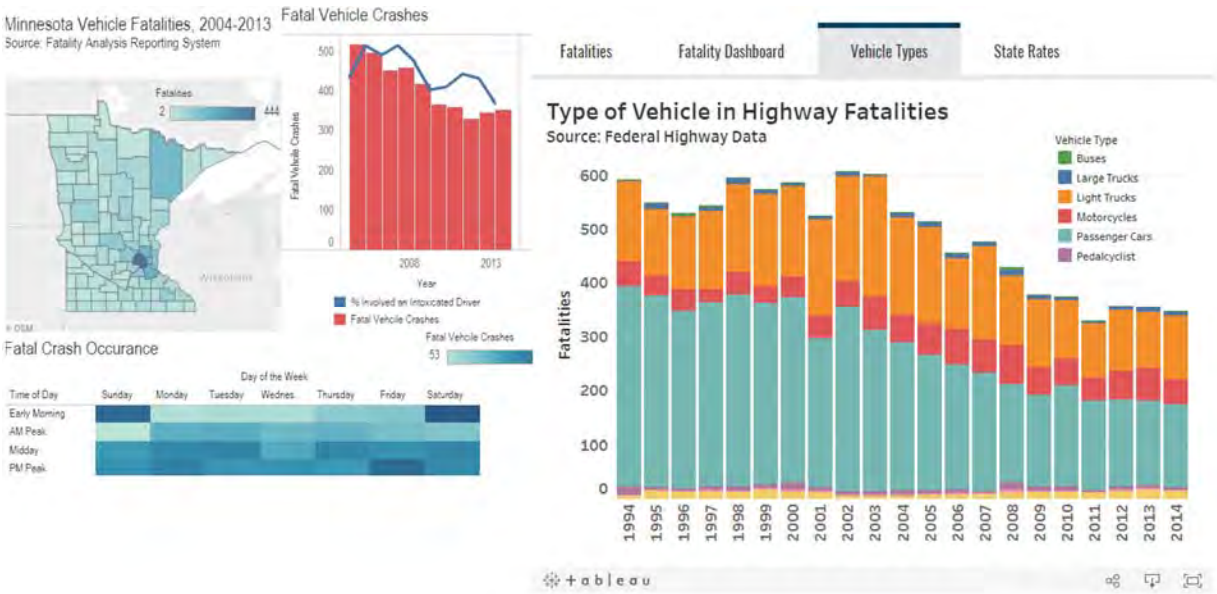


FIGURE 49 Using a Tableau dashboard to tell stories.

the story behind a successful policy or illustrating challenges from various dimensions. The metrics provided a number of factors (e.g., fatalities by time of day and day of week, intoxicated drivers, type of vehicles in fatal accidents over time, and reliability measures).

FLASH REPORT—USING DATA FOR INFORMED DECISION MAKING EVERY DAY

Hyeeum Tortora

Dashboarding can enable a transit provider to make large amounts of data understandable and immediately useful. These dashboards encourage a culture of data usage. The daily Flash meeting at the Chicago Transit Authority (CTA) is an opportunity for upper level management to monitor performance and coordinate daily and ongoing projects and interventions. The Performance Management team provides data and metrics for this meeting, with the goal of placing yesterday's results in a historical context, in order to anticipate developing trends, and identify problem areas. The CTA has been forward thinking in developing this capacity and using it daily, recognizing the importance of accessing growing datasets and incorporating them into our decision-making processes every day.

Initially, the reporting relied on an inefficient Excel and PowerPoint-based process, but now have a systematic data infrastructure to include more meaningful and customer focused metrics that rely on much larger datasets. Developing these metrics required distilling complex data streams into brief but actionable insights, and conveying their meaning to decision-makers. This has evolved developing an interactive online dashboard in which the user can drill through various levels of granularity, depending on their question. Repeatedly proving data accuracy is encouraging broad adoption. In addition, departmental collaboration contributes to the development of metrics and useful tools. With easy access to accurate, timely, contextualized data, the CTA has been able to foresee problems and identify effective interventions. As issues crop up, staff are able to respond quickly with data-driven solutions, resulting in a more efficient organization that provides better, safer service for our customers. Figure 50 displays the Daily Flash Report, a composite of graphs and tables with information on trends and summaries.

The Dashboard for bus and rail provides160 metrics with long and short-term analysis. For example, it provides a measure for delay for rail operations identify trends. It can monitor defects for maintenance with links to additional information and location of fleet. The output is 50 pages long. Staff hold monthly sessions to discuss feedback from operations. Currently, the system is 98% automated, with manual entry available, if necessary.

FIGURE 50 Daily Flash Report with trends and summaries, with details.

SESSION 6D: WORKS IN PROGRESS: RESEARCH AND CAPACITY BUILDING INITIATIVES TO ADVANCE DATA-DRIVEN DECISION MAKING

Robert Hazlett, *Maricopa Association of Governments, presiding*
Harlan Miller, *Federal Highway Administration, recorder*
Michael Nesbitt, *Federal Highway Administration*
David Schneider, *Federal Transit Administration Office of Research and Innovation*
Michael Grant, *ICF*
Ann Hartell, *Transportation Research Board*
Hannah Twaddell, *ICF*
Matt Hardy, *American Association of State Highway and Transportation Officials*
Bill Keyrouze, *Association of Metropolitan Planning Organizations*

FHWA TRANSPORTATION PROGRAM MANAGEMENT IMPLEMENTATION SURVEY OF DOTs AND MPOs

Michael Nesbitt

Background

The role of the federal government in surface transportation has evolved since the passage of the Federal-Aid Highway Act of 1956 that authorized the building of the Interstate Highway System. The role of the federal government has evolved from a focus on project selection, design, and construction, to a focus on the process used by States and MPOs to plan, design, and build the system. The Federal-Aid Highway program is a federally assisted and State-administered program. States and MPOs develop plans and program investment strategies to support local, regional, and national needs. States, the Federal Land Management Agency (FLMA), and local governments, also design, construct, maintain, and operate the various systems. The FHWA provides national leadership, technical assistance, and program oversight. FHWA prides itself in being proactive to meet these evolutionary challenges. Recent initiatives have demonstrated our ability to lead and spur innovation and positive change across the transportation industries. Now with the passage of MAP-21, the focus targets outcomes, including managing system performance. Good data is essential to managing system performance management, or Transportation Performance Management (TPM).

The rulemaking process makes it difficult to talk to stakeholders about certain issues. As a result, surveys are used to gather information regarding rule making. FHWA has observed that agencies with the ability to make continued process on their various performance measurement tasks tend to be more capable of producing good outcomes. In addition, while the survey is not a compliance review, FHWA has also observed that those agencies with strong TPM- and PBPP-centered processes are better prepared to implement TPM- and PBPP- related regulations and provisions. The survey design specifically addresses each agency's TPM, Performance-based Planning and Programming (PBPP), and Asset Management (AM) processes, the state of the practice, and capacity to implement TPM, PBPP, and AM practices. The survey was not intended to gather information on the outcomes of those processes (e.g., ability to meet the performance targets and goals), nor did it look at an agency's ability to comply with MAP-21 and FAST Act regulations and provisions.

Methods and Measures

The National TPM Implementation Review Survey collected information primarily from state DOTs and MPOs about how they are applying transportation performance management, performance-based-planning and programming principles, and MAP-21 and FAST Act performance provisions. The survey also seeks to collect information about transit via state DOTs and MPOs that are also responsible for managing transit assets and operations. It also looked at topics related to the progress of FHWA and its partners are making with implementing TPM practices, determining how effective PBPP, TPM, and AM are, and determining additional resources that FHWA partners need. Topics covered in the survey included whether FHWA and its partner agencies are making progress implementing TPM best practices that relate to MAP-21 and FAST Act performance provisions. What is the effectiveness of PBPP processes, TPM processes, and AM processes? What additional resources do FHWA's partner agencies need to advance the state of the practice? The survey also sought to consolidate several smaller subject matter specific surveys (e.g., as safety, infrastructure condition, system performance) into a single survey, contributing to the survey length. The additional topics included highway safety, infrastructure condition, system performance, traffic congestion, on-road mobile source missions, freight movement, transit state of good repair, and transit safety.

With respect to participation in the survey 47 state DOTs, and 158 MPOs responded to the main section. The official surveying period was from December 12, 2018 to February 28, 2019 (responses received up until March 2019 were also included). With respect to the challenges associated with implementation, respondents indicated that while it was challenging, it was not overwhelming. Implementation was less challenging for highway safety and infrastructure condition (e.g., pavement and bridge conditions) than for CMAQ, travel time related measures, and on-road mobile source emissions (ORME).

Contributions

The survey was part of USDOT's TPM capacity building efforts. The results inform the needs and progress already made and help document the state of the practice and contribute to efforts to plan for the ever-growing demand for TPM technical assistance. In addition, the results will assist in channeling resources to meet capacity development and training needs and the development and refinement for TPM guidance. It also will help to identify and prioritize TPM research needs to tie funding and investments to performance outcomes.

FTA RESEARCH AND CAPACITY BUILDING INITIATIVES

David Schneider

Transit infrastructure in the U.S. includes 12,617 miles of track, 3,281 rail stations, 1,698 maintenance facilities, and 109,012 urban buses (with an average cost of $550,000-$800,000). Additionally, there are 10,668 transit vehicles in rural areas, and 21,393 rail vehicles. Public transit exists in 98% of urbanized areas with at least a population of 50,000, in 81% of the counties in the U.S., with ridership that increased from 2000 to 2017 by 16% (8.7 billion to 10.1 billion unlinked passenger trips). In addition, transit and ride hailing are linked as travel options.

The mission of the FTA is to advance public transportation innovation by leading research, development, demonstration, deployment, evaluation, and implementation practices and technologies that enhance effectiveness, increase efficiency, expand quality, promote safety, and ultimately improve the transit rider's experience. For example, the Federal Transit Administration (FTA) Research Investments program includes $76 million for National Fuel Cell Bus, and $6 million for other infrastructure projects, over the last three years. FTA relies on industry feedback, particularly for cross-sectional research into operations, travelers' experiences, and economic growth, as well as the three areas of mobility innovation, infrastructure, and safety.

Methods and Measures

Traveler expectations have changed with the advent of the Smartphone. Now potential transit riders can make payments, get real-time information, remain "connected" 24/7, and have point-to-point convenience. Using the same technology, the private sector is able to compete in the same market as many public transportation systems as business destinations and shared rides/mobility services become a "movement." Bus technologies have evolved to include "drive-by-wire" capabilities that require new maintenance models. In addition, new technologies are affecting operations (e.g., real-time surveillance for security, telematics for asset management). Transit automation could expand the market share for public transportation. Major programs underway include:

- Mobility on Demand (MOD) Sandbox ($9.7million);
- Accessible Transportation Technologies Research Initiative (ATTRI) ($2.5million);
- Transit and Health Care Access Initiative ($ 2.3 million);
- Human Service Coordination Research ($2.2 million);
- Strategic Transit Automation Research ($1.9 million); and
- Mobility Services for All Americans ($333,000).

Figure 51 illustrates the concept of the Complete Trip that focuses on the individual, starting when anyone decides to travel. The technology takes any prospective travelers through all the steps to accomplish their trip. The process covers planning, booking, payments, and receiving special assistance, if needed. Barriers to trip completion are minimized, or removed, making travel more convenient and seamless, to accommodate traveler needs, capabilities, and circumstances.

FIGURE 51 The Complete Trip.

The San Francisco Bay Area Rapid Transit (BART) has initiated a pilot program that integrates carpooling with transit. The pilot program matches carpool users traveling to BART stations, providing them with a method to reserve and pay for sought-after parking locations at the stations. As of April 2019, more than 16,000 carpoolers were using the system monthly, with 30% of users reporting riding BART more because of the carpooling (versus 4% less often). Another example is the Valley Metro Rail of Phoenix Pass2Go app that integrates mobile ticketing and multimodal trip planning. The app gives travelers easier access to a range of mobility providers, including ride hailing services. Phase 1, launched in March 2018, and included a basic trip planner and full day fare mobile ticketing with visual validation. About 40% of users reported using buses more often; about 50% reported using rail more often; while about a quarter of survey respondents reported walking more often. More than 25% of travelers surveyed reported shorter wait times, and 29% reported shorter travel times.

Contributions

The mobility innovation program has demonstrated increased visibility of the benefit of public/private partnerships, helped public transit see transportation network companies as partners, and increased the use of new mobility models. Partnerships formed between transit agencies and private mobility solutions firms has increased from three in 2010 to 42 by 2017. Future innovations will explore new business approaches and technology solutions that support mobility, enable communities to adopt innovative mobility solutions that enhance transportation efficiency and effectiveness.

FTA is fostering performance-based approaches that include training staff (e.g., measuring staff performance using a logic model), building a culture of data that promotes analysis and analytics. The Center of Urban Transportation Research (CUTR) is implementing FTA's vision of a tiered (nested) evaluation framework. Efforts are underway to promote data, management for planning, and inventorying and leveraging DOT data investments (e.g., Secure

Data Commons, National Transportation Library, Bureau of Transportation Statistics, and the National Transit Database). FTA is also promoting the use of business intelligence tools that include data visualization for presentation and analysis. Finally, Research to Practice (T2/RP) strategies underway include: a new Technical Assistance Center for T2/RP; knowledge transfer through training; industry diffusion; operation testing and demonstration; new partnerships; standards development; formal dissemination (e.g., webinars, training, website); creation of Communities of Practice; and social network marketing.

TRB COOPERATIVE RESEARCH PROGRAMS RESEARCH INITIATIVES

Michael Grant, Hannah Twaddell, and Ann Hartell

National Cooperative Highway Research Program 02-27: Making Targets Matter

Michael Grant and Hannah Twaddell

Despite progress in developing resources and guidance for performance measurement, practitioners still lack adequate tools and methods to assist in the establishment of an effective feedback loop between observed performance and agency performance management decisions. Having access to such feedback would be of benefit to agencies to maintain, or adjust their management strategies. Linking performance targets to desired performance outcomes requires a better understanding of how best to monitor performance, and then to make data-driven decisions.

The scope of NCHRP Project 02-27, "Making Targets Matter: Managing Performance to Enhance Decision-Making" included a survey of state DOTs, MPOs, transit agencies and other local transportation agencies. The question regarding whether monitoring provided "early warning" of performance issues resulted in more "no" than "yes" responses. These responses indicate that either monitoring is not taking place, it is ineffective, or that no performance problems have arisen. The question asking if monitoring led to making adjustments in activities or decisions received predominantly "yes" answers. The types of activities affected most included operations, investment allocations, and project prioritization. Questions covered the following topics.

- Data management: *Is the right data collected at the right frequency and accessible when and where it is needed?*
- Data analysis: *Does your agency have the right analytical tools and skills to turn it into knowledge?*
- Coordination and communication: *Does knowledge make its way to the right people at the right time?*
- Organization and culture: *Are the right people empowered to influence decisions in reaction to new knowledge?*

The research included conducting four peer exchanges, one in each AASHTO region, to develop a guidance document on performance targets. The proposed app will demonstrate linkages—connecting decision making to target attainment, reaching different audiences, and pedagogy—rather than acting as a planning tool.

National Cooperative Highway Research Program (NCHRP)—Status Report of Ongoing Projects of Significance

Ann Hartell

The American Association of State Highway Transportation Officials (AASHTO) Research and Innovation (R&I) met in April 2019 to review the 116 research needs statements submitted. Funding was approved for 11 continuations, and 56 new projects. Three synthesis topics are listed below.

- NCHRP 23-07: Guidebook for Identifying and Implementing Forecasting Techniques for Effective Target Setting
- NCHRP 22-44: Development of a Crash Data Collection Tool and Application Guidelines for MASH In-Service Performance
- NCHRP 23-06: Developing an AASHTO Guide to System-Level Asset Valuation in Support of Transportation Asset Management Decision Making

Recent Releases include the following.

- *NCHRP Research Report 905: Measuring the Effectiveness of Public Involvement in Transportation Planning and Project Development*
- *TCRP Research Report 205: Social and Economic Sustainability Performance Measures for Public Transportation: Final Guidance Document*
- *NCHRP Research Report 920: Management and Use of Data for Transportation Performance Management: Guide for Practitioners*

Projects underway address the topics listed below.

Performance Management:

- NCHRP 20-24(127): Performance Management Implementation Concerns, Issues and Challenges
- NCHRP 02-27: Making Targets Matter: Managing Performance to Enhance Decision-Making

Performance-Based Programming and Planning:

- NCHRP 08-121: Accessibility Measures in Practice: Guidance for Transportation Agencies

Performance Management for Asset Management:

- NCHRP 08-113: Integrating Effective Transportation Performance, Risk, and Asset Management Practices
- NCHRP 08-115: Guidebook for Data and Information Systems for Transportation Asset Management

Data for Governance and Management:

- NCHRP 20-102(14): Data Management Strategies for CV/AV Applications for Operations
- NCHRP 08-119: Data Integration, Sharing, and Management for Transportation Planning and Traffic Operations
- NCHRP Synthesis 20-05 Topic 51-05: Practices for Coordinating Asset Management Performance Measurement & Monitoring between State Transportation Agencies & MPOs
- ACRP 01-46: Geospatial Data Governance--Organizational Factors and Best Practices

Data for Safety:

- NCHRP 17-86: Estimating Effectiveness of Safety Treatments in the Absence of Crash Data
- NCHRP 17-93: Updating Safety Performance Functions for Data-Driven Safety Analysis
- NCHRP 22-46: Supporting Data-Driven Decision Making through an Expansion of the Human Factors Guidelines for Road Systems

Data Sources and Applications:

- NCHRP 20-102(13): Planning Data Needs and Collection Techniques for CV/AV Applications
- NCHRP 08-116: Framework for Managing Data from Emerging Transportation Technologies to Support Decision-Making
- NCHRP 08-123: Census Transportation Data Field Guide for Transportation Applications
- NCHRP Synthesis 20-05/Topic 51-19: Public-Private Partnership Arrangements and Performance Metrics
- NCHRP Synthesis 20-05/Topic 51-06: State DOT Use of Vehicle Probe and Cellular GPS Data for Monitoring and Planning
- NCHRP 20-05/Topic 50-10: Availability of Pedestrian Infrastructure Data For Routing and Network Analysis

Finally, the most recent research moving forward includes:

- TCRP G-18: Improving Access and Management of Transit ITS Data

To get involved with NCHRP, develop a problem statement and submit it by the first of November every year. The format is available online (https://rns.trb.org/rnsinstructions.asp). Research can be surveys, interviews, information requests, pilots, workshops, interim activity, and project panel participation. There is special funding available for implementation of research studies, as NCHRP 20-44 projects. (http://www.trb.org/NCHRP/NCHRPImplementationSupportProgram.aspx).

This program focuses on the implementation phase of completed NCHRP research results and products, as well as products still under development. Criteria for receiving these funds

include readiness level of the research project, having an implementation plan, the likelihood of the proposed project will lead to a state DOT actually incorporating the research into their day-to-day operations, and potential impacts from the implementation.

Transit Cooperative Research Project H-54—Guide to Equity Analysis in Regional Transportation Planning
Hannah Twaddell

Transportation agencies that manage federally funded programs and projects are responsible for ensuring that their plans, programs, policies, services, and investments benefit everyone in their jurisdiction equitably. Historically, certain individuals and communities, including those from minority, low-income, and limited English proficiency populations, have not benefitted equitably from transportation investments and programs. Federal laws and directives developed to address this disparity include Title VI of the Civil Rights Act of 1964, and two Presidential Executive Orders: *EO 12989 Federal Actions to Address Environmental Justice (EJ) in Minority Populations and Low-Income Populations; and EO 13166 Improving Access to Services for Persons with Limited English Proficiency*.

Title VI prohibits discrimination based on race, color, and national origin in programs receiving federal assistance. Title VI and the EJ Executive Order require transportation agencies to identify underserved persons, analyze whether transportation projects have a disparate impact on them, and if so, either demonstrate that these impacts are unavoidable or identify ways to mitigate them. The LEP Executive Order supports Title VI by requiring agencies to make federally funded services, programs, and activities accessible to persons with a limited ability to read, write, speak, or understand English. It does not require a full equity analysis, but consideration of LEP needs and concerns can complement a meaningful analysis. The essence of effective environmental justice practice, distilled into three fundamental principles, and summarized in USDOT and FHWA guidance is as follows:

- Avoid, minimize, or mitigate disproportionately high and adverse human health and environmental effects, including social and economic effects, on minority populations and low-income populations;
- Ensure the full and fair participation by all potentially affected communities in the transportation decision-making process; and
- Prevent the denial of, reduction in, or significant delay in the receipt of benefits by minority and low-income populations.

The primary purpose of the TCRP H-54 study was to develop a reference guide for regional transportation planners on addressing equity in transportation plans, programs, and decision-making processes. The reference guide covers uncertainty about methods including how to deal with regional scale issues, planning and programming stages, meaningful analysis, and effective public involvement. Previous inconsistencies in approaches have resulted in difficulties with interpretations and comparability of methods. The project began in February of 2017. The research team conducted an in-depth review of long-range plans, transportation improvement programs, and related agency documents of the selected MPOs to identify the key elements of their equity analysis methods and outcomes. From the 65 identified MPOs, the research team

conducted 25 in-depth interviews and analysis. Interviews included questions on technical capacity, analysis, and decision-making process.

The reference guide was pilot tested with four MPOs to help refine the contents of the guide and to assist pilot agencies in their efforts to better address equity. The four MPOs included Mid-Ohio Regional Planning Commission (MORPC) in Columbus, Ohio, Denver Regional Council of Governments (DRCOG) in Denver, Mid-American Regional Council (MARC) in Kansas City, and Metro in Portland, Oregon. MARC developed a plan to engage its Regional Equity Network (REN) members as advisors and community "ambassadors" in the upcoming transportation plan update. MARC also explored a population-weighted approach for equity assessments. DRCOG explored a population-weighted approach for identifying impacts of transportation activities on relevant population groups. MORPC tested an approach for assessing needs related to multimodal connectivity in low-income and minority areas impacted by a new "smart cities" transit project. The agency also shared insights about its population-weighted approach with DRCOG and MARC. Metro developed communications strategies and public outreach techniques to help convey the findings of its extensive and complex equity analyses with stakeholders.

The reference guide lays out a five-step equity analysis framework, supported by a strong foundation of public involvement with equity stakeholders. It also includes a checklist of activities and resources that agencies can use to help structure their own analyses. For each step, the guide describes methods and examples to help agencies develop and implement equity analyses that reflect varying regional contexts and agency capabilities. Inclusive public involvement in the transportation planning processes involves three main strategies: connect, educate, and sustain. MPOs use demographic data and public input to identify locations and characteristics of underserved persons.

The first step in conducting an equity analysis is to define population groups for analysis, including identifying regional distribution of underserved persons, high priority areas, and being able to understand demographic change. Most MPOs develop maps of concentrations of underserved or required populations by Traffic Analysis Zones (TAZ), using thresholds. MPOs find it challenging to balance the use of thresholds with the need for inclusive and meaningful results. A potential best practice is to use geographic-based and population-based approaches to provide more than one perspective. For example, heat maps, dot-density maps, TAZs, and Census block threshold maps all provide additional insights. All MPOs reviewed consider low-income and minority groups in their demographic analysis; many include other underserved populations. Sometimes a combined analysis loses specificity about the required populations. Another potential best practice is to consider needs relevant to the region's demographics, addressing any required populations (including Limited English Proficient (LEP) persons).

The second step is to identify needs and concerns at both the regional and neighborhood level, documenting findings for use in other steps. While all MPOs document some level of public engagement to identify needs, some MPOs include narratives and maps to describe needs. A potential best practice is to document findings consistently with narratives, maps and charts. Only a few MPOs document how regional and neighborhood information informs other steps or the Metropolitan Transportation Plan (MTP) or Transportation Improvement Plans (TIPs). A potential best practice is to identify performance measures, policies, projects, and other elements that tie the needs assessment to subsequent analyses and plans. MPOs assess plans and projects for equitable distributions between underserved persons and the population, in general.

The third step is to measure impacts of proposed agency activities, including selection indicators, differentiating project types for evaluation, measuring outputs, measuring outcomes, and documenting these processes for use in the next steps. Most analyses for impacts consisted of maps of future projects and/or funds overlaid onto maps of required populations. Staff assign benefits when an area with specific populations intersects with a project or funding location. This identification then requires a description (qualitatively and/or quantitatively) of the specific benefits and/or burdens associated with proposed investments. Some analyses listed impacts in terms of outputs or outcomes, but not both. A potential best practice would be to discuss indicators that capture outputs (travel times by mode, vehicle traffic congestion) and outcomes (access to jobs, exposure to pollutants). A potential best practice would clearly connect the proposed investments in Step 3 to the needs assessment in Step 2, with regard to required populations.

The fourth and final step determines whether identified differences are disparate by reviewing data, screening for disparate impacts using quantitative methods, and validating findings with qualitative methods and stakeholder involvement. If staff identify disparate elements, it is important to diagnose the underlying reasons contributing to these disparities.

None of the MTPs or TIPs reviewed identified a disparate impact in Step 3, so there was no documentation of Step 4 analyses. A potential best practice would be to consider a rigorous approach to the Step 3 analysis to ensure agencies identify benefits or burdens. Another potential best practice would document the identification and resolution of disparities before or during the Step 3 analysis. The final step is to develop strategies to avoid or mitigate inequities by investing in projects that advance equity and addressing equity in all phases of planning and decision making. If the impact analysis reveals that a plan or project has a disproportionate impact on underserved persons, MPOs must examine alternatives that mitigate these impacts.

Some MPOs are taking proactive approaches regardless of findings of need or impacts. A potential best practice would prioritize equity in project selection, create equity advisory committees/community liaisons, and engage stakeholders in equity analyses. MPOs should continue advancing proactive approaches, being sure to connect them to any needs identified. Some MPOs award “points” to MTP or TIP projects that address equity-related prioritization or selection criteria, but the rationale and calculation methods for the point systems are not always clear. A potential best practice when using equity-related project selection criteria would be to define expected benefits and needs consistently applied, and then apply quantitative and/or qualitative methods, tying them to the equity analysis findings.

Future research identified include:

- Setting measurable public involvement objectives and evaluating progress;
- Mapping locations of required populations that do not depend on setting bright-line population concentration thresholds;
- Developing and selecting indicators of current needs and of potential impacts;
- Identifying and documenting existing and potential disparate impacts relevant to a plan or program, which is broader and more complex than a determination of disparate impacts for a single project; and
- Developing performance-oriented strategies that enable practitioners to estimate the potential positive impacts of a proposed strategy.

AASHTO COMMUNITIES OF PRACTICE AND RELATED INITIATIVES

Matt Hardy

AASHTO members, especially state DOTs across the U.S., want to focus on outcomes rather than outputs. For example, members can use economic data to perform before and after analyses of transportation projects to determine the outcome of a particular project. AASHTO has a pooled fund study underway, as a follow-on to *ECON Works,* a SHRP 2 product focused on before-and-after case studies. The new project will have some sketch planning modeling aspects. State DOTs (with MPOs) can join for $20,000 ($4,000/year for five years per member). Members have access to the *ECON Works* tool enhanced with 128 multimodal, case studies. Some additional resources being developed by AASHTO include the Transit Asset Management (TAM) Guide and Portal on the AASHTO website for access to state asset management plans and the TAM/Transportation Performance Management (TPM)/asset management benchmarking portal.

AMPO TECHNICAL WORKING GROUPS AND RELATED INITIATIVES

Bill Keyrouze

The Association of Metropolitan Planning Organizations (AMPO) is a non-profit, membership organization established in 1994 to serve the needs and interests of Metropolitan Planning Organizations (MPOs). AMPO offers its member MPOs technical assistance and training, conferences and workshops, legislative and rulemaking updates, newsletters and communications, research, a forum for transportation policy development and coalition building, and a variety of other services. AMPO facilitates several long-standing technical working groups focused on transportation planning topic areas that are required or of interest to MPOs. The topic covered include:

- Air Quality;
- GIS;
- Performance-based Planning & Programming;
- Public Involvement;
- Travel Modeling; and
- Vehicle Connectivity and Automation.

The working groups serve as a mechanism to:

- Build technical, institutional, and policy capacity;
- Identify challenges, opportunities;
- Identify and provide needed resources;
- Advance the state of the practice; and
- Support USDOT, state DOTs, MPOs, and stakeholder efforts.

AMPO has developed a number of resources that it shares with its members and other interested in the topics. These resources include a *National Framework for Regional Vehicle Connectivity and Automation Planning* (January 2019*). Performance Measures White Papers* (Safety [PM1])

(Fall/Winter 2019), *Pavement & Bridge* (PM2) (Winter 2020), *System Performance/CMAQ/ Freight* (PM3) (Winter/Spring 2020), *Transit Measures* (Spring 2020*), Congestion Mitigation and Air Quality Improvement Program (CMAQ) White Paper* (Fall/Winter 2019), and the *Transportation Conformity White Paper* (Winter/Spring 2020).

The AMPO *National Framework for Regional Vehicle Connectivity and Automation Planning* document provides a framework for MPOs to incorporate vehicle connectivity and automation into their metropolitan transportation planning process and work to guide its deployment to help meet regional transportation needs and goals. The framework and materials are available at www.ampo.org.

The *Performance Measures White Paper*s are to assist MPOs as they continue to integrate transportation performance management into their metropolitan transportation planning process to help meet regional transportation needs and goals. The papers will share timely information regarding transportation performance management issues, including addressing challenges and solutions, and assisting MPOs in educating decision-makers on key issues.

Looking more closely at establishing targets, some potential data topics include access to data (e.g., direct, data request forms, Application Programming Interface (API)), considerations for supplementing with local data sets, and standardization. Data analysis can be qualitative, quantitative, or both, requiring validation, QA/QC, and staff to conduct various analyses. Some analysis may require data-sharing agreement templates, FHWA/DOT mapping tools with API access, and visualizations. Challenges include matching multi-state datasets; cleaning, matching schema, and rolling up data; and dealing with lag time and missing data, recognizing the time it takes to receive current data, given when targets need to be approved. In addition, there are challenges with bike and pedestrian volume data, crash data, emerging modes, and new technologies (e.g., dockless scooters). Other techniques that may be needed include integration with existing plans and programming (e.g., MTP/TIP/UPWP), safety studies, road safety audits (RSAs), and project scoring and prioritization. Staff need to communicate findings that use these various data with boards, committees and the public.

SESSION 7D: ACHIEVING THE NATIONAL GOALS SUPPORTED BY FEDERALLY REQUIRED PERFORMANCE MEASURES

Harlan Miller, *Federal Highway Administration, presiding*
Michael Grant, *ICF, recorder*
Michael Nesbitt, *Federal Highway Administration*
Ken Cervenka, *Federal Transit Administration*

FHWA TPM IMPLEMENTATION STRATEGY OF DOTs and MPOs

Michael Nesbitt

If the phrase, “what gets measured, gets done” is true, then it also true that “what has data gets measured, reported, and used in decision-making.” MPOs, state DOTs, and federal agencies collect and produce data to support transportation decision making at various levels of government. However, the decisions an agency makes about what data to collect and how they source their data for performance reporting may impact the decision making at other agencies.

The data sourced by MPOs, state DOTs, and federal agencies influences the performance story those agencies report internally and externally. The data also affects what agencies report regarding:

- Performance Metrics: a quantifiable indicator of performance or condition;
- Performance Measures: an expression that is defined based on metric(s) used to track progress towards goals, objectives, and achievement of established targets;
- Scopes: the intended coverage of the performance measures in terms of locations and time periods;
- Granularity: the determination of what each data record will represent; and
- Calculations: the specification of systematic calculations for the performance measure reduces inconsistent results.

To better understand how state DOTs and MPOs are meeting the challenges of Performance-Based Planning and Programming (PBPP), a survey was deployed between December 12, 2018 to February 28, 2019 (responses received through March were included). The following are specific questions addressed.

How does your agency incorporate PBPP into its long range statewide transportation plan/metropolitan transportation plan?

The majority of state DOTs and MPOs reported their Long Range Statewide Transportation Plan (LRSTP)/Metropolitan Transportation Plan (MTP) performance measures correspond to MAP-21 national goals; link to their plan's vision, goals, or objectives; and link to project selection or screening criteria for STIP/TIP programming. They also reported their LRSTP/MTP set performance targets for goals. A minority of state DOTs and MPOs LRSTP/MTP included a monitoring plan for evaluating the results of LRSTP/MTP investments using performance measures and evaluated multiple scenarios based on established performance measures.

How do agencies incorporate PBPP into statewide transportation improvement programs (STIPs) and transportation improvement programs (TIPs)?

The majority of state DOTs and MPOs have LRSTP/MTP goals and performance measures reflected in their STIP/TIP project selection or screening. They prioritized STIP/TIP investments are determined or informed by performance measures. Their STIP/TIP project selection or screening includes a discussion as to how the investment program will achieve targets. A minority of state DOTs and MPOs review the results of STIP/TIP investments by monitoring outcomes using performance measures. A minority evaluated their STIP/TIP alternative investment scenarios based on LRSTP/MTP goals and performance measures.

Concerning the outcomes of the PBPP process, the majority of state DOTs and MPOs reported making progress toward achieving performance targets, including the identification of the outcomes they want from the transportation planning and programming process. A majority of state DOTs, but a minority of MPOs (mostly larger ones), indicated they regularly monitor the effects of project and strategies funded in the STIP/TIP and apply the evaluation of investment effectiveness in future programming decisions.

INTRODUCTION TO PERFORMANCE MANAGEMENT AND PERFORMANCE-BASED PLANNING

Michael Nesbitt, Harlan Miller, and Ken Cervenka

Transportation Performance Management (TPM) is a strategic approach that uses system information to make investment and policy decisions to achieve national performance goals. It is important because it provides a link between goals and specific actions, and can guide decisions on best use of available resources. It can evaluate the effectiveness of policies, plans, programs and projects, and track system performance over time. It is important to communicate the results to internal and external audiences to strengthen accountability. The Federal Highway Administration (FHWA) and Federal Transit Administration (FTA) define TPM as a strategic approach that uses system information (i.e., quality performance measures of the transportation system) to make investment and policy decisions to achieve national performance goals. Systematically applied transportation performance management strategies provide key information to assist decision-makers in understanding the consequences of investment decisions across multiple performance areas. The process improves communications among decision-makers, stakeholders, and the traveling public, ensuring targets and measures are developed in cooperative partnerships, based on data and objective information. It is applicable to all aspects of transportation, and ties closely to the planning and programming process and asset management.

Congress expects USDOT to tell them how federal investments function and what outcomes resulted. The American Recovery and Reinvestment Act (ARRA) included an unprecedented level of transparency for allocated funds, including outcomes. Prior to MAP-21, there were no explicit requirements for a state DOT to demonstrate how its transportation program supported national performance outcomes. State DOTs were not required to measure performance, establish targets, assess progress toward targets, or report on performance in a nationally consistent manner that FHWA could use to assess the entire system. Without states reporting on these factors, FHWA cannot adequately examine the effectiveness of the Federal-Aid Highway program as a means to address surface transportation performance at a national level. MAP–21 was a paradigm shift. It focuses on a select set of national goals and directs USDOT to establish national performance measures. It also requires state DOTs and MPOs to establish targets in support of national measures. National goals defined in the MAP-21 and FAST Acts are:

- *Safety* - To achieve a significant reduction in traffic fatalities and serious injuries on all public roads.
- *Infrastructure Condition* - To maintain the highway infrastructure asset system in a state of good repair.
- *Congestion Reduction* - To achieve a significant reduction in congestion on the National Highway System.
- *System Reliability* - To improve the efficiency of the surface transportation system.
- *Freight Movement and Economic Vitality* - To improve the national freight network, strengthen the ability of rural communities to access national and international trade markets and support regional economic development.
- *Environmental Sustainability* - To enhance the performance of the transportation system while protecting and enhancing the natural environment.

- *Reduced Project Delivery Delays* - To reduce project costs, promote jobs and the economy and expedite the movement of people and goods by accelerating project completion through eliminating delays in the project development and delivery process, including reducing regulatory burdens and improving agencies' work practices.

The legislation, 23 CFR, Part 490, created three performance measures. The measures cover five major areas: safety; condition of pavements and bridges; system performance; freight movement; and CMAQ carried out under four funding programs. The legislation provides for seventeen measures, describes the application of each measure, indicates what data is needed to support the measures, and includes target due dates. For example, state DOTs have one year from the effective date of the application of the final rule, while MPOs have 180 days after the state DOT deadline. The legislation also describes the performance period, the reporting requirements and the timeline. It also defines the process for significant progress determination.

Safety Measures (PM1) stem from the Highway Safety Improvement Program (HSIP). Agencies may need to adjust their data management processes to meet new reporting and target setting requirements, including processes involving MPO-state DOT coordination. The final safety measures may affect existing safety data management practices, including reporting of serious injuries (based on the Model Minimum Uniform Crash Criteria [MMUCC] Suspected Serious Injury attribute) and non-motorized serious injuries (based on ANSI D15. 1-2007). Both of these elements are available from the state motor vehicle crash database. States are already reporting the fatality and VMT data needed via Fatality Analysis Reporting System (FARS) and HPMS. MPOs electing to set a performance target for fatality and injury rates are required to supply a VMT estimate because the HPMS does not include MPO-specific VMT. In addition to the statewide targets, “state DOTs may select any number and combination of urbanized area boundaries and may also select a single non-urbanized area boundary for the establishment of additional targets. The boundaries used by the state DOT for additional targets shall be contained within the geographic boundary of the State.” The following data resources are available for calculating safety performance measures.

- The FARS is a long-standing Federal data source that tracks fatalities. All States contribute to this data source, managed by NHTSA.
- MPOs can estimate VMT using a number of different methods (e.g., traffic count samples, models, population-based forecasts).
- The Highway Performance Monitoring System (HPMS) is available for States to calculate VMT.
- State Reported Data, maintained by individual States, include data derived from police crash reports.

Pavement and Bridge Measures (PM2) consists of four pavement condition measures, and two bridge condition measures. The pavement condition measures include the percentage of pavement in good condition on both the Interstate and non-Interstate NHS, and the percentage of pavement in poor condition on the Interstate and non-Interstate NHS. The two measures for assessing bridge condition apply to all NHS bridges and are the percentage of those bridges classified as in good condition and in poor condition.

There are national pavement and bridge measures, which are generally in alignment with currently available data. Pavement measures rely on International Roughness Index (IRI), cracking, rutting and faulting data—much of which may be already collected, though some agencies will need to adjust collection methods and quality assurance protocols. In addition, agencies will need to implement processes to filter out bridges from the data used to calculate pavement condition measures. Bridge measures rely on existing National Bridge Inspection (NBI) ratings, so the only implication for bridge data management is that agencies will need to implement a process to calculate the good-fair-poor measures, based on the NBI data. As with the safety measures, states may establish additional targets for urbanized and non-urbanized areas. The "% of pavements" refers to the percent of pavement lane miles and the "% of bridges" (weighted by bridge deck area). Data sources include:

- National Bridge Inventory (NBI)
- Highway Performance Monitoring System (HPMS)

Pavement measures are applicable to all interstate and non-interstate NHS systems regardless of ownership or maintenance responsibilities within a given state or metropolitan planning area. This policy also applies to bridge measures, including bridges on ramps connecting to the NHS and NHS bridges that cross a state border. Pavement condition thresholds use a variety of measures (e.g., the IRI, cracking, rutting/faulting). Each has thresholds for good, fair and poor. For example, the IRI threshold is good if it is less than 95, fair if it is between 95 and 170, and poor if it is over 170, regardless of population. Pavement rated as "good" has all three metrics rated "good" for asphalt and jointed concrete pavements, or IRI and cracking, rated "good" for continuous concrete pavements. Similarly, pavement rated "poor" has two or more metrics rated poor for asphalt and jointed concrete pavements, or both the IRI and cracking rated "poor" for continuous concrete pavements. Bridge conditions use the minimum values of the condition ratings for deck (NBI Item 58), superstructure (NBI Item 59), substructure (NBI Item 60) and culvert (NBI Item 62). If the minimum rating is 7 or greater, the bridge is in "good" condition. If it is 4 or lower, the bridge is in "poor" condition. If it is 5 or 6, the bridge is in "fair" condition.

The System Performance Measures (PM3) are for the NHS and rely on detailed travel time data sets. Agencies can use data from the National Performance Measure Research Data Set (NPMRDS), or an equivalent data set. New data management practices and skill sets may be required in some agencies in order to work with these "big data" sets in order to integrate travel time data with agency road inventory data. However, FHWA intends to work with state DOTs and MPOs, using a pooled fund approach, to acquire services and tools that will help process and analyze data. Level of Travel Time Reliability (LOTTR) is defined as the ratio of the longer travel times (80th percentile) to a "normal" travel time (50th percentile). Data are aggregated into 15-minute segments during all time periods between 6 a.m. and 8 p.m. local time. The measures are the percent of person-miles traveled on the relevant portion of the NHS that are reliable. Person-miles take into account the users of the NHS. Data to reflect the users can include bus, auto, and truck occupancy levels. FHWA, through a private sector vendor, provides NPMRDS monthly to state DOTs and MPOs. The data uses a variety of vehicle probes (e.g., mobile phones, vehicle transponders, portable navigation devices) on contiguous segments of roadway covering the entire NHS.

Freight Performance Measures (PM3) are system performance measures for freight movements. These measures rely on the same data source as the system performance measures and have similar implications for agency data management practices. The LOTTR is the ratio of the 95th percentile truck travel time to the 50th percentile truck travel time for an interstate segment(s) throughout a full calendar year. The mileage-uncongested measure uses a threshold of average truck speed of 50 mph for the segment across the entire year. If the annual average truck speed is greater than 50 mph, the segment is uncongested. The TTTR Index is the sum of maximum TTTR for each segment, divided by total interstate miles. States may use travel time data from either the NPMRDS or an FHWA-approved equivalent data set. Bottlenecks require special attention, with the following characteristics:

- Roadway segment with constraints causing significant impact on freight mobility and reliability.
- May include highway sections not meeting thresholds for freight reliability or other locations identified by the state.
- Causes may include recurring congestion causing delays in freight movement.
- Causes may include roadway features that impact truck movements such as:
  - Steep grades;
  - Substandard vertical or horizontal clearances;
  - Weight restrictions;
  - Delays at border crossings or terminals; or
  - Truck operating restrictions.

In addition, bottleneck regulations allow states to utilize metrics that relate to the unique transportation needs of each state, including:

- Transportation infrastructure condition and issues;
- Geographic conditions of each state;
- Types of industries;
- Transportation issues affecting freight movement; and
- Closely tied to State Freight Plans.

Congestion Mitigation and Air Quality (CMAQ) (PM3) are system performance measures for CMAQ. These measures apply only to nonattainment areas, requiring data be geographically filtered. The first measure requires use of the NPMRDS (or equivalent), state reported traffic volumes and Census data—so agencies will need to implement processes for working with travel time data sets and integrating these data sets with available traffic data sets. The third measure relies on the CMAQ Public Access System—which is the system currently in use for agencies to report emission reduction estimates for their CMAQ. The U.S. EPA designates nonattainment and maintenance areas, which are necessary to use for the traffic congestion and on-road mobile source emissions performance measures. The Peak Hour of Excessive Delay (PHED) and Non-SOV Travel Measures are applicable to designated urbanized areas, containing NHS mileage, with a population over 200,000—in addition to nonattainment or maintenance areas with ozone (O3), carbon monoxide (CO), or particulate matter (PM10 or PM2.5). All MPOs and state DOTs that have NHS mileage that overlaps with an applicable urbanized area must coordinate on a

single, unified target and report on the measures. For the first performance period only, the population criteria applies to urbanized areas with populations over 1 million. There are special data requirements for Non-SOV Travel calculations, with three possible methodologies:

- Method A: Five-Year Estimate for "Commuting to Work" totaled by mode, as of August 15 of year Performance Report is due (American Community Survey [Table DP03]);
- Method B: Travel mode choices gathered within two years of the start of the Performance Period (Local Survey); or
- Method C: Sample or continuous count of travelers using different modes (Modal Counts).

Note: An NPRM proposing to repeal the Green House Gases (GHG) measure was published on Oct. 5, 2017.

Transit Asset Management evaluates:

- Rolling stock - percent of revenue vehicles exceeding Useful Life Benchmark (ULB);
- Equipment - percent of non-revenue service vehicles exceeding ULB;
- Facilities - percent of facilities rated under 3.0 on the Transit Economic Requirements Model (TERM) scale; and
- Infrastructure - percent of track segments under performance restriction.

Transit Safety Measures include:

- Fatalities - Total number of reportable fatalities and rate per total revenue miles by mode;
- Injuries - Total number of reportable injuries and rate per total vehicle revenue miles by mode;
- Safety events -Total number of reportable events and rate per total vehicle revenue miles by mode; and
- System reliability - Mean distance between major mechanical failures by mode.

The Final Rules were adopted in *23 CFR Part 490, 49 CFR Part 625, 49 CFR Part 673,* and all the measures identified, the description of the applicability of measures, and the information on the data needed to calculate the measures. The target dates when state DOTs and MPOs must report their numbers are as follows.

- State DOTs and Transit Providers - One year from the effective date of the applicable final rule.
- MPOs: 180 days after the state DOT/Transit Provider.

Performance-Based Planning and Programming (PBPP) is the integration of TPM into the transportation planning process. It is a data-driven decision-making process that uses goals, objectives, performance measures, performance targets, and investment decision making in the planning process to achieve performance outcomes. The PBPP process requires target setting coordination, meaning state DOTs, transit providers, and MPOs shall coordinate when setting targets to ensure consistency to the maximum extent practicable. MPOs can establish their own quantifiable performance targets, or adopt its state's performance targets, and support state

efforts to achieve those targets. In the same way, MPOs can adopt the transit provider's performance targets, supporting their efforts, as long as MPOs have established targets.

The PBPP states MPO(s), state DOTs, and public transit agencies shall *jointly* establish written agreements for a metropolitan area describing roles and responsibilities for PBPP including:

- Coordination on target setting;
- Data collection;
- Data analysis;
- Reporting on progress toward target achievement; and
- Data collection for the NHS asset management plan.

The PBPP requires participants to integrate the goals, objectives, performance measures, and targets from other performance-based plans and programs into the transportation planning process. For example, other plans requiring integration include highway and transit asset management plans, the Strategic Highway Safety Plan, freight plans, and congestion management plans (CMPs). The PBPP includes two new plans, the Metropolitan Transportation Plan, and the Long Range State Transportation Plan. These two plans contain the performance measures and targets, with a description of the progress made towards achieving since the plan's last update. In addition, the Transportation Improvement Plan (TIP) needs to focus on the achievement of the performance targets in the plan. To accomplish the expected transparency and accountability in performance management, the Performance Progress Report is to include the following.

- FHWA assessment of state DOT target achievement (annually).
- Highway Safety Improvement Program (HSIP) - Safety performance.
- FHWA assessment of state DOT target achievement (every two years).
  - Applied to statewide National Highway Performance Program (NHPP) and National Highway Freight Program (NHFP) targets only.
  - NHPP:
    - Pavement condition;
    - Bridge condition; and
    - Interstate and non-interstate NHS Travel Time Reliability measures.
  - NHFP:
    - Freight Reliability measure.

The rules established minimum condition levels for state DOTs for interstate pavements and National Highway System (NHS) Bridges (as previously mentioned). The final rule stipulates a penalty if for three consecutive years the minimum condition level is not met (e.g., for more than 5% interstate pavement designated as poor). A state must obligate and set aside NHPP funds for eligible bridge projects on the NHS. A number of TPM resources are now available to assist state DOTs and MPOs in executing their PBPP. For example, the following resources are available from the National Highway Institute (NHI).

- NHI Training Courses

- NHI-138007: Performance-based Planning and Programming
- NHI-151053: Transportation Planning Process
- NHI-138004: TPM Overview for the MAP-21 and FAST Acts
- NHI-138011: The Role of Data in TPM
- NHI-138006: TPM for Safety
- NHI-138012: Steps to Effective Target Setting for TPM
- NHI-136106 and 136106B: TPM – Transportation Asset Management and Asset Management Plans
- NHI 136002: Financial Planning for Transportation Asset Management
- NHI-138005: TPM Overview (web-based)
- NHI-138008: TPM for Bridges
- NHI-138009: TPM for Pavement
- NHI-138010: TPM for Congestion (Including Freight)

Additional Resources

Federal Highway Administration (FHWA). *Freight Movement on the Interstate System (Subpart F)*. (2016). (http://www.fhwa.dot.gov/tpm/rule/freightmeas20042016.pdf)

Federal Highway Administration (FHWA). *Performance of the National Highway System (Subpart E)*. (2016). http://www.fhwa.dot.gov/tpm/rule/systemperf20042016.pdf

Federal Highway Administration (FHWA). *Traffic Congestion (Subpart G) and On-Road Mobile Source Emissions (Subpart H)*. (2016). http://www.fhwa.dot.gov/tpm/rule/cmaq20042016.pdf

Federal Highway Administration (FHWA). *Transportation Performance Management.* (No date). https://www.fhwa.dot.gov/tpm/rule/pm3/reliability.pdf

Federal Highway Administration (FHWA). *Transportation Planning Capacity Building*. (2019). https://www.planning.dot.gov/.

Federal Register. *National Performance Management Measures.* (2017). https://www.federalregister.gov/documents/2017/01/18/2017-00681/national-performance-management-measures-assessing-performance-of-the-national-highway-system

USDOT. *National Performance Management Measures to Assess System Performance, Freight Movement, and CMAQ Improvement Program.* (2017). https://www.fhwa.dot.gov/tpm/rule/170601pm3.pdf.

USDOT. *Safety Performance Management*. (no date). https://safety.fhwa.dot.gov/hsip/spm/)

U.S. Government Printing Office. U.S. Code Title 23, Code of Federal Regulation. (2017). https://www.govinfo.gov/content/pkg/CFR-2017-title23-vol1/pdf/CFR-2017-title23-vol1-chapI.pdf [*see* 490.207, 490.307, and 490, 407].

USDOT. *Transportation Performance Management (TPM)*. (No date), http://www.fhwa.dot.gov/tpm/about/index.cfm.

USDOT. *Transportation Performance Management (TPM) Implementation Plan.* (No date). https://www.fhwa.dot.gov/tpm/plan.pdf.

U.S. Government Printing Office. U.S. Code Title 23. (2018). https://www.govinfo.gov/content/pkg/USCODE-2018-title23/pdf/USCODE-2018-title23.pdf [*see* 119, 134, 135, 148, 150, 167].

Chapter 10

Conference Closing Session: Bringing It All Together

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Penelope Weinberger, *American Association of State Highway and Transportation Officials, recorder*
John Kaliski, *Cambridge Systematics*
Jordon Holt, *Washington Metropolitan Area Transit Authority*
David Wasserman, *North Carolina Department of Transportation*
Hannah Twaddell, *ICF*

INTRODUCTION

Robert Hazlett

Throughout this conference, participants have been pinning their suggestions on topic boards. The relevant TRB Committees will analyze these suggestions for potential Research Need Statements (RNS). The question now is have we missed anything in our presentations and discussions? In this final session, leaders from the four topic areas will provide their reflections on what they heard (e.g., recurring themes), what they learned (e.g., innovative trends), and what they see are next steps to improve performance and data in transportation decision-making.

MULTIMODAL PLANNING

John Kaliski

Integrating multimodal issues into planning goals, into the various plans, across the many processes, is critical to addressing the need for multimodal performance evaluation. In addition, we need to integrate multimodal issues in order to accomplish effective institutional partnerships. Over the last three days, we have seen a range of presentations focused on these topics and it is impressive how quickly the data and tools are evolving. Comparing our progress to our performance and data conference two years ago, we clearly have increased data availability and have better functioning tools to enable information to guide planning discussions. We can now measure mobility and accessibility in new ways, using big data and modern processing. We have a more level playing field to focus on customers. In the past, planners were limited to traffic counts, now we have data to understand a trip taken on different modes, and ways to measure dwell time, time searching for parking, and transfer time between modes. These measures will provide a more complete picture for agencies to make better planning decisions. For example, previously, freight planning had limited truck counts and some economic data. The proof-of-concept study on freight fluidity (being conducted by FHWA and the I-95 Corridor Coalition) informs our understanding of how supply chains operate, and how to measure them. A number of future research topics relate to hyper-mobility as a new area of research. Developments related to new tools address sharing and visualizing data. We have always measured a number of aspects

(e.g., safety, asset management), but now we can communicate more effectively with decision-makers. Additionally, state DOTs, MPOs, and transit agencies, are using the same data, sharing and working towards the same targets and the same goals.

Our new data sources and tools are making analysis more robust. It is possible to identify pain points for agencies (e.g., methodology developed for the Iowa's interstate management plan). What would it really take to use a long-term stewardship approach, how much money would it take to maintain it over time, and what are the implications of investing in that level on the rest of the system? Illinois' freight plan highlights whether to invest in interstates for major truck flows, or off-system projects for last mile issues. Florida is looking at safety with their strategic highway safety plan, setting the target at zero fatalities, and incorporating safety into every planning effort. There are numerous examples of agencies moving from planning to resource allocation using data rich approaches, with modern processing techniques. They are moving from goals, objectives and measures, into actually making a resource allocation decision. El Paso's "achievable complexity" points to the ability to take steps to use data and processes, maybe not perfectly, but sufficiently, to achieve what is achievable today. The Wichita MPO project selection staff discussion addresses how much time to spend on ranking project specifically compared to just bucketing best and poorly performing projects.

Planning alignment remains a challenge with the number of required plans (e.g., Long Range Transportation Plan (LRTP), a Transportation Management Plan (TMP), a safety plan, a freight plan, models and system plans). For example, in Pennsylvania, they are using their targets to update their plans, their funding formula, with a transition plan over time to shift to a new funding formula. In Minnesota's approach of a family of plans, staff are looking at practical ways to coordinate planning guidance make connections among all the different plans over time. Another form of coordination is occurring with stakeholders, as well as with the data used to keep them informed. All of these advances assist with the development of common targets, based on shared data, moving towards strategies and funding solutions. We know what we want to do in our plans, with stakeholder partnerships made stronger with data sharing, and people working towards the same measures, rather than just trying to share projects as we did in the past.

PERFORMANCE AND DATA

Jordan Holt

Both Business Intelligence (BI) and data governance (DG) were prominent in the presentations and discussions, as are aspects requiring executive support, at a tipping point in practice. For example, in several sessions, 50% of the participants had a formal BI program or a formal DG program. For BI, there is a tension between the democratization of data (making it available for everyone to use in its native form) and curating data (use of interactive tools with standardized approaches with defined data). There is a wide variety in the models used for BI (e.g., consultant support, data analyst services for different business units). To find answers and acquire information from data, some models are building dashboards and tools that allow staff in different business units to interact with the data and derive their own conclusions. A key issue for both BI and DG is the return-on-investment (ROI) as data operations are not cheap and require a method for determining ROI.

There are a number of issues surrounding the location of the DG function within an agency and how it relate to IT, to the business units, both internally and externally. To be

successful, DG requires a process, rather than a project, that is non-evasive, with a strong change management approach. Several DOTs have had success with a change management process with upper management by starting with the pain point, and starting with a very specific goal to accomplish. A final issue for data and performance is the use of private data. Session participants indicated that over 50% were using some form of private data. Throughout the sessions, three topic areas emerged. The first was private versus public data. The second was overcoming data biases, how to build in safeguards against these biases, and impacts on decisions. Finally, the new concept of data as a service requires transportation agencies to make a series of decisions. For example, agencies may need to determine whether to move towards outsourcing data ownership and data management. Some agencies feel their data is core to their agencies' business, and critical for decision making. For these agencies, data operations need to remain inside their own agency to preserve data transparency.

PROGRAMMING AND INVESTMENT PRIORITIZATION

David Wasserman

The conference planning committee made the decision to make programming and investment prioritization sessions similar to a peer exchange to allow agencies to discuss their experiences and learn from others. Common themes emerged including: know your political climate; make sure you have champions; make sure you have support, both internally and externally; and key factors to success. To develop a program, agencies need to build the process incrementally, gathering support along the way, which could result in a surplus of data. It is best to keep it simple, to strive to be transparent, and to show all your work as much as possible to build confidence and support. At the same time, you want to accept feedback. Staff need to correct identified issues with the data, communicate the corrections, and disseminate the process followed to foster a continuous culture of improvement.

Throughout the gathering and responding to feedback to changing elements, have stakeholders involved, both internal stakeholders and external stakeholders. If you are a state, make sure your MPOs are involved. If you are an MPO, make sure you have your localities involved, and build trust and confidence with continued communications. Another aspect for success is to target communications for different types of audiences (e.g., technical experts will want to see the spreadsheets and columns, but board members might not). We have heard throughout sessions that the data is evolving, meaning that as you move through the prioritization process, you will need to test the data, making sure it is appropriate for your purpose. Do not start using a new data set and then test it – it will turn your program upside-down. There are many tools that consultants are willing to help you use to test data and may suggest developing an application to automate your process. However, while automation is good, any new procedure needs to be described and displayed manually, with all the steps performed in an analysis transparent to all the parties involved. Otherwise, staff become burdened with overtime work when stakeholders want to know what the automation is doing, and ask how the results are generated.

COMMUNICATION AND STAKEHOLDER ENGAGEMENT

Hannah Twaddell

The sessions demonstrated how quickly visualization techniques are becoming desirable for planning. Many working in transportation feel under skilled to use software to visualize data online (e.g., Tableau, Power BI, Slido). Traditional graphics staff skills (e.g., making logos, branding graphics) are insufficient for conveying a travel time index (TTI) for highway corridors. Even trying to explain how to use programming languages (e.g., Python) for visualizations is beyond the skillset of most transportation professionals. There is a need to understand how to incorporate these skills into an agency, coordinating with visualization specialists (e.g., staffing up and bringing in a few professionals and learning the tools for Infographics). While there is a need for a new set of technical literacy skills from journalism schools, skills most transportation professionals never learned, there is still a need to use pen and paper, or post-it notes on boards. The public still expects handouts at public meetings. Communications need to come from a variety of platforms and mediums, matching the appropriate form to the right audience, requiring a fresh look at what we need for a particular situation. (The Slido outputs from conference sessions are available in Appendix C). While many agencies are developing dashboards and portals, we are now finding that information located only on a website may become obsolete because fewer people visit websites. People appear to prefer to have information provided to them on their mobile devices. The need to cater to mobile devices will drive the interface that we use (e.g., twitter, republished graphics) to ensure the communications are correctly interpreted. The transportation industry previously talked to reporters who did not necessary have experience reporting on transportation issues. While new online tools pop-up visualizations, there is still a need for the resource information to be available. Someone may want to have access to the original 47-page spreadsheet. Having resources accessible through a portal, with online tools, will allow users to drill down to the level they want.

Even with the many new sources of data and analysis techniques, we still need to improve our storytelling skills. We all have in-person exchanges as agency representatives, when we leave our PowerPoints and Tableau behind, and just need to tell people why a project is so important, or what a score really means. We need the skills to explain technical aspects in different ways to different audiences who need information in a manner that makes sense to them. This means we also need to improve our ability to speak about visual things. This conference has revealed the gap in skillsets for transportation professionals. In just about every session, we all recognized the tremendous transformation has occurred over the last five years in communicating information from data. The entire process is beginning to change. For example, Virginia DOT allocated $3B for their SMART SCALE program and then leveraged another $7B to encourage localities to collaborate with them. This is very different from five years ago. The process has resulted in on-time and in-budget projects. There is now a strong relationship between local implementers and projects based on tracking techniques. Staff can roll up results and share them with the public. Performance data provides a method for digging down and figuring out why something is happening (e.g., going down underground on the metro tracks at 5:00 AM to find out why the track repair projects aren’t going as planned and be able to talk to people about performance with information at hand).

SUMMARY REFLECTIONS

Robert Hazlett

A critical take away from this conference is the preference for information access on a small screen format on a mobile device. This means that the transportation community will need to make the most effective information in that format to reach our stakeholders. We will need the assistance of other disciplines to tell our stories to the public and to decision-makers. For example, Arizona State University (ASU) has professionals with storytelling skills. At the same time, portals provide information to those wanting to conduct or review analyses. For example, data is available for the creation of graphics and maps, contributing to the democratization of data. Yet there remains the question of how much data to disseminate to the public, how much should remain private, or in the case of commercial vendors, proprietary?

To address the efficacy of how we use data, we need to make certain that planners and researchers do their best to reduce bias. Planners need to maintain a neutral approach using the ethics expected of planning professionals, and providing the safeguards for data expected by the public. As custodians of the data, we need to provide accurate information for making decisions. Finally, we all have the challenge ahead of keeping abreast with relevant technologies (e.g., Tableau). All planners will need to take advantage of opportunities to learn new techniques, new approaches, and new ways of applying analysis.

Appendix A

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Appendix B

Acronyms

Acronym	Definition
A4T	All 4 Transportation
AAA	American Automobile Association
AADT	Annual Average Daily Traffic
AARP	American Association of Retired Persons
AASHTO	American Association of State Highway and Transportation Officials
ABMVIZ	Activity-Based Model Visualization Platform
ABS	Antilock Brake System
ADOT	Arizona Department of Transportation
ADT	Average Daily Traffic
AI	Artificial Intelligence
AIS	Automatic Identification System
AM	Asset Management
AMPO	Association of Metropolitan Planning Organizations
ANF	Executive Office of Administration and Finance
APC	Automatic Passenger Counter
API	Application Programming Interface
ARC	Atlanta Regional Council
ARRA	American Recovery and Reinvestment Act
ARS	Arizona Revised Statutes
ARTP	Atlanta Regional Transit Plan
ASI	Asset Sustainability Index
ASU	Arizona State University
ATP	ActiveTrans Priority
AWS	Amazon Web Services
BART	Bay Area Rapid Transit
BCA	Benefit-Cost Analysis
BHISD	Bridge and Highway Information System Database
BI	Business Intelligence
BOT	Board of Transportation
BRT	Bus Rapid Transit
BSM I	Basic Safety Message I
CalEPA	California Environmental Protection Agency
Caltrans	California Department of Transportation
CARB	California Air Resources Board
CATS	Charlotte Area Transit System
CATT Lab	Center for Advanced Tranpsoration Technology Laboratory
CAV	Connected and Automated Vehicles
CCTV	Closed-Circuit Television

CDO	Chief Data Officer
CDOT	Colorado Department of Transportation
CED	Cabinet for Economic Development
CEO	Chief Executive Officer
CFO	Chief Financial Officer
CFR	Code of Federal Regulations
CHAF	Continuous Highway Analysis Framework
CHCNGA-TPO	Chattanooga/Hamilton County/North Georgia Transportation Planning Organization
CIP	Capital Investment Plan
CMAQ	Congestion Mitigation and Air Quality
CMB	Cable Median Barrier
CMC	Crossover Median Crashes
CMF	Crash Modification Factors
CMM	Capability Maturity Model
CMP	Congestion Management Process
CMP	Congestion Management Plan
CMS	Congestion Management System
CNN	Convolutional Neural Networks
COO	Chief Operating Official
CO_2	Carbon Dioxide
COGs	Councils of Government
COST	Central Office System Timing
CPD	Capital Planning Database
CTA	Chicago Transit Authority
CTB	Commonwealth Transportation Board
CTPP	Census Transportation Planning Products
CUTR	Center of Urban Transportation Research
CV	Connected Vehicles
DBE	Disadvantage Business Enterprise
DDSA	Data-Driven Safety Analysis
DDI	Diversion Diamond Interchange
DG	Data Governance
DMS	Dynamic Message Sign
DMV	Department of Motor Vehicles
DOE	Department of Energy
DOT	Department of Transportation
DRCOG	Denver Regional Council of Governments
DRPT	Department of Rail and Public Transportation
EAMS	Enterprise Asset Management System
EEMS	Energy Efficient Mobility System
EIM	Enterprise Infornation Management
EJ	Environmental Justice
EPDO	Equivalent Property Damage Only

EPMPO	El Paso Metropolitan Planning Organization
ETG	Expert Task Group
ETL	Extract, Transform, and Load
EV	Electric Vehicle
FAC	Freight Advisory Committees
FARS	Fatality Analysis Reporting System
FAST	Fixing America's Surface Transportation
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
FIP	Freight Investment Program
FLMA	Federal Land Management Agency
FRA	Federal Railroad Administration
FTA	Federal Transit Administration FY Fiscal Year
FTC	Florida Transportation Commission
FTN	Frequency Transit Network
GAO	Government Accountability Office
GDOT	Georgia Department of Transportation
GHG	Greenhouse Gas
GIS	Geographic Information Systems
GPS	Global Positioning Systems
GTFS	General Transit Feed Specification
HIS	Interstate Highway System
HOFM	FHWA Office of Freight Management and Operations
HOT	High-occupancy Toll Lanes
HOV	High-occupancy Vehicles
HPMS	Highway Performance Monitoring System
HR	Human Resources
HSIP	Highway Safety Improvement Plan
HSM	Highway Safety Manual
HUD	Housing and Urban Development
ICFP	Illinois Competitive Freight Program
ICM	Integrated Corridor Management
IDOT	Illinois Department of Transportation
IoT	Internet of Things
IP	Intellectual Property
IRI	International Roughness Index
ISFAC	Illinois State Freight Advisory Council
IT	Information Technology
ITS	Intelligent Transportation Systems
ITIP	Integrated Transportation Information Platform
ITRE	Institute for Transportation Research and Education
KDP	Key Decision Points
KM	Knowledge Management
KPIs	Key Performance Indicators

KTC	Kentucky Transportation Center
LA Metro	Los Angeles County Metropolitan Transportation Authority
LBS	Location-Based Services
LCCP	Life cycle Cost Analysis
LEHD	Longitudinal Employer-Household Dynamic
LEP	Limited English Proficiency
LINK-D	Nebraska Linking Infrastructure Challenges with Data
LOS	Level-of-Service
LOTTR	Level of Travel Time Reliability
LPP	Local Partnership Program
LRTPs	Long Range Transportation Plans
MAG	Mariposa Association of Governments
MAP-21	Moving Ahead for Progress in the 21st Century
MARC	Mid-American Regional Council
MARK1	Measurement, Accuracy, and Reliability Kit
MARTA	Metropolitan Atlanta Rapid Transit Authority
MassDOT	Massachusetts Department of Transportation
MBTA	Massachusetts Bay Transportation Authority
MDOT	Maryland Department of Transportation
MDOT	Michigan Department of Transportation
MEP	Mobility Energy Productivity
MFT	Motor Fuel Tax
ML or Mllib	Machine Learning Library
MMUCC	Model Minimum Uniform Crash Criteria
MnDOT	Minnesota Department of Transportation
MnSHIP	Minnesota State Highway Investment Plan
MOD	Mobility on Demand
MORPC	Mid-Ohio Regional Planning Commission
MOU	Memorandum of Understanding
MPMs	Mobility Performance Measures
MPO	Metropolitan Planning Organization
MPO	MetroPlan Orlando
MPOAC	Metropolitan Planning Organization Advisory Council
MTA	Maryland Transit Administration
MTC	Metropolitan Transportation Commission
MTP	Metropolitan Transportation Plan
NACTO	National Association of City Transportation Officials
NBI	National Bridge Inventory
NCDOT	North Carolina Department of Transportation
NCHRP	National Cooperative Highway Research Program
NCTCOG	North Central Texas Council of Governments
NDOT	Nebraska Department of Transportation
NDOT	Nevada Department of Transportation

NHFP	National Highway Freight Program
NHI	National Highway Institute
NHPP	National Highway Performance Program
NHS	National Highway System
NHTS	National Household Travel Survey
NHTSA	National Highway Traffic Safety Administration
NIRPC	Northern Indiana Regional Planning Commission
NMDOT	New Mexico Department of Transportation
NO	Number of Oscillations
NOFA	Notice of Funding Availability
Non-SOV	Non-Single Occupancy Vehicle
NPMRDS	National Performance Management Research Data Set
NPRM	Notice of Proposed Rulemaking
NRF	Non-Revenue Fleet
NTD	National Transit Database
NTP	National Transportation Plan
NVTA	Northern Virginia Transportation Authority
NVTC	North Virginia Transportation Commission
NWI	Northwestern Indiana
NYCDOT	New York City Department of Transportation
O/D	Origins and Destinations
O3	Ozone
OGT	Operation Governance Team
OPMI	Office of Performance Management and Innovation
ORME	On-road Mobile Source Emissions
P2P	Planning to Programming
PADT	Peak Average Daily Traffic
PAG	Pima Association of Governments
PANYNJ	Port Authority of New York and New Jersey
PBPP	Performance-Based Planning and Programming
PCI	Pavement Condition Index
PDC	Planning District Commission
PDI	Pavement Distress Index
PE	Preliminary Engineering
PEL	Planning Environmental Linkage
PennDOT	Pennsylvania Department of Transportation
PfP	Planning for Performance
PHED	Peak Hour Excessive Delay
PII	Personally Identifiable Information
PIR	Performance Implementation Roadmap
PIS	Program Investment Scenarios
PM	Performance Management
PM%	Preventive Maintenance %
PM1	Performance Measure Rule 1 (Safety)

PM2	Performance Measure Rule 2 (Pavement and Bridge Condition)
PM3	Performance Measure Rule 3 (System Performance, Freight, and CMAQ)
PMP	Preventive Maintenance Performance
PMG	Performance Monitoring Guidelines
PMs	Performance Measures
PPI	Pavement Preservation Index
PSAC	Project Selection Advisory Council
QA/QC	Quality Assurance/Quality Control
QUAAD	Quality, Utilization, Accessibility, Analytics and Discovery
RACI	Responsible, Accountable, Consulted, Informed
RAMPCAP	Risk Analysis and Management for Critical Asset Protection
RDIP	Roadway Data Improvement Program
RDMS	Relational Database Management System
REMI	Regional Economic Models, Inc.
REN	Regional Equity Network
RFI	Request for Interest
RFP	Request for Proposals
RIC	Recommended Investment Choice
RITIS	Regional Integrated Transportation Information System
RNN	Recurrent Neural Networks
RNS	Research Need Statements
ROI	Return-on-Investment
ROW	Right-of-Way
RPC	Regional Planning Commission
RSA	Road Safety Audit
RTC	Regional Transportation Commission
RTP	Regional Transportation Plan
RTPOs	Regional Transportation Planning Organizations
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SCAG	Southern California Association of Governments
SCDOT	South Carolina Department of Transportation
SCVTA	Santa Clara Valley Transportation Authority
SDOT	State Departments of Transportation
SFMR	San Francisco Metropolitan Region
SFP	State Freight Plan
SHIFT	Strategic Highway Investment Formula for Tomorrow
SHSO	State Highway Safety Office
SHSPs	Strategic Highway Safety Plans
SHTF	State Highway Trust Fund
SIS SIT Tool	Strategic Intermodal System Strategic Investment Tool
SLRTP	Statewide Long Range Transportation Plan
SME	Subject Matter Expert

SMT	Statewide Mobility Team
SMTP	Statewide Multimodal Transportation Plan
SOP	Standard Operating Procedure
SOV	Single Occupancy Vehicle
SPUI	Single-Point Urban Interchange
SRRI	Statewide Rural Reliability Index
STBG	Surface Transportation Block Grant
STI	Strategic Transportation Investments
STIP	State Transportation Improvement Program
SVM	Support Vector Machines
SWITRS	Statewide Integrated Traffic Records System
SYIP	Six-Year Improvement Program
T2/RP	Research to Practice
TaaS	Transportation As a Service
TAM	Transportation Asset Management
TAMP	Transportation Asset Management Plan
TAP	Transportation Alternatives Program
TAZ	Traffic Analysis Zone
TCS	Traction Control System
TDM	Transportation Demand Management
TERM	Transit Economic Requirements Model
TET	Time Exposed Time
TIP	Transportation Improvement Program
TMA	Transportation Management Association
TMA	Transportation Management Areas
TMC	Traffic Management Center
TNC	Transportation Network Companies
TPM	Transportation Performance Management
TOD	Transit-Oriented Development
TRB	Transportation Research Board
TSMO	Transportation System Management and Operations
TSA	Traffic Safety Analytics
TSP	Transit Signal Priority
TTI	Time To Insight
TTI	Travel Time Index
TTI	Texas Transportation Institute
TTTR	Truck Travel Time Reliability
TxDOT	Texas Department of Transportation
UGP	Unified Growth Policy
ULB	Useful Life Benchmark
UPWP	Unified Planning Work Programs
USDA	United States Department of Agriculture
USDOT	United States Department of Transportation
UTP	Unified Transportation Program

V/C	Volume/Capacity
V2I	Vehicle-to-Infrastructure
VDOT	Virginia Department of Transportation
VMT	Vehicle Miles Traveled
VTBA	Vermont Truck and Bus Association
VTrans	Vermont Agency of Transportation
WAMPO	Wichita Area Metropolitan Planning Organization
WMATA	Washington Metropolitan Area Transit Authority
WSDOT	Washington Department of Transportation
WSTC	Washington State Transportation Commission
WVDOH	West Virginia Division of Highways

Appendix C

Mobile App Surveying Technique

One of the new communication strategies available for planners to engage with live audiences is to use an electronic interface (e.g., Slido). Questions are posed to the audience, projected on a screen and then participants post their responses using a mobile devices (e.g., Smart Phone, Ipad) to a specific web address. The software uses organizing algorithms to sort and produce relationships among the words posted by the audience in real time. For example, Figure 52 displays the responses when the audience was asked early in the conference for one word that expressed their expectations for the conference. The predominant response of the participants was "*learn,*" followed by "*insights,*" and "*ideas.*" YOU ARE HERE

The second set of responses (*see* Figure 53), addressed a summary of what was learned from the previous day's interactions. The predominant response was "*Performance*", followed by "*Project selection*" and "*data*". There is a marked difference in the level of response from the 22 participants, with the rest of the responses being very individualistic. The third example addressed what participants learned from the conference (*see* Figure 54). Here, the predominant responses were "*governance*", followed by "*data*", "*project*" and "*performance*". For this question, there were a number of other relatively strong response, indicating a much broad set of responses (e.g., "*process*", "*alan alda*", "*selection*" and "*equity*"). This technique, provided the IT support is adequate and the audience is prepared in advance to bring a charger device, enlivens the dialogue and can focus participants on key concepts and shared terms.

FIGURE 52 In one word, what are your expectations for this week's conference?

FIGURE 53 Briefly, what did you learn from yesterday's sessions?

FIGURE 54 What do you know now that you didn't before?

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