Peer Exchange Workshop on the "Perfect World of Measuring Congestion"

Workshop Summary Report

Washington, D.C.
December 17-18, 2013

U.S. Department of Transportation
Federal Highway Administration

FHWA-HOP-14-009

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WORKSHOP OVERVIEW AND OBJECTIVES

The Federal Highway Administration's (FHWA's) Operations Performance Measurement Program (http://www.ops.fhwa.dot.gov/perf_measurement) sponsored a Peer Exchange Workshop titled "the Perfect World of Measuring Congestion" held in Washington, D.C. on December 17-18, 2013. The focus of the workshop was to identify the "perfect world" of measuring congestion from an operations perspective, as well as possible research and implementation efforts that could be undertaken in the next five years by FHWA to get there. The workshop agenda and a list of participants are included in Appendix A and B, respectively.

The results of the workshop are being used to provide input to FHWA's Operations Performance Measures and Management Program five-year Road Map. The Road Map will include research and implementation projects that FHWA could fund over the next five years as well as related projects that other groups (other FHWA programs, TRB, etc.) might want to undertake.

In an effort to stimulate discussion at the workshop, four brief white papers were prepared and distributed prior to the workshop. These white papers are included in Appendix C.

PERFECT WORLD FOR MEASURING CONGESTION

The morning session of December 17th focused on attendee perspectives regarding what the perfect world of congestion measurement might look like. The Operations Performance Management Capability Maturity Model (OPMCMM) (presented in white paper #1 (see Appendix C)) was used to facilitate the discussion.

Five prevalent themes emerged that workshop attendees would like to see in a "perfect world" of measuring congestion for operations:

1. Flexible Decision-Making Framework: Public-agency transportation staff are often inundated with questions from varied stakeholders who have specific needs or decisions to make. **The perfect world will have a flexible decision-making framework that is suitable for communicating to several audiences – travelers, operators, planners, and political/decision-makers.**

2. Automated Monitoring at all Geographic Levels: **The perfect world will have monitoring everywhere for system needs, but allows for filtering out specific/local transportation project/program improvements.** This continuous multimodal monitoring would provide benefit-cost information for specific projects (rural or urban), and allow automated report creation.

3. Data Consistency: There is a need for consistency in data set formats within and across agencies. **The perfect world will have consistency in data formats to improve understanding of the data.**

4. Measures and Methods Consensus: In some urban areas and states, there is a difference of opinion on performance measures, thresholds (to define congestion), appropriate targets for the measures, calculation procedures and assumptions used. **The perfect world will have consensus on the measures and calculation methods.**

5. Fusion of Mode-Specific Datasets: Thorough transportation decision-making requires mode-specific data. **The perfect world will have a fusion and redundancy of mode-specific data sets across roadway facilities for decision-making in a multimodal and multi-agency environment.**

IMPLEMENTATION HURDLES AND NEEDS

After discussing the vision for the perfect world of congestion measurement for operations, workshop attendees identified implementation hurdles and needs in the areas of data, external factors and data analysis tools. These needs are listed in the sections below.

DATA NEEDS

Workshop attendees identified the following data needs ("new" or "improvements on existing"):

- Travel characteristics (needed for all modes on roadways)
  - Volume data
    - Person-volume
    - Density information
    - Data by lane
  - Latent/induced demand
  - Real-time speed
  - Capacity
- Information on causes of congestion
- Trip Information
  - Multimodal information (transit, bicyclist, and pedestrian data) – and how to fuse modes together
  - Origin-destination data
- Improved spatial coverage
  - Rural areas
  - Arterials
- Data governance guidance
  - Data business plan, data standardization
- Data use information
  - How are users using the data
  - What do they look at? How are they changing their decisions?
- Accessibility/Livability data
- How to fuse crowd-sourced and sensor data

EXTERNAL FACTORS

Workshop attendees identified the following external factors that serve as hurdles to performance monitoring because they may lead to fluctuations in performance measure values.

- Weather
- Economic factors
    - Employment rates
    - Population growth
    - Gross state product (or gross metropolitan product)
- Demand (where is it now? – temporally and spatially)
- Accessibility/livability must be incorporated and considered
- Quantitative extent of tourism and visitors (e.g., from Chamber of Commerce)
- Military base volumes/impacts

External factors are further discussed in white paper #4 (see Appendix C).

DATA ANALYSIS TOOLS

Workshop attendees identified the following analysis tools or provided the following observations for overcoming analysis barriers for measuring congestion for operations:

- FHWA National Performance Management Research Data Set (NPMRDS) is valuable, but a national tool is needed to analyze the dataset
- The University of Maryland has developed many data analysis tools (see http://www.cattlab.umd.edu/?portfolio=ritis) for the I-95 Corridor Coalition
- Many DOTs not present at the workshop likely need help in telling their message
- Tools must model/adjust/forecast and be more nimble

STEPPING STONES TO IDEAL STATE

Based on discussions throughout the workshop, seven primary themes emerged as "stepping stones" to get to the ideal state of congestion measurement for operations. These seven theme areas are:

1) Decision-making context;
2) Measure definition and calculation;
3) Customer engagement;
4) Data needs;
5) Analysis tools and methods;
6) Facility coverage; and
7) Traveler choices.

A brief discussion of each of these theme areas is included in the sections below.

1. DECISION-MAKING CONTEXT

There is a need to better understand the context in which decisions are being made and the evolving nature of these decisions. In light of this information, there is a need for transportation professionals to understand their role in the decision-making process for varied audiences (travelers, operators, planners, policy makers), and to understand that their credibility is at stake when providing information to these audiences.

There is a link between the operations decisions that can be made and the quality of the data upon which those decisions are being made. Because of this link, data availability and value is important. In some cases, there is a need for a culture change within transportation agencies to place a high value on quality data for decision-making.

2. MEASURE DEFINITION AND CALCULATION

There is a need for consistency in how the industry defines, calculates and applies congestion measures for operations. Consistency – or at a minimum clear documentation – of measure calculation steps and methods used to identify congestion thresholds is important. Transparency in reliability measure calculation and application is even more critical because reliability measures are based upon distributions rather than averages.

Related to measure definition and calculation is the need for consideration of multimodal elements in the performance measures and targets. Workshop attendees acknowledge the need for guidance on setting targets, while seeking flexibility in target-setting. Consideration of land use, accessibility and emissions impacts is important in multimodal measure definition and target-setting.

3. CUSTOMER ENGAGEMENT

There is a need to understand the best practices and tools for communicating with customers – particularly the four audiences previously mentioned (travelers, operators, planners, policy makers). Several workshop attendees expressed the importance of communication. There are different methods for communication to varied audiences, including panels, focus groups, smartphone apps, social media, etc. Likewise, the public audiences have spatially-differing community values and needs. It is important to anticipate needs of varied audiences and be proactive, while also managing expectations.

4. DATA NEEDS

There was extensive discussion by workshop attendees about data needs and needs related to data integration to improve congestion measurement for operations. A list of specific data needs was generated by attendees (see prior section of this documentation). Integration of multiple sources of data to meet decision needs is often required. There is a need for reducing the "friction" of data exchange through common application programming interfaces (APIs), segment definitions, location referencing, etc. A better understanding is needed for best practices of data use for reporting external factors (e.g., induced demand, land use change, economic activity, employment or changing demographics) to provide context and correlation with performance activities.

Within public transportation agencies, incorporating data governance and disseminating data policies is important so all users understand the data and use limitations. Workshop attendees also discussed the possibility of public-private and public-public partnerships for data acquisition when mutual gains are possible.

5. ANALYSIS TOOLS AND METHODS

There is a need for more guidance on performing before-and-after evaluations of operational treatments. More specifically, attendees were interested in better understanding when and where evaluations should be performed, the integrity of the underlying data sources, how to define the baseline for analysis, how to control for external factors, etc. Attendees discussed the concern with consistency in data sources (e.g., probe data) over time and how to handle that in before-after evaluations. There is a related need and interest in ultimately having analysis tools and methods that are integrated between the project-level, corridor-level and system-level. Attendees expressed interest in predictive analysis tools for planning and preliminary engineering purposes that incorporate external factors and can assist in target setting.

6. FACILITY COVERAGE

There is a need for better data on arterials and in rural areas to improve congestion measurement for operations. In the arterial environment, there is a pressing need for both better data, and also multimodal analysis methods. In the rural environment, there is a need for better corridor coverage where there is a focus on congestion issues. One specific difficulty is that the geographic length of traffic message channels (TMCs) used by private-sector speed providers are often many miles. Locations of localized rural congestion are therefore "washed-out" over these longer reporting segments. Rural coverage is also valuable because many rural corridors are critical for goods movement, tourism, and economic development.

7. TRAVELER CHOICES

There is a need for information about how transportation system users are using and reacting to operational treatments such as traffic information and controls. Data are needed for all system users – travelers as well as freight shippers. As an example, understanding how travelers behave or react to traffic information and controls can help transportation professionals better understand what type(s) of traffic information messaging cause a particular type of mode shift.

PROJECT SUGGESTIONS

The concluding activities on Day 2 of the Peer Exchange Workshop included developing project ideas to help get to the "perfect world" of congestion measurement for operations. The following project suggestions were identified during the discussion.

- Compile terminology and develop glossary: Development of a guidebook of common terminology for operations performance measurement, including methods for calculating measures using standard inputs.

- Guidance on the target setting process: Development of a guidebook including a synthesis and guidance at both the program and project level for target setting.

- Identifying a process for performance-based decision-making: Development of a process for decision-making, which might include a predictive modeling tool, identifying the value of data in decision-making, and recognizing tradeoffs with limited resources.

- Understanding best practices for customer engagement: Perform synthesis of best practices for engaging customers (e.g., panels, focus groups, social media, etc.) and include decision-makers as customers.

- Investigation and documentation of external factors that can impact operations performance measurement: Identify key attributes that should be tracked and reported and provide guidance on the process (extension of peer exchange background white paper #4).

- Synthesis and guidance on non-traditional performance measures: Non-traditional measures are ones that capture land use, multimodal aspects, and environmental effects (e.g., Greenhouse Gases).

- Technical Support for National Performance Management Research Data Set (NPMRDS): Includes user's forums and data crosswalk and integration issues (particularly with fusing NPMRDS to existing data sets). Project could be established as a pooled fund study.

- Identification of additional benefits and opportunities with private-company data: investigation of the potential for private-company data sources beyond just travel time and origin-destination data (e.g., individualized data from private providers for traveler choices).

- Improved arterial data: Guidance is needed to identify available data and calculation procedures for performance measures in the arterial environment (particularly the non-freeway National Highway System).

- Development of data governance policies for public agencies: A guidance document that identifies best practices for managing and sharing data within and among public agencies.

- Analysis tool for computing required performance statistics: A pooled fund for a "bare-bones" analysis tool to compute required performance statistics.

- Guidance on before-after evaluations of operational treatments: Guidebook to perform effective before-after studies of operational projects and programs including integrity of data sources, defining baseline, controlling for external factors, etc.

- Best practices online library on performance monitoring and management: Development and support of a web "presence" where this information could be queried and accessed.

- Value-added threshold: Better defining those facilities (using an average daily traffic [ADT] or ADT per lane threshold on arterials, for example) that are important for regional management and traveler information.

CONCLUSIONS AND NEXT STEPS

The focus of the December 17-18, 2013 Peer Exchange Workshop was to identify the "perfect world" of measuring congestion from an operations perspective. The Peer Exchange Workshop highlighted several themes and corresponding needs that are critical to meet to advance performance monitoring and management for operations toward this "perfect world." These themes and needs have been summarized in this document. The next steps will involve crafting these needs identified in the workshop into a Road Map for FHWA's Operations Performance Measures Program.

APPENDIX A: WORKSHOP AGENDA

Peer Exchange Workshop on the "Perfect World of Measuring Congestion"
Federal Highway Administration, Office of Operations

December 17-18, 2013
USDOT Conference Room #6
1200 New Jersey Ave, SE, Washington, DC

Dec 17th AM 8:30a to 12p	**_Session 1: Setting the Stage and Expectations_** • Introductions • Overview of FHWA project • Workshop goal: provide input for FHWA 5-year research plan. • Brief summary of white papers, focusing on capability maturity framework.
	Session 2: Visioning/ Ideal State/Best Practices • Open discussion by all participants. • If time/resources/data were unconstrained, how would we structure performance monitoring and management programs? • Address data, tools, external variables, etc.
Dec 17th PM 1p to 4:30p	**_Session 3: Barriers, Hurdles, Unresolved Issues_** • What are barriers to the "Ideal State" discussed before lunch? • Don't limit to big or small barriers, or easily solved barriers, just compile a listing of most important.
	Session 4: Stepping Stones to the Ideal State • Provide structure and priority to barrier removal. • What barriers, when removed or mitigated, could provide the most cost-effective advances in operations performance management practices?
Dec 18th AM 8:30a to 11:30a	**_Session 5: Crafting a Research Plan_** • Summarize yesterday's discussion of barriers and hurdles, gather feedback/confirmation. • Discuss logical research projects that address priority barriers. • Identify related efforts and stakeholders.
	Session 6: Closure and Next Steps • Summarize research project concepts, gather feedback/confirmation. • Distribution of workshop notes to participants. • Discuss future avenues for involvement and peer exchange.

APPENDIX B: WORKSHOP PARTICIPANTS

No.	Name	Organization
1	Jesse Beurk	Delaware Valley Regional Planning Commission
2	Daniela Bremmer	Washington State DOT
3	Mara Campbell	Missouri Department of Transportation
4	Michael Chamberlain	Texas DOT
5	Mark Demidovich	Georgia DOT
6	Rick Dowling	Kittelson
7	Bill Eisele	Texas A&M Transportation Institute
8	Mike Fontaine	Virginia DOT/VCTIR
9	Brian Gardner	Federal Highway Administration
10	Mark Hallenbeck	University of Washington
11	Trish Hendren	Washington Metropolitan Area Transit Authority
12	Brian Hoeft	Las Vegas Regional Transportation Commission
13	William Hyman	Transportation Research Board/SHRP 2 Reliability
14	Jim Kranig	Minnesota DOT
15	Doug Laird	Federal Highway Administration
16	Jeff Lindley	Federal Highway Administration
17	Mena Lockwood	Virginia DOT
18	Tim Lomax	Texas A&M Transportation Institute
19	Rich Margiotta	Cambridge Systematics
20	Doug McLeod	Florida DOT
21	Andrew Meese	Metro Washington Council of Governments
22	Harlan Miller	Federal Highway Administration
23	Keith Nichols	Hampton Roads Transp. Planning Organization
24	Michael Pack	University of Maryland
25	Karl Petty	Iteris
26	Joan Sollenberger	Caltrans
27	Pete Stephanos	Federal Highway Administration
28	Paul Szatkowski	Virginia DOT
29	Rich Taylor	Federal Highway Administration
30	Shawn Turner	Texas A&M Transportation Institute
31	Stan Young	University of Maryland

APPENDIX C: WHITE PAPERS

To stimulate discussion at the Workshop, four "white papers" on key performance monitoring and management topics were prepared and distributed in advance. These papers were not intended as an exhaustive treatment of the topics, but a discussion of important issues, question, and practices. The four white papers are as follows:

1. **Framework for Gauging State-of-the-Practice in Performance Monitoring and Management.** This paper presents a framework that can be used to classify best practices in performance monitoring. The framework is based on these categories:
   a. Performance measures (content and form);
   b. Performance management (agency culture);
   c. Data used;
   d. Transportation modes;
   e. Facility and trip coverage; and
   f. Traveler preferences and tradeoffs consideration.

2. **Advancing Best Practices in Performance Monitoring: How and Where to Take the Next Steps?** This paper described ways in which best practices in performance monitoring (in terms of data types, coverage, measures, etc.) could be further improved in the next five to ten years.

3. **Connecting the Dots: How to Better Link Project-Level Performance Monitoring to Policy-Level Performance Management?** This paper outlined important considerations for performance monitoring and management at varying levels of detail to meet different decision-making needs.

4. **Operations Performance Management: How Should External Events and Trends be Considered?** This paper identified the key external influences that may lead to fluctuations in performance measure values. These external influences include things like changes in travel demand, economy, development and land use patterns, housing cost and school quality, travel technology (e.g., connected vehicles or telecommuting), etc.

Paper #1: Framework for Gauging State-of-the-Practice in Performance Monitoring and Management

Prepared for:
Peer Exchange Workshop on the "Perfect World of Measuring Congestion"
FHWA Office of Operations

Prepared by:
Texas A&M Transportation Institute and Battelle

FINAL
December 10, 2013

1. Introduction

This background paper is paper number one (1) of four (4) developed in preparation for the Peer Exchange Workshop to be held on December 17-18, 2013 in Washington, D.C. The objective of this paper is to describe a framework to gauge the state-of-the-practice in performance monitoring. The framework includes examples, best practices, reporting and typical data sources. These examples discuss how current congestion measures are used to support transportation investment decisions including operational strategies.

The paper begins by presenting a summary of the proposed framework developed by the Texas A&M Transportation Institute (TTI) for gauging current best practices. The framework was informed by observation of general industry practices related to performance monitoring. The remainder of the report supports these observations with additional details and examples.

2. Highlights of Framework for Gauging State-of-the-Practice

Observation of practices for performance monitoring and management provides evidence of a varying degree of the extent that performance data are used in decision-making for transportation projects and programs. Figure 1 introduces an Operations Performance Management Capability Maturity Model (OPMCMM) to identify characteristics of the performance management maturity continuum, which is evident in practice. The OPMCMM provides a method for grading agency practices on several characteristics important for performance management to be a seamless practice in a transportation organization. The six (6) categories are 1) performance measures (content and form), 2) performance management (agency culture), 3) data, 4) modes, 5) facility and trip coverage, and 6) traveler preferences and tradeoffs.   The proposed framework illustrates four (4) "ribbon categories" of bronze, silver, gold and platinum to illustrate maturity level for the given characteristics.

The capability maturity model illustrated in Figure 1 was inspired by the capability maturity model applied to systems operations and management described in SHRP 2 Report L06 (Institutional Architectures to Improve Systems Operations and Management).[1] While the SHRP 2 Report L06 used four (4) levels, here "ribbon levels" are proposed for the maturity scale. The following are general highlights about the OPMCMM and observations from selected practices:

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[1] http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_S2-L06-RR-1.pdf

- In the OPMCMM, performance monitoring and management evolves to interactive/automated performance results, becomes data-driven using real-time or near real-time information, and has a performance connection between project-level and system-wide performance.
- At the bronze level of the OPMCMM, data sets are "siloed" in agencies and become more transparent, accessible and connected with maturity.
- The platinum level of the OPMCMM is characterized by complete modal information and understanding not only how you traveled, but how/where you really wanted to travel.
- There are a number of external sources and transportation-related contributing factors to congestion that are not currently imbedded in typical performance practice (e.g., economy, societal factors [development patterns, housing prices], weather, incidents, work zones, connected/autonomous vehicles) – these external factors will be described in background white paper #4.

The characteristics and examples suggested in Figure 1 are described further in the remainder of this paper. Background paper #2 will further describe how the industry can get to the "perfect world" (platinum level) identified in Figure 1.

Figure 1. Illustration of Proposed Operations Performance Management Capability Maturity Model for Gauging Current Practice

100%

Degree to which performance data are used in decision-making

Platinum

Gold

Silver

Bronze

0%

| Engineering judgment/ intuition/anecdotal | Project-specific performance | Network performance reporting | Feedback loop in decision-making | Data-informed | Data-driven |

Operations Performance Management Capability Maturity Model (OPMCMM)

Perf. Measures (Content):	*All "ribbon levels" typically use travel time-based or delay performance measures, including total delay, delay per mile, travel time index, planning time index, etc. Measures are computed at the spatial and temporal scales of interest.*		*Full/seamless family of output/outcome measures across organization; real-time link (and decision-making) between project-level and system reporting; averages and reliability*
	Limited, project-specific "after" study; snapshot of outcome measures (averages) (e.g., GA TRIP evaluation, CA Traffic Signal Program) →	*Only required ("siloed") reporting* →	*Family of output and outcome measures in some areas of organization* →
Perf. Mgmt (Culture):	*Minimal perf mgmt interest; performed only as required* →	*Isolated champions of perf mgmt; nothing coordinated across any agency "silos"* →	*Evidence of entire portions of agency implementing and making decisions with perf measures; evidence of "data-informed" process to select projects (e.g., WA Gray Notebook)* →	*Perf mgmt is ubiquitous in agency culture; entire agency speaks "perf mgmt language" – it feeds mgmt decision-making; "data-driven" decisions using real-time information*
Data:	*All "ribbon levels" typically use speed, volume and roadway inventory information at spatial and temporal scales of interest. As the industry matures to the "platinum level," real-time performance management and decision-making are possible.*			
	"Siloed" datasets; no connections →	*Dataset connections possible – requires programming/processing (e.g., TTI UMR, FHWA's UCR)* →	*Evidence of some coordination of datasets across traditional agency "silos" (e.g., I-95 Corridor Coalition Future Performance Activities)* →	*Connected with other agency datasets (volume, crashes, pavement, etc.); graphical user interface (GUI) to visualize/query data for decision-making*
Modes:	*Mode areas are "siloed" in agency; limited communication* →	*Some ability to capture/estimate mode shifts within "silo" of interest* →	*Ability to capture mode shifts across entire agency* →	*Ability to capture mode shifts over time and across the agency, including intermodal considerations (freight and person)*
Facility and Trip Coverage:	*Limited temporal/ spatial coverage in "silos"* →	*Selected modes/facilities and temporal coverage (e.g., TX 100 Roadways, IN/MD Mobility Reports)* →	*All modes, all facilities, all days, all times covered* →	*In addition to gold level, ability to capture diversion from traveler info or control strategies*
Traveler Preferences/ Tradeoffs:	*Limited ability to capture trip preferences or revealed behavior (e.g., new Google Maps® preferences feature)* →	*Some ability in selected agency "silos" to capture some trip preferences* →	*Technological methods identified/used to capture trip preferences or revealed behavior* →	*Agency ability to gauge or capture traveler preferences and revealed behavior (i.e., how you traveled and How/where you really wanted to travel)*

3. Current Practice in Measuring Congestion

The ultimate goal of measuring congestion is improved transportation investment decision-making. Initially, performance measures provide a baseline of conditions, and, over time, allow for trend analyses of what types of transportation investments are working and where. These performance insights inform future investment decisions for transportation projects, programs and strategies.

An evaluation of the current practice in measuring congestion provides evidence that there are varying degrees to which performance data are used in transportation investment decision-making. This varied nature of the profession is captured in Figure 1 (the OPMCMM). Current practice can be viewed on a scale of increasing performance management maturity, and from left to right in Figure 1, there is increased maturity in performance management. At the left end of the scale there is a minimal degree of performance data used in decision making, and this improves as the reader tracks their eyes to the right along the graphic at the top of Figure 1. For perspective, the graphic identifies four (4) "ribbon categories" (bronze, silver, gold, and platinum) from left to right as the degree of performance data are used in decision-making.

Just below the graphic at the top of Figure 1 are short characterizations to describe the OPMCMM continuum. While there are four (4) ribbon categories, there are six (6) general short-description observations related to data in decision-making along the maturity continuum. At the far left where there is zero performance data used in decision-making, decisions are made with engineering judgment, are highly intuitive and/or based on anecdotal evidence. Progressing to the right are specific projects, characterized by a "snapshot" of performance for a project evaluation that is not really connected to system-wide performance activities. As one progresses along the maturity scale, network performance reporting is encountered. Moving further along the maturation scale, the next step includes a feedback loop in decision-making (i.e., an evaluation process is in place after decisions are made to evaluate the decision and the process). The next steps include data-informed decisions – not entirely data-driven, but data play a key role – and are then followed by data-driven decisions from performance data (in near real-time or real-time).

This section of the paper describes the following characteristics of the performance management maturity scale highlighted in Figure 1:
- Performance measures (content and form);
- Performance management (agency culture);
- Data used;
- Transportation modes;
- Facility and trip coverage; and
- Traveler preferences and tradeoffs consideration.

Selected examples of different characteristics and ribbon levels are also provided in the following section.

Performance Measures (Content and Form) at Each Ribbon Level

All ribbon levels typically use travel time-based or delay performance measures (e.g., total delay, delay per mile, travel time index, planning time index, etc.). Measures are computed at the spatial and temporal scales of interest.

- _Bronze Level_: Characterized by limited project and program evaluations. Typically these project evaluations are for a specific intersection analysis or segment of road where a project or program will be implemented (before study) or to evaluate the impacts after implementation (after study). The evaluation informs the public agency if the project/program was successful and whether improvements are needed. Typically it is just a snapshot of average (rather than reliability) outcome performance measures.

- _Silver Level_: At this level only mandated or legislated (required) reporting is performed by the agency, and these activities are "siloed" into the divisions or groups of the agency required to report.

- _Gold Level_: At this level measures captured include both public sector efforts (output) and performance results from the field (outcome) in selected areas of the organization (e.g., operations section of the agency reports on the number of motorist assistance patrols on the freeway system in a particular urban area [output measure] as well as average travel time information on the urban roadway system [outcome measure]).

- _Platinum Level:_ Full and seamless family of output and outcome measures used by the agency. There is a real-time link between project-level and system reporting that facilitates real-time (or near real-time decision-making). With continuous data readily available at this level, reliability measures can be easily produced in addition to average conditions.

Performance Management (Agency Culture) at Each Ribbon Level

Equally important to the measures themselves is the culture of the transportation agency in adapting performance management into their decision-making processes; therefore, the OPMCMM includes this characteristic.

- _Bronze Level_: Minimal performance management interest in the agency. Performance measurement only performed when mandated or legislated as required. Performed to "check a box."

- _Silver Level_: Isolated champions emerge in the agency with strong interest in performance management. Any performance management activities still siloed.

- _Gold Level_: Evidence of entire portions of the agency implementing and making decisions with performance measures. There is evidence of "data-informed" processes to select projects.

- _Platinum Level:_ Performance management is ubiquitous in agency culture. Entire agency speaks "performance management language" fluently, and it feeds management decision-making. Decisions are "data-driven" using real-time information.

Data Used

All ribbon categories along the maturity scale typically use speed, volume and roadway inventory data at spatial and temporal scales of interest. As the industry matures to the "platinum level," real-time performance management and decision-making are possible.

- *Bronze Level*: "Siloed" datasets with no connections. Data are sought for the project evaluation or analysis at hand and are typically acquired from different groups within the agency.

- *Silver Level*: Dataset connections are possible, but it requires programming/processing.

- *Gold Level*: Similar to the silver level where dataset connections are possible, but it requires programming/processing. At the gold level there is evidence of some coordination of datasets across agency "silos."

- *Platinum Level:* At the platinum level of the maturity scale, all database types are connected (e.g., volume, crashes, pavement quality, etc.) and available through automated methods (e.g., relational database, GIS, etc.).

Transportation Modes

This characteristic of the OPMCMM relates to an agency's ability to understand multimodal and intermodal trip characteristics.

- *Bronze Level*: Mode knowledge and related data and information are "siloed" in the agency and there is limited communication across modes in the organization.

- *Silver Level*: Some ability to capture or estimate mode shifts within agency "silo" of interest.

- *Gold Level*: Ability to capture mode shifts across the entire agency.

- *Platinum Level:* The ability to capture mode shifts over time and across the agency, including intermodal considerations (i.e., freight and person movement).

Facility and Trip Coverage

The geographic scope of travel is captured in this characteristic.

- *Bronze Level*: Limited temporal and spatial coverage available for performance monitoring.

- *Silver Level*: Selected modes and/or facilities and related temporal coverage.

- *Gold Level*: All modes, all facilities, all days, and all times covered.

- *Platinum Level:* In addition to all gold level characteristics, also ability to capture diversion from traveler information or control strategies.

Traveler Preferences and Tradeoffs

The final characteristic identified in Figure 1 relates to an agency's ability to capture traveler preferences and tradeoffs.

- *Bronze Level*: Limited ability to capture trip preferences or revealed behavior. "Revealed behavior" relates to methods or technologies to provide insights or understanding about how and where particular trips are made from start to finish.

- *Silver Level*: Some ability in selected agency "silos" to capture some trip preferences or revealed behavior.

- *Gold Level*: Technological methods identified/used to capture trip preferences.

- *Platinum Level:* An agency has the ability to gauge or capture traveler preferences and revealed behavior. This means an agency can identify how you traveled, <u>and</u> has information about how you really wanted to travel. This makes the important distinction that travelers must use the built system (and modes present), but may really want to take other routes/modes if they were available.

The platinum level as defined here is admittedly far off; however, it is important to keep an eye on the fact that as transportation professionals better understand traveler trip preferences, this will help them develop the system for all users.

4. Selected Examples of Different Characteristics and Ribbon Levels

There are several examples provided in Figure 1 to help the reader identify where some selected current practice and activities might fall on the OPMCMM framework. These examples are only intended to start a discussion about how the OPMCMM can be used to grade different types of agency performance management activities.

OPMCMM Characteristic: Performance Measures (Content and Form) – Bronze Level

There are numerous examples of performance activities at the bronze level, characterized by project-specific studies. Below are a few transportation operations examples recently highlighted in FHWA's *2012 Urban Congestion Trends Report.*[2] These types of evaluations are project specific and provide a snapshot of performance. Table 1 includes examples of performance measures (content and form) at the bronze level.

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[2] http://ops.fhwa.dot.gov/publications/fhwahop13016/index.htm

Table 1. Examples of Performance Measures (Content and Form) at the Bronze Level
(source: FHWA's 2012 Urban Congestion Trends Report)

Towing and Recovery Incentive Program (TRIP) (Atlanta, Georgia)	
Description	TRIP provides monetary incentives for timely clearance of crashes involving commercial vehicles. A recent Georgia Department of Transportation (GDOT) study evaluated TRIP, and found that it allowed roadway opening at least 2 hours and 45 minutes faster than in 2007 (before TRIP). Other key findings were that TRIP decreased average incident cost by 70 percent, saved over $9 million in delay, wasted fuel and emissions from inception to 2009, and results in a benefit of nearly $11 for each $1 spent.
Data	Modeling of "pre-TRIP incidents" using clearance times to estimate benefits if TRIP were in place.
Measures	Costs of delay, wasted fuel, emissions, benefit-to-cost ratio.

Traffic Light Synchronization Program (California)	
Description	Caltrans recently funded the Traffic Light Synchronization Program (TLSP) at $250 million from successful passage in November 2006 of California's Proposition 1B (Transportation). Several projects have been implemented and have either met or exceeded estimated benefits. Two examples of benefits are in San Ramon, CA where ASCTs were installed on Crow Canyon Road and Bollinger Canyon Road. Both locations resulted in reductions in travel time, fuel consumption, emissions and collisions.
Data	Data sources include travel time from travel time runs, traffic volume measurement, and database of crashes.
Measures	Travel time, total delay, stopped time, congested time, fuel consumption, and emissions. Fuel consumption and emissions were estimated from SYNCHRO software.

OPMCMM Characteristic: Performance Management (Agency Culture) – Gold Level

Table 2 includes an example of performance management (agency culture) at the gold level of the Washington State DOT's Gray Notebook.

**Table 2. Examples of Performance Management (Agency Culture) at the Gold Level
(Source: WSDOT's Gray Notebook)[3]**

WSDOT's Gray Notebook	
Description	The Washington DOT's Gray Notebook (GNB) is the basis of WSDOT's external performance reporting. It is recognized nationally for setting a high standard for accessible and accurate updates on programs and projects. The report is released quarterly with sections clearly related to the six statewide transportation policy goals of safety, preservation, mobility (congestion relief), environment, economic vitality and stewardship.
Data and Measures	The report uses a number of data sources and performance measures across the six policy goal areas. WSDOT's Performance Dashboard (page vii of the GNB Edition 50) highlights key mobility measures as annual weekday vehicle-hours of delay, average clearance times for major incidents, percentage of ferries departing on time and percentage of Amtrak Cascades trips arriving on time.

[3] http://www.wsdot.wa.gov/Accountability/default.htm

Table 3 includes examples of the "data" characteristic at the silver level of TTI's *Urban Mobility Report* and FHWA's *Urban Congestion Reports.*

Table 3. Examples of Data at the Silver Level (Sources: TTI's Urban Mobility Report, FHWA's Urban Congestion Reports)[4]

TTI's *Urban Mobility Report*	
Description	The *Urban Mobility Report* reports congestion in all U.S. urban areas. In the *2012 Urban Mobility Report,* trend data are available from 1982 to 2011. Detailed congestion statistics are provided for 101 urban areas, and summary statistics are provided for the 498 urban areas throughout the U.S. Statistics are presented in tables by urban areas population size. The report is widely quoted on congestion and associated costs.
Data	The *Urban Mobility Report* is powered by huge datasets, including: 1) FHWA Highway Performance Monitoring System (HPMS) volume data, 2) INRIX 15-minute annual average speed data (850,000 miles of road), 3) FHWA Freight Analysis Framework commodity value and tonnage for trucks.
Measures	Delay per auto commuter, total delay, travel time index, excess fuel per auto commuter (gallons), congestion cost per auto commuter (wasted time and fuel), truck congestion cost, truck delay, planning time index, carbon dioxide production, truck commodity value, commuter stress index, and total peak period travel time.

FHWA's *Urban Congestion Reports*	
Description	The *Urban Congestion Report* is produced quarterly to characterize emerging traffic congestion and reliability trends at the national and city level. The reports currently include 19 urban areas in the U.S.
Data	State DOT archived traffic operations data. Data for those roadways that are instrumented with traffic sensors for the purposes for real-time traffic management are included in the dataset.
Measures	Congested hours, travel time index, planning time index.

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[4] http://mobility.tamu.edu/ums, http://www.ops.fhwa.dot.gov/perf_measurement/ucr/index.htm

Table 4 includes an example of the "data" characteristic at the gold level of a future performance activity with the I-95 Corridor Coalition.

Table 4. Examples of Data at the Gold Level (Sources: I-95 Corridor Coalition Website)[5]

I-95 Corridor Coalition Future Performance Activities	
Description	One example that incorporates some aspects of this level is the planned performance measurement activities of the I-95 Corridor Coalition. The Coalition's website discusses the ongoing development of *"a corridor-wide, web-based visual analytics monitoring system for identifying major bottlenecks, reporting travel time reliability and displaying other congestion measures using private-sector vehicle probe data fused with agency incident/event data where available. This system demonstrates how states can create a congestion monitoring program using a variety of data sources."* The system will allow the users to view both real-time and historical performance at various zoom levels
Data	Real-time INRIX speed data and agency incident/event data (where available)
Measures	Travel time index, travel time reliability, hours of congestion per mile and buffer index

OPMCMM Characteristic: Facility and Trip Coverage – Silver Level

Table 5 includes an example of the facility and trip coverage characteristic at the silver level including TxDOT's 100 Most Congested Roadways List*.*

Table 5. Examples of Facility and Trip Coverage at the Silver Level (Sources: TxDOT's 100 Most Congested Roadways List)[6]

TxDOT's 100 Most Congested Roadways List	
Description	Since 2009, Texas DOT has sponsored TTI to produce a list of the most congested roadway sections in the state on the TxDOT website. The two agencies have developed an approach that combines annual speed archive data from private companies with basic roadway geometry, and traffic counts published in the TxDOT statewide roadway inventory file (RHiNo) to calculate congestion-related performance measures. The list is used for Texas DOT to program dollars to address the worst traffic locations across the State.
Data	Annual average traffic speeds from private-sector company and basic geometry and traffic volume from TxDOT roadway inventory.
Measures	Annual hours of delay per mile, annual hours of truck delay per mile, Texas congestion index (form of travel time index), planning time index, commuter stress index, annual congestion cost, and truck congestion cost.

The Indiana Mobility Report[7] and the Maryland State Highway Mobility Report[8] also represent examples of the facility and trip coverage characteristic at the silver level. Both reports use private-sector speed data to estimate mobility performance measures. Both reports include evaluations and mobility improvements due to specific projects in the state; therefore identifying the mobility benefits of specific transportation investments to further inform future decision-making.

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[5] http://www.i95coalition.org/i95/Default.aspx
[6] http://www.txdot.gov/inside-txdot/projects/100-congested-roadways.html
[7] http://docs.lib.purdue.edu/imr/4/
[8] http://www.roads.maryland.gov/OPPEN/2013_Maryland__Mobility.pdf

The *2013 Maryland State Highway Mobility Report* goes a step further by integrating the speed data with volume information to compute delay and associated wasted time and fuel costs due to congestion (using the same methodology as TTI's *Urban Mobility Report*). Maryland's Report also includes the planning time index reliability measure.

OPMCMM Characteristic: Traveler Preferences and Tradeoffs – Bronze Level

Google Maps® has a new preferences feature that allows you to make maps of places that matter to you, allows you to save places to find them quickly later, and allows you to rate places you know to discover new places you might like. This is just an example of the types of Internet tools that can provide information about the types of places people want to go and perhaps how they choose to get there. Market tools and technologies will continue to evolve that can help agencies better understand traveler preferences and where travelers really want to go.

**Paper #2: Advancing Best Practices in Performance Monitoring:
How and Where to Take the Next Steps?**

Prepared for:
Peer Exchange Workshop on the "Perfect World of Measuring Congestion"
FHWA Office of Operations

Prepared by:
Texas A&M Transportation Institute and Battelle

FINAL
December 10, 2013

1. Introduction

This is one of four papers prepared for the Peer Workshop on Operations Performance Measures to be held on December 17-18, 2013 in Washington, D.C. The objective of this paper is to describe ways in which best practices in performance monitoring (in terms of data types, coverage, measures, etc.) could be further improved in the next 5 to 10 years. This paper is intended to stimulate discussion at the December Peer Workshop and is not intended as an exhaustive treatment of this topic area. In fact, workshop participants are encouraged to add their own ways to advance best practices in performance monitoring and management.

This paper will use the same six categories as Paper #1, which are:
1. Performance measures;
2. Performance management (agency culture);
3. Data;
4. Modes;
5. Trip and facility coverage; and
6. Traveler preferences and tradeoffs.

For each of these six categories, several speculative ideas are presented for discussion that could advance best practices within that particular category.

2. Category 1: Performance Measures

This category refers to the types of performance measures, as well as the measures themselves. Also included in this section are calculation procedures and input parameters.

- **User-centric (trip-based) view of performance/congestion**: Trip-based measures have been proposed as a way to better connect with individual experiences. Many traveler information interfaces have the ability to build and customize common travel routes. So in addition to facility- and system-based measures, would a "personal congestion calculator" on public agency performance reporting sites aid in building credibility with the general commuting public? With the increasing coverage of network-wide travel times, this could be fairly easy to program. But does it help with public comprehension and understanding?

- **Standardized or consensus definition of delay**: Clearly defined user delay calculation procedures could help to ensure consistency among publicly reported performance statistics. For example, imagine the confusion that would result if each state climatology

department defined a different temperature scale. Minnesotans might define 10° F as freezing cold, whereas Floridians might define freezing cold at 50° F. Should user delay be treated as a physical property like temperature, and then targets be used to capture the desired goal or user perception? Even in our example, the only way that "freezing cold" is comparable between the two states is because of the consensus temperature measurement scale of Fahrenheit.

- **Standardizing measure calculation details**: As with clearly defining delay, it would be helpful to clearly define data processing and calculation details to ensure consistency among reported performance measures. For example, it has been shown that time mean speed calculations provide different results than space mean speed calculations. It has also been shown that "snapshot" travel times provide different results than "simulated traversal" travel times. Similarly, the calculation of reliability measures uses percentiles from a travel time distribution—but what range of dates and times should be included in the distribution?

- **Market segmentation/differentiation of value of user delay**: All transportation system user delay does not have the same value. Given that delay has been proposed as one of the measures for MAP-21 performance reporting, it would be helpful to have a better, more current understanding of how transportation system users value delay. Commuter and freight/truck delay costs are the most common differentiation. However, these are very broad categories that contain a very wide variety of users with even wider value judgments of delay. For example, some motorists view their morning commute as "wake up" time or their evening commute as "wind-down" time. With high-speed Internet connectivity, some transit riders extend their work hours into their commuting time, or extend their personal time (e.g., pleasure reading) into their commuting time. Even within the freight category, it has been hypothesized that delay may not have nearly as much value as travel time reliability.

3. Category 2: Performance Management (Agency Culture)

This category refers to the agency implementation of performance measures, and how deeply integrated performance measures are in agency decision-making and other agency processes.

- **Professional capacity for data analytics**: Big Data analytics is becoming more common in many different areas; transportation is no exception. Recent advances have got us squarely into the "big data" era in terms of the amount of data generated. However, some transportation departments lag behind in their ability to store, manipulate, process, and report on these Big Data sets for performance reporting. General "data analytics" training courses are available regardless of specific data application (e.g., through organizations like The Data Warehouse Institute). Ideally, however, a few training courses could be developed and delivered for transportation performance measure-specific data analytics.

- **Recognition of performance goals and targets**: Performance goals and targets are understood and embraced by all employees. The performance goals are not something that is only published in an annual report or website, but something that permeates the culture and day-to-day decisions of the agency.

- **Individual or workgroup incentives for meeting targets**: Meeting or exceeding performance targets could be incentivized (through bonuses, awards, etc.) at the employee, workgroup, or department level. Meeting performance targets could be prioritized more highly than adherence to a static, non-creative process.

- **Culture of evaluation**: Agencies should regularly conduct "before-after" evaluations that quantify the impacts of capital or operational improvements. These evaluation results should be incorporated into a feedback loop that better informs the policy, planning and programming process. This is the subject of Paper #3 in this series (titled "Connecting the Dots").

4. Category 3: Data

This category refers to data that is required for calculating performance measures or putting performance measures in the correct context.

- **Better system-wide data on flows and throughput**: Based on private sector advancements in recent years, system-wide travel times and speeds are now available. Similar advancements are needed in flow data (i.e., traffic counts by vehicle class). Many public agencies have fixed-point sensors that monitor the most congested freeways, but less commonly on rural or free-flowing highways and arterial streets. Additionally, where fixed-point sensors are installed, inadequate maintenance sometimes limits data availability. It may be that flow sensors for performance monitoring may only be needed between major interchanges or cross streets, a spacing that is wider than most current operations-based installations.

- **Readily available data on management actions**: Historic/analytic data should be available for all transportation infrastructure management and control strategies. For example, all displayed signal phasing, ramp meter sequences, dynamic lane assignments, managed lane prices, traveler information, highway condition and road closure information, ozone alerts, etc. This "strategy parameters" data could be used to evaluate and calibrate management strategies.

- **Readily available data on external variables and influences**: There are many influences on transportation demand outside of what many agencies currently consider (the subject of Paper #4 in this series). Ideally, these external variables and influences are identified and somehow incorporated into performance monitoring and target setting processes.

5. Categories 4 and 5: Mode, Trip, and Facility Coverage

This category refers to the mode, trip, and facility coverage characteristics of performance measures and the supporting data. Many of the advancements in this category relate to gathering better individualized but anonymous data about person trips. With individualized but anonymous data, one can see an individual trip trace or origin-destination, but has no idea who made that trip.

- **Trip patterns**: Trip-based measures are sometimes seen as more customer-centric than facility-based measures. Both are needed, but being able to identify actual trips, trip patterns, and trip experience would provide a better understanding of system performance. Actual trips may only be known about a select subset of all travelers who choose to opt in.

- **Habitual trip patterns**: There is benefit to understanding habitual trip patterns for unique but anonymous travelers or goods. For example, for those travelers who choose to opt in, demographic and socioeconomic information could be known. For goods movement shippers who decide to opt in, basic commodity information could be known. However, "opt

in" processes could create sample bias that must be addressed in experimental design or data analysis.

- **Deviations from habitual trip patterns**: Once habitual trip patterns are known for a selected subset of travelers and/or goods, then deviations from habitual patterns can be identified, as well as causes for these deviations. For example, did a phone call or text message from a family member trigger the deviation (e.g., run errand on way home from work)? Did a traveler information alert prompt a detour to a less congested route? Or was a managed/toll lane used on this commute because a mother was running late for the big soccer game on her calendar?

- **Capturing mode shifts**: To accurately capture the effects of various demand management strategies, better information is required about mode shifts. For example, did an employer-based demand management strategy actually reduce motor vehicle trips or create a shift to more other modes? To take this one step further, one could also measure the trips not taken (i.e., telecommuting, Internet shopping, etc.). This capability would require knowing habitual trip patterns, as well as planned trip patterns and preferences (i.e., does this individual usually prefer to shop brick-and-mortar or online?).

- **Going beyond door-to-door trip measurement**: In a perfect world, door-to-door trip information could be extended to an actual trip end inside a building, such as when a walking trip begins inside a large building or complex. This capability may be more prevalent in the future as mapping companies extend their reach (using WiFi signal recognition) inside buildings.

- **Inferring trip purpose**: Trip purpose is known or can be inferred with high confidence from trip ends. Associations or "friendships" between companion travelers can be determined from similar trip ends and trip traces, thereby allowing one to determine carpooling or ridesharing, as well as companion use of public transit. Capturing long-distance travel is another possibility.

6. Category 6: Traveler Preferences and Tradeoffs

This category refers to information about traveler preferences and tradeoffs that could be used to better understand trip-based information and characteristics.

- **More individualized data on travelers and their preferences**: Private sector advancements in recent years have resulted in greater availability of system-wide travel times and speeds. However, some of the "richness" of this data has been lost in its aggregation among multiple users. Knowing more detailed yet anonymous traveler preferences (and perhaps demographics) could help our understanding of trip making and how we measure its performance. Some of this information is more important for transportation demand management, but the benefits of more individualized, trip-centric data could also flow into performance monitoring. The benefits of this anonymous yet individualized information have already been recognized within USDOT's Data Capture and Management program (see Figures 1 and 2).

  It is not immediately clear how this measurement capability could be scaled to a national level to represent a significant sample of travelers. Most likely, though, it would require some type of incentive for travelers to voluntarily participate and provide their individual but

anonymous information and preferences. It could be similar to smart phone apps that are currently being used in limited research tests and pilot deployments, whereby financial incentives (e.g., coupons, free traveler info or services). Another option could be implementation within the mileage-based user fee process, whereby travelers or shippers who decide to opt in and provide certain types of individualized information receive a credit towards their mileage-based user fee.
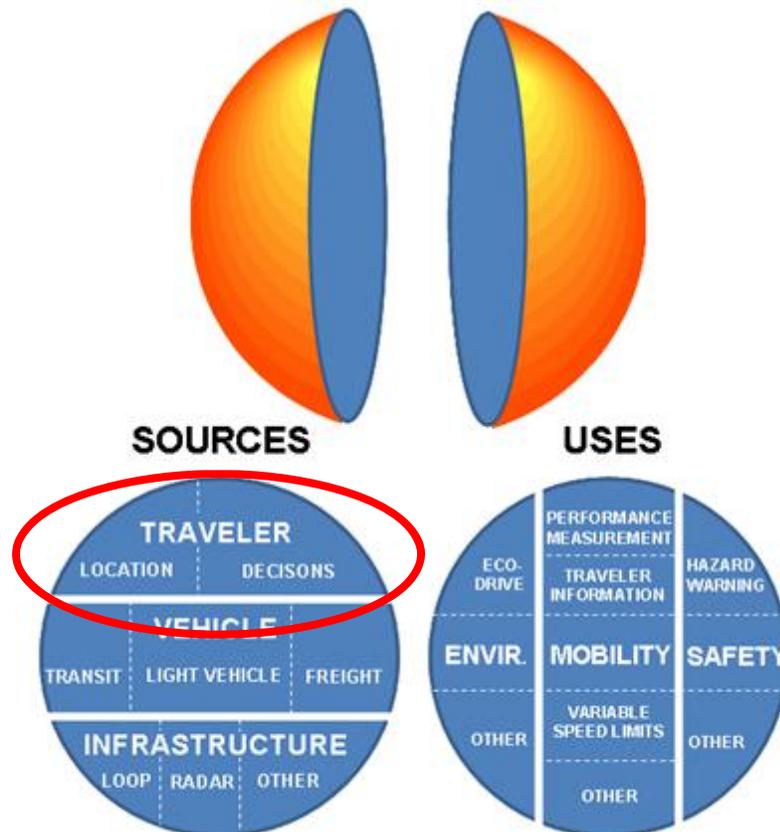
**Figure 1. Data Sources Envisioned within US DOT Data Capture and Management Program,
with Individualized Traveler Data Highlighted inside Red Ellipse**

(Source: *Real-Time Data Capture and Management Program Vision: Objectives, Core Concepts and Projected Outcomes*, April 2010,
http://www.its.dot.gov/data_capture/datacapture_management_vision1.htm)
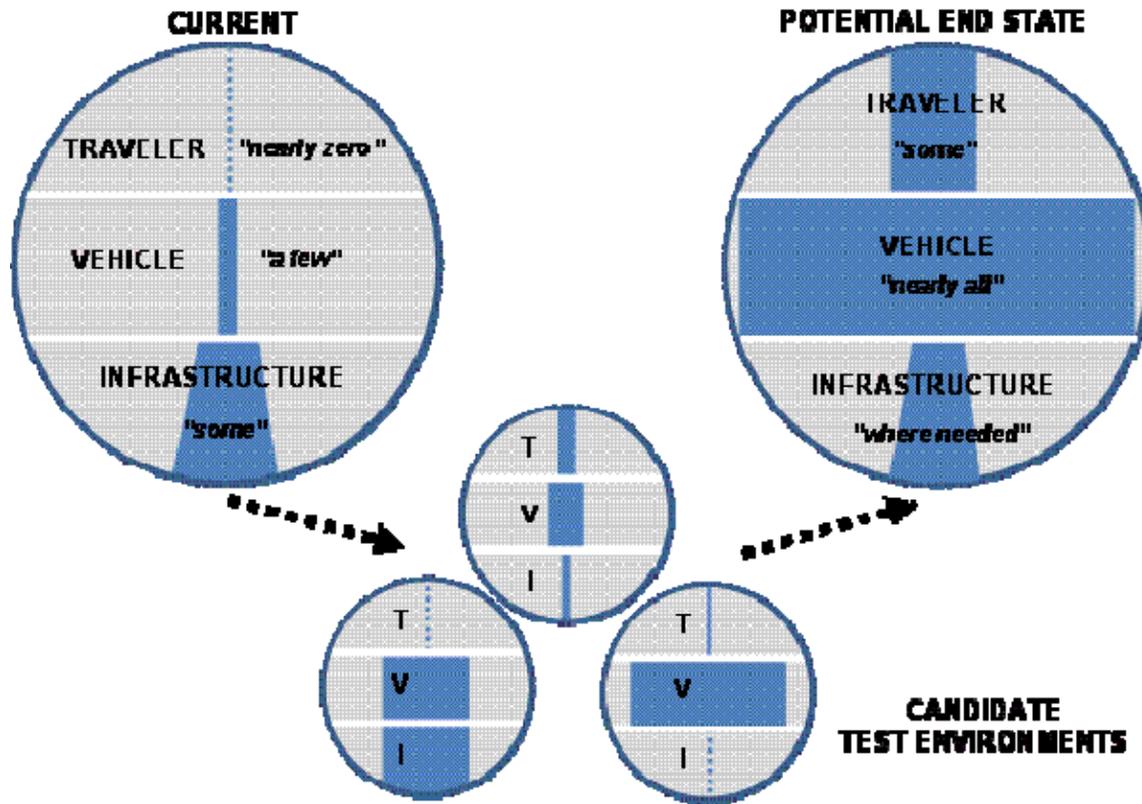
**Figure 2. Evolution of Data Environments in US DOT Data Capture and Management Program,
with Individualized Traveler Data Highlighted inside Red Ellipse**

(Source: *Real-Time Data Capture and Management Program Vision: Objectives, Core Concepts and Projected Outcomes*, April 2010,
http://www.its.dot.gov/data_capture/datacapture_management_vision1.htm)

7. Conclusions

This paper identified several different ways in which practices could be further advanced within the areas of performance measurement and management. The possibilities offered in this paper are meant to stimulate discussion at the December Peer Workshop and are not considered to be an exhaustive list. In fact, as workshop participants are skimming this paper prior to the December Workshop, it is hoped that they will add any thoughts or ideas to the margins of this paper, and bring those ideas and possibilities for discussion at the Workshop.

Paper #3: Connecting the Dots: How to Better Link Project-Level Performance Monitoring to Policy-Level Performance Management?

Prepared for:
Peer Exchange Workshop on the "Perfect World of Measuring Congestion"
FHWA Office of Operations

Prepared by:
Texas A&M Transportation Institute and Battelle

FINAL
December 10, 2013

1. Introduction

This is one of four papers prepared for the Peer Workshop on Operations Performance Measures to be held on December 17-18, 2013 in Washington, D.C. The objective of this paper is to outline the important considerations for performance monitoring and management at varying levels of detail to meet different decision-making needs. This paper is intended to stimulate discussion at the December Peer Workshop and is not intended as an exhaustive treatment of this topic area.

2. Continuum of Performance Management

Performance measures can be used in a very wide range of transportation decisions, from making real-time traffic signal adjustments at a single intersection, to making multi-billion dollar transportation investment decisions over the next 20 years in a state of 38 million people.

In some cases, performance measures are also used to determine the effectiveness of improvements (through before-and-after evaluations). For example, did the incident management program improve incident response and clearance times, and further, did it reduce congestion and improve reliability? If certain strategies are more effective than others, than those strategies are more likely to be deployed in the future.

In many cases, performance measures are used to provide situational awareness. For example, is congestion getting better or worse? Which locations have the most congestion? What are the trends over time?

In other cases, performance measures are used to guide transportation investments. For example, where are the most congested or least reliable highways, and therefore the highest return on highway investment? Performance measures can also be used for multimodal alternatives analysis and tradeoff. For example, what combination of land use policies, operations and management strategies, public transit, and highway investments will produce the most favorable performance outcome?

It is clear that performance measures are used by many different audiences for many different types of decisions (see Figures 1 and 2). There may or may not be discrete boundaries between these different types of decisions; instead, a continuum exists. In some agencies, even the lines between "operations" and "planning" become less clear.

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Figure 1. Performance Measures Provide Answers to Questions at Several Levels

Time Resolution (y-axis):
- Annual or multi-year trends
- Single or multiple months
- Specific days or times

Geographic Resolution (x-axis):
- Intersection or link
- Facility, corridor, or route
- "Systemwide" for political jurisdiction (e.g., county, metro area, state)

"Up at the 50,000 ft. level"

Typical questions here:
- Is system performance getting better or worse?
- Were statewide performance targets met?
- Are policy/programming changes required?

Typical questions here:
- Where are worst performing facilities?
- What projects (capital and operations) to fund?
- Are certain strategies delivering expected benefits?

Typical questions here:
- Did signal retiming improve performance?
- Is the ramp meter improving conditions?
- Is the managed lane increasing throughput and reliability?

"Down in the weeds"

Continuum

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Figure 2. General Characterization of Performance Reporting Parameters

"Up at the 50,000 ft. level"

Typical performance reporting parameters:
- Routine monitoring or future scenario forecasting
- High-level time and geographic resolution
- Outcome measures directly tied to agency goals

Typical performance reporting parameters:
- Usually routine monitoring
- Sometimes project-specific evaluation
- Mid-level time and geographic resolution
- Both strategy-specific measures and overall outcome measures (delay)

Typical performance reporting parameters:
- Usually project-specific before-and-after evaluation
- Sometimes routine monitoring
- Disaggregate locations and times
- Strategy-specific measures (e.g., # of failed signal cycles)

Time Resolution

Annual or multi-year trends

Single or multiple months

Specific days or times

"Down in the weeds"

Continuum

Intersection or link

Facility, corridor, or route

"Systemwide" for political jurisdiction (e.g., county, metro area, state)

Geographic Resolution

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Several questions arise when considering the use of performance measures in such a wide range of decisions:

- How varied are the performance measures used for "microscopic" vs. "macroscopic" decisions?
- If different performance measures are used at different decision levels, how can one ensure logical consistency between decisions made at "micro" and "macro" levels? In other words, do performance measures at the "micro" level "tell a different story" than performance measures at the "macro" level?
- If the same or very similar performance measures are used throughout the different levels, can the same or very similar datasets be used for performance-based decisions at these different levels?
- Is it necessary to measure performance at all these different levels? Can we just measure everything at the "micro" level?

We will explore these questions and other issues in more detail at the Peer Workshop in mid-December. Workshop participants are encouraged to share their perspectives and experiences with performance-based decisions at their respective agencies.

3. Illustrative Example

Specific examples are usually best to help illustrate key concepts. This section includes two examples[1] that illustrate different ends of the spectrum in regards to performance measurement:
1. A project-specific performance evaluation of I-465 in Indianapolis, Indiana.
2. A statewide ranking of annual performance trends in Indiana.

The first example illustrates the congestion reduction impacts of a specific transportation improvement called Accelerate I-465, a series of geometric design improvements and capacity additions along an 11-mile section of I-465. However, the more detailed nature of this performance assessment is equally applicable to before-and-after operational improvements.

Figure 3 shows a color-coded speed diagram that visually indicates the congestion at several interchanges for all months in 2011, while Figure 4 shows the same speed diagram for all months in 2012. The congestion improvement from 2011 to 2012 is readily apparent, as the 2012 diagram has fewer yellow blocks (indicating speeds of 45 to 54 mph) and more green blocks (indicating speeds of 55 to 64 mph). The congestion improvements are also quantified in terms of several quantitative performance measures; however, these "qualitative" illustrations (i.e., speed diagrams) are a helpful visual aid that provides time- and location-specific detail.

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[1] Both examples and all associated graphics are from the *2012 Indiana Mobility Report*, available at http://docs.lib.purdue.edu/imr/.

Figure 3. 2011 Speed Diagram for I-465 (During Construction)

Source: *2012 Indiana Mobility Report*, http://docs.lib.purdue.edu/imr/.

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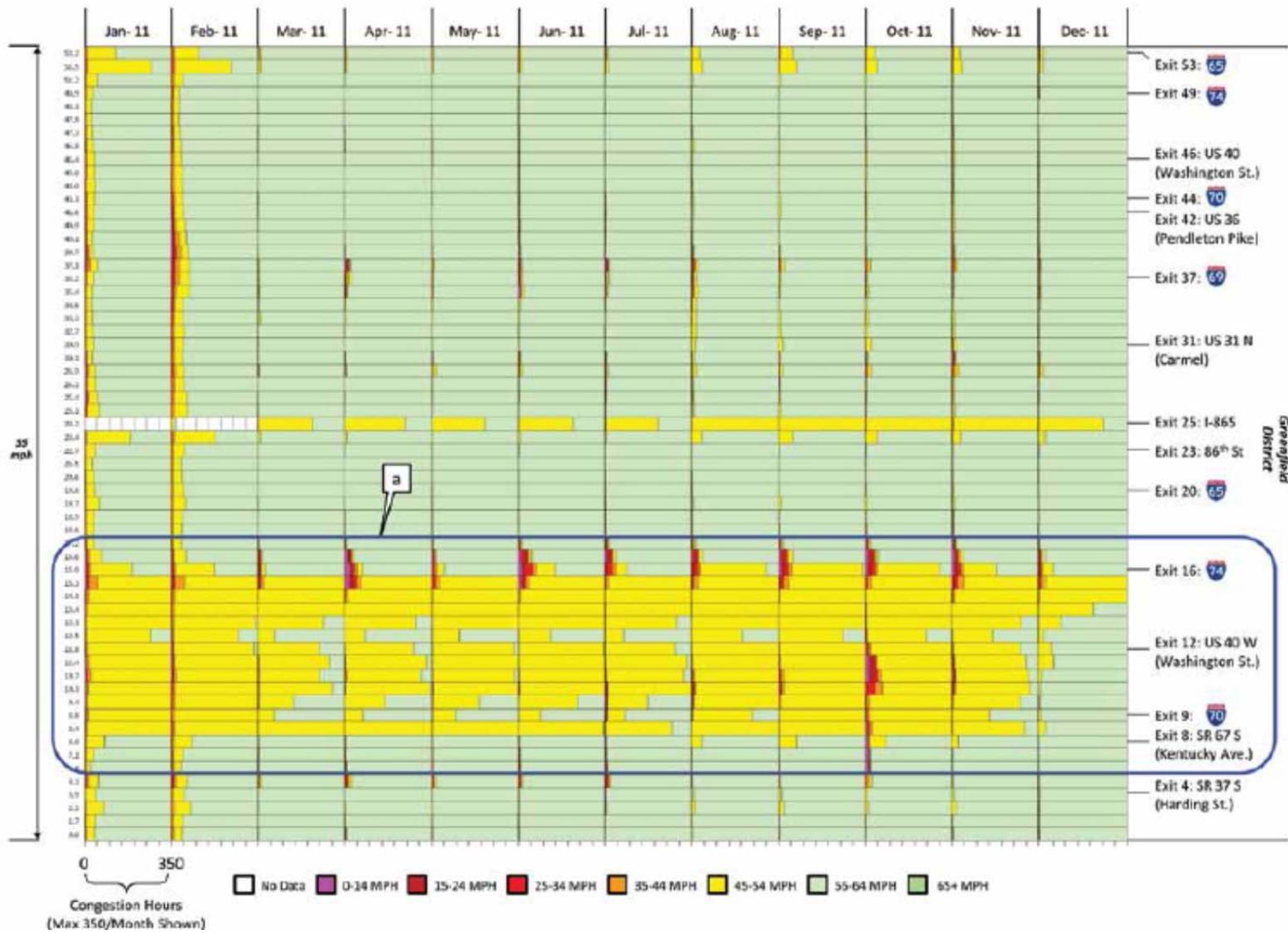
Figure 4. 2012 Speed Diagram for I-465 (After Construction)

Source: *2012 Indiana Mobility Report*, http://docs.lib.purdue.edu/imr/.

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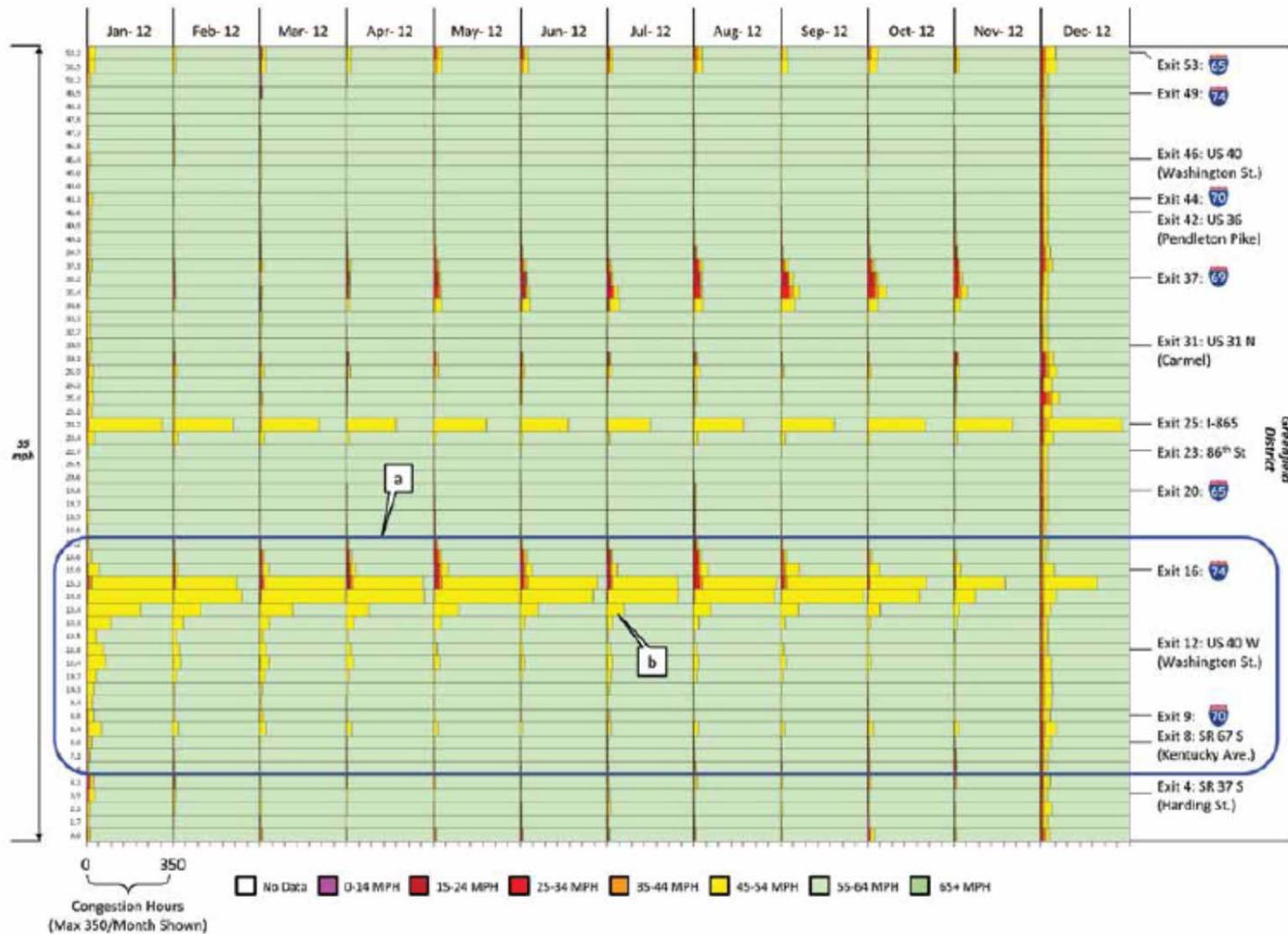
Figure 5 illustrates the second example, which provides a statewide perspective on the most improved Interstate segments based on 2011-2012 changes in the travel time deficit. The section of I-465 that showed the significant improvement in Figures 3 and 4 is ranked as #16 in the Top 20 Most Improved segments across Indiana's monitored roadway system.

Figure 5. Top 20 Most Improved Performance (Based on Change in Travel Time Deficit, 2011-2012)

RANK	INTERSTATE	LENGTH (miles)	SEGMENTS (mile markers)	2011 TTD (hours)	2012 TTD (hours)	Difference (2011-2012)
1	I-94 E	1.80	6.9 to 8.7	153.6	11.8	141.8
2	I-70 W	4.04	72.4 to 68.4	118.8	1.9	116.9
3	I-70 W	4.55	65.5 to 60.5	143.4	39.0	104.4
4	I-94 E	0.74	8.7 to 9.5	108.1	8.4	99.7
5	I-65 N	9.14	205.3 to 214.4	66.3	2.5	63.8
6	I-70 E	2.93	3.8 to 6.7	67.3	10.3	57.0
7	I-70 E	4.45	60.5 to 65.5	79.2	25.5	53.6
8	I-70 E	7.09	115.4 to 122.5	50.6	2.1	48.5
9	I-70 E	2.32	0.9 to 3.2	56.7	8.4	48.3
10	I-69 N	9.96	316.0 to 326.0	57.3	10.9	46.4
11	I-94 E	0.73	9.8 to 10.5	54.6	9.4	45.2
12	I-70 W	4.60	95.5 to 91.0	58.6	14.4	44.2
13	I-65 S	9.20	214.7 to 205.5	49.5	6.7	42.9
14	I-69 N	4.58	205.4 to 210.0	53.0	11.9	41.1
15	I-65 S	1.78	5.3 to 3.6	77.5	37.2	40.4
16	I-465 IL	1.30	13.9 to 15.2	59.7	22.3	37.4
17	I-65 S	14.28	229.6 to 215.3	64.3	27.8	36.4
18	I-94 E	0.28	9.5 to 9.8	40.6	4.5	36.0
19	I-65 S	0.42	2.2 to 1.7	85.9	50.4	35.5
20	I-65 S	0.44	1.7 to 1.3	111.6	77.2	34.3

Source: *2012 Indiana Mobility Report*, http://docs.lib.purdue.edu/imr/.

Figure 6 provides a systemwide context for specific improvements along I-465. The leftmost chart shows distance-weighted congestion hours, and the I-465 congestion quantities are shown as the dark and light purple slivers (a small proportion of the overall congestion). Similarly, the rightmost chart shows total travel time deficit, and the I-465 congestion quantities are shown in dark and light purple. Figure 6 appears to be an effective way to "connect the dots" and make the link between project-specific benefits and system-wide performance.

Figure 6. Specific Facility Improvements Shown in Statewide Context

Source: *2012 Indiana Mobility Report*, http://docs.lib.purdue.edu/imr/.

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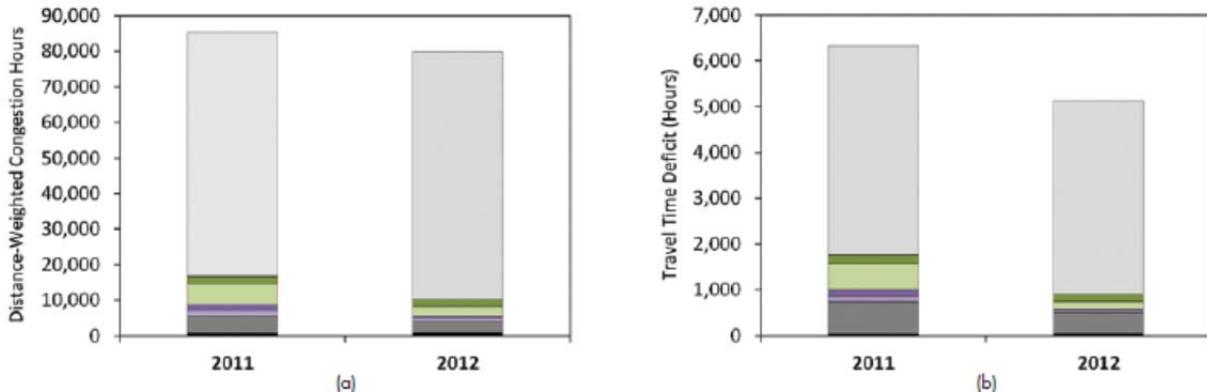
4. Findings and Conclusions

The previous section showed two illustrative examples of performance measurement that were at different ends of the spectrum in regards to level of detail. Figures 3 and 4 visually illustrated time- and location-specific congestion reduction impacts of a specific project on I-465. Figures 5 and 6 provided a "big picture" view of system (i.e., statewide) performance, and showed the I-465 project in this system-wide context.

Figure 6 is a general characterization of performance reporting parameters. Only three levels are shown in this graphic for the sake of clarity. In practice, however, there is a continuum of level of detail and information requirements, and these may vary between different agencies depending upon its decision-making process.

There are several other performance reporting efforts in the U.S. in which one could find similar examples that span a range of detail, from specific facilities/projects to system-wide. The best practices appear to have these characteristics:

- **Project-specific examples** that clearly show the benefits of specific transportation improvements in easily-understood terms. These examples may be qualitative (e.g., visual) and/or quantitative. These project-specific examples are more detailed and are likely to help decision-makers relate to real-world examples. However, project-specific examples don't provide the "big picture" in terms of overall system performance.

- **System-wide statistics** are necessary to show the "big picture" view for higher-level decision-makers. System-wide trends over multiple years are also desirable, even if all of the change may not be fully attributable to specific transportation improvements. However, system-wide reporting is not ideal for showing specific problem areas or specific causes.

- **Showing specific improvements in the context of overall system changes** (as shown in Figure 6) is important to logically connect specific projects to the overall system performance. By providing this context, decision-makers can see what impact specific projects have on the overall problem.

- **Using the same or logically similar performance measures at different levels of detail** helps provide continuity and consistency between specific project impacts and overall system performance. For example, Figures 3 and 4 used speeds as a performance measure, while Figures 5 and 6 used travel time deficit. In this case, speeds and travel times are logically similar and provide continuity between different levels of reporting.

- Ideally, one could **use the same data for performance reporting at all levels of detail**, from project specific to system-wide. Due to current limitations in data, this may not always be feasible in current practice.

- **Aggregate, system-wide reporting is more likely to be influenced by external variables** (the subject of another white paper for this workshop) outside of public agency control. Conversely, project-specific evaluations are more likely to control for these external variables to isolate the impacts of the investment or strategy.

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Performance Monitoring to Policy-Level Performance Management?

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Paper #4: Operations Performance Management: How Should External Events and Trends be Considered?

Prepared for:
Peer Exchange Workshop on the "Perfect World of Measuring Congestion"
FHWA Office of Operations

Prepared by:
Texas A&M Transportation Institute and Battelle

FINAL
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1. Introduction

There are many independent variables (or external factors) for which state DOTs, metropolitan planning organizations and USDOT have little control over. These variables may affect performance measures or trends. Therefore, when using performance measures for reporting and/or decision-making, these variables must either be incorporated or their impact recognized in the performance of the transportation system and in the results of project evaluations.

For many of these variables, the relative change may be more important than the actual value. For example, in an operations context, it may be more important to the evaluators to know the change in employment in a region and how that might have affected operations rather than knowing the base year number of workers. Adjustments in calculation procedures or communication can be made to incorporate some of these factors, but others can only be recognized and their possible effect communicated.

This paper identifies the key external influences that may lead to fluctuations in performance measure values. It also includes proposed adjustments to alleviate these fluctuations. These variables will be discussed in more detail at the workshop. When developing the proposed adjustments, the following elements were considered: Can we generally accommodate the variable? Can we connect it to congestion and reliability measures? Can we use the information to explain why the measure is changing? Can we use the measures to make investments, policy changes or practice adjustments that will reduce congestion? What needs to happen to achieve this level of analysis?

This paper is designed to help achieve the following two workshop objectives:
- Design of a "platinum standard" monitoring program; and
- Development of a practical FHWA research roadmap by the end of the workshop.

In the text below, a recommendation accompanies each variable to describe how the phenomenon or issue should be accommodated.
- Explanatory information – describes a variable that has an effect on transportation system performance, but cannot be included in the analytical construct of the measure.
- Modifying factors – includes variables that can be accommodated with a change in the measure or the calculation procedures

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2. The Big Picture Variables

The independent variables included in this document may have an effect on performance measures. Specifically, the variables may impact the changes in performance measurement values between reporting periods. While these variables may not be reported in every case, they should be in the menu of questions that are asked. There may also be some contexts where the variables are more important: regional vs. corridor analyses, monthly vs. annual summaries, operating decisions vs. summary reports.

- **Economy** –The 2008 recession once again illustrated the important role that non-transportation actions or occurrences play in congestion levels. Local recessions have caused drops in the congestion level in the past – see the big California cities in 2000 with the dot.com bubble burst. Measures such as those below can be included as a regular component of operations reports to explain the role of changes in the economy – both good and bad:

    o Gross metropolitan product – the local version of gross domestic product
    o Total salary and wages – essentially the job-related portion of GMP
    o Employment - number of jobs
    o Unemployment rate
    o Population
    o Gas and diesel fuel prices

    ➤ **Recommendation**: Include an economy measure as an overarching system explanation unless there is significant sub-regional variation in employment changes (e.g., large assembly plant or corporation ceases operations).

- **Societal** – Decisions made to improve the quality of life or enhance economic opportunity often have an effect on system operations. These may be regional, corridor or neighborhood level changes and may be accompanied by changes in operation. As operating policies, practices and technologies are deployed, it is also important to capture other 'outside the right-of-way' events or phenomena that affect operations. This need not be a comprehensive investigation of the urban condition, and it may be reported only occasionally or displayed as an appendix/additional information element; some examples include the following.

    o **Development Patterns** – Density, magnitude and mix of land uses would be typical descriptors. Part of most long range metro plans is to concentrate more population and jobs into dense neighborhoods and centers and to move more people by transit and carpools. These changes are typically estimated to support more economic development and person travel for a given level of congestion. Vehicle ownership rates and vehicle use might be very useful to explain what is causing changes in several types of performance measures.
    o **Housing Cost** – Separate from, but related to, development patterns is the issue of housing cost. This could be ownership or rental cost – the key element is to capture the changes in cost that might tend to shift commuting and other travel patterns.
    o **School Quality** – Changes in school quality may cause changes in residential and job patterns that might result in vehicle travel changes. Much of the effect of this variable might be illustrated by changes in vehicle-miles of travel (see below) but the causation might be important. Suburban real estate agents reportedly (*1*)

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identify school quality as a cause of home purchases, explaining some of the 'suburban sprawl' that occurs despite long and unreliable commute times.

- o **Generational Differences in Travel** – Travel data from the first decade of the 21st Century appear to indicate changes in the travel patterns of the younger end of the workforce. While some of this change is related to differences in employment numbers and rates, there also appears to be increased use of electronic means (such as telework or teleshop) for making trips and greater use of shared ride services among younger travelers. Additional descriptive information and alterations to trend calculation methods may be required if the 'millennial travel shift' is an enduring part of transportation.
- o **Connected Travel** – In placing a value on extra travel time due to congestion or unreliability, the role of travelers being wirelessly connected should be considered. The value adjustment(s) may be addressed in other research, but the penalty to a traveler, especially one on public transit or in a shared-ride, may not be as significant as in the past. The fact that travelers can work during this time may allow them to accept worse travel conditions, with no decrease in quality of life or economic condition.

➢ **Recommendation:** Examine the potential role of these variables annually and include an explanation of the possible role in changing congestion or reliability levels and in altering the trends or values of the key performance measures.

3. Specific Variables

These variables might have a direct effect on the travel speed dataset. An operator typically has relatively little ability to affect these but performance measures can be significantly affected by them.

- **Changes in Travel Demand** – More or fewer travelers and/or vehicles can alter the context of several measures. In addition to the broad measure of total travel, the following sources might also be considered to better understand the effect that changes in vehicle-miles or person-miles of travel may have on congestion and reliability:

  - o Latent demand is an associated issue; operations treatments can improve travel conditions and draw traffic volume from other routes, causing the improvement to appear to be less significant than if demand were constant.
  - o Effect of TDM programs which may change the vehicle volume, trip departure times or travel route; or trips that were not made due to electronic substitution
  - o Mode Share – If an agency is trying to get transit-oriented development and mode shift, mode share should be measured.

  ➢ **Recommendation:** Examine the primary route and any routes that might be affected – typically parallel routes but if signal timing will be revised, significant crossing roadways should also be examined.

- **Person volume** – If a particular approach or strategy will cause shifts to buses and carpools, person volume should be accommodated in the measure.

  ➢ **Recommendation:** Include an estimate of person volume in all reports; collect data on person-volume to support estimates when usage changes (e.g., high-occupancy vehicle lanes).

- **Parallel routes** – Major streets or other freeways should be included in the analysis if they will be substantially affected by an improvement. If the effect is not substantial they should be included in an explanation.

  - ➤ **Recommendation:** Examine congestion and reliability of any routes that might be affected by a corridor improvement.

- **Weather, Incidents and Road Work** - The location and timing of events that affect system performance (including incident clearance data) should be linked with congestion data to improve performance management. The base case should include descriptive information as explanatory variables.

  - ➤ **Recommendation:** Initially, include explanatory variables of these events in any report -- this may be as simple as number of rain days or incidents. As the datasets for these elements are integrated, there may be an ability to parse the sources of congestion using a set of allocation rules.

- **Connected vehicles or autonomous vehicles** – At some point these will begin to affect operating performance of the system and therefore the measures and the data.

  - ➤ **Recommendation:** Develop a description of the presence of infrastructure and vehicle attributes to characterize the reason for changes in operations performance measures.

- **Modal Accessibility** – The ease of use of transit, walking and bike modes is an important aspect of describing the role of single occupancy vehicle (SOV) alternatives. Ease of transit use, etc.

  - ➤ **Recommendation:** An explanatory measure such as number or percent of urban residents with access to a nearby transit stop may be a useful initial measure. Other elements such as sidewalks, bike lanes and paths, bikeshare, car sharing should also be described if they begin to play significant role in the region or corridor.

4. Aggregation Level

The more disaggregate the measures are, the more likely they are to capture effects of improvements. But they cannot be too disaggregate or too narrow or the "spillover effects" may be missed. For example, freeway improvements could improve freeway speeds and throughput, which could draw traffic from a parallel arterial, thereby also improving the arterial operations.

- ➤ **Recommendation:** There are a number of guidance documents that can aid performance measurement professionals in developing a consistent dataset. The specific actions depend on the uses for the measures and users should expect that some changes will be necessary as measurement, management and investment decisions evolve.

5. Customer Expectations and Target Setting

Comparisons of urban, suburban and rural congestion are often a part of regional congestion discussions. At the statewide level, similar comparisons are made between large and small urban area congestion levels.   These often are generated by differences in expectations and, to

date, all the technical 'solutions' have been found wanting in the public discussion of how the comparisons should be reflected in project or program investments.

> **Recommendation:** The use of the data and measures will be key in the decision about this element. At a broad regional scale, the long range planning process should be used to investigate public opinion on expectations; the level of 'unacceptable congestion' can be used to develop performance measure targets. For system reporting – such as a freeway operations report, a good first step may be choose some target level (for example, the speed at which the maximum volume occurs) and explain the use of that target. It appears that a map of acceptable congestion levels will be needed to identify where system improvements are needed, and where the community has decided to not aggressively attack congestion in lieu of other attributes.

REFERENCES

(1) *Nonlinear Effects of School Quality on House Prices.* Abbigail J. Chiodo, Rubén Hernández-Murillo, and Michael T. Owyang. Federal Reserve Bank of St. Louis Review, May/June 2010, 92(3), pp. 185-204.