Performance Measures for Evaluating Multi-State Freight Projects

Lead Author: Jason Bittner, CFIRE, University of Wisconsin
Additional Authors:

Robert Gollnik
Ernie Wittwer
Teresa Adams

Performance measures for the movement of freight have been discussed in many forums. Travel speed and dependability are two commonly discussed measures of the performance of the freight moving transportation system. Safety, as expressed by crash numbers or rates or fatality numbers or rates, is also frequently suggested. Such measures are useful in looking at the performance of a transportation system. They can also increase our understanding of the impact of an infrastructure improvement on freight productivity. At a time when transportation officials are increasingly being asked to understand the regional nature of freight-related transportation facilities and projects, are these the most appropriate measures? If so, how can they be used to understand how the benefits of an improvement to the system will be distributed to states, or other political jurisdictions, beyond the one that hosts the improvement?

These are the questions that researchers attempted to answer in this research. Investments in the built environment have only rarely been analyzed for their effect on economic development and increased movements for freight. In many cases, the link between system improvements and system performance is anecdotal at best. Using the CREATE project in Chicago as a test case, an effort was made to understand the measurable benefits projected to occur with the completion of the project. Improved travel time and reliability and safety enhancements are three primary benefits documented by the project sponsors. While a significant portion of those benefits will accrue to the Chicago metropolitan area and the state of Illinois, a large share will be enjoyed by the businesses located in surrounding states that use the highway and rail systems that converge on Chicago.

Based on previous reports, researchers assembled a table of commonly used transportation performance measures and assembled data within these categories for each of the ten Mid-American Freight Coalition States. A focus was placed on using data that is publicly and/or widely available. The research effort found many gaps in the available data and in the analytic procedures used to develop the project if the benefits are theoretically allocated to adjoining states. The research team makes an assignment of benefits using available data. It also notes key assumptions that must be made in producing these assignments and suggests steps that might be taken to improve the data and make the assumptions more reliable.

The poster presentation will detail the processes used by the research team, the outcomes to date, and the future opportunities for the project. It will also highlight relatively recent results from an April 2011 workshop among the 10 state DOTs that make up the Mid-America Freight Coalition.
The Economics of Return on Investment: Evaluating the Life Cycle to Drive Performance

Lead Author: Nathaniel Coley, Federal Highway Administration
Additional Authors:

Public and private organizations have advised of the level of investment required to maintain and restore the transportation system in the United States to a safe and economically competitive level. There has also been a common reality of limited budgets for addressing transportation needs. This paper presents a practical approach to managing transportation assets through return on investment analysis. The approach uses established software tools and existing data sources to estimate expected network performance trends. Project level investment candidates are then identified to address those trends. Economic analysis processes such as benefit-cost analysis and life-cycle cost analysis are used to determine the mix of actions that would maximize the returns from available budgets.
Aggregated Performance Measures for Interdependent Assets

Lead Author: Mohammadsaied Dehghanisanij, Virginia Tech
Additional Authors:
Jack Verhoeven, Gerardo Flintsch

We evaluated the strengths and weaknesses of different approaches such as index approach where component or alternative system data is aggregated into a single measure. We also studied the method of unique but possibly correlated measures for components (assets) of an infrastructure system. In doing so, we developed a generalized framework which determines the integrated performance measure for the system which consists of components that are working together and provide service as an infrastructure.

We used the framework in a simplified case study to measure the performance of a highway corridor, I-81. The assets evaluated in this case study were only pavements and bridges. The performance indicators evaluated were associated with functional and structural condition of the highway. The data and information were collected from VDOT. We show how our framework provides integrated performance measures for the corridor in a more enhance way compared to index approach. We also emphasize that the model has the capacity to be generalized to other infrastructure systems and to incorporated more assets.
Developing and Applying Fluidity Performance Indicators in Canada to Evaluate Freight System Efficiency

Lead Author: William Eisele, Texas Transportation Institute
Additional Authors:

Louis-Paul Tardif, Director, Transport Canada
Juan C. Villa, Program Manager, Texas Transportation Institute
David L. Schrank, Research Scientist, Texas Transportation Institute

As part of Transport Canada’s Gateways and Trade Corridors Initiative, the Directorate of Economic Analysis was interested in developing freight performance measurements for goods using Canada’s international gateways and traveling along its freight transportation corridors. These performance indicators—termed “fluidity” measures—will assist Transport Canada in painting a clear picture of system efficiency for their freight significant corridors. The indicators will ultimately aid Transport Canada in identifying to what extent the Government of Canada’s policies and investment in infrastructure are being leveraged and operated to support trade and economic prosperity.

Transport Canada contracted with the Texas Transportation Institute (TTI) to develop and apply the indicators for measuring freight system performance. Researchers created two “fluidity indicators” using an index-approach. One indicator captures average conditions (Fluidity Index, FI), while the other indicator captures daily variation in travel time (Planning Time Index, PTI). Because freight moves according to both travel time and delivery requirement schedules, and because travel time varies according to mode, the performance measures use a normalizing concept to allow comparisons within a mode and across an entire supply chain. Researchers used both truck global positioning system (GPS) data and truck dispatch data from shipping manifests to estimate the measures.

Researchers developed and applied both of the measures. Researchers performed two applications of the measures—one demonstrating how the fluidity measures are computed and presented using shipping manifests. This application indicated the importance of computing the performance measures for each trip urgency group (i.e., “fast drivers,” “medium drivers,” “slow drivers”).

In the second application, researchers demonstrated the use of the fluidity measures for monitoring freight system performance for an international and multimodal corridor from Shanghai, China to Toronto, Ontario, Canada. In this example, the multi-modal trip included the following transport elements:

- Ocean Travel Time,
- Port Dwell Time,
- Port Drayage Time,
- Rail Dwell Time awaiting Departure,
- Rail Travel Time,
- Rail Dwell Time upon Arrival,
- Rail Drayage Time to a Distribution Center,
• Truck Travel Time, and
• Truck Dwell Time upon Arrival.

Individual trip FI and PTI values were weighted based on their contribution to the entire supply chain to calculate a representative “weighted” overall FI and PTI for the entire supply chain. Researchers used TEU-hours, where TEUs are twenty-foot equivalent units, to weight the individual trip indexes. Researchers demonstrate how the FI and PTI can provide supply chain performance information by mode and include a method to create annual measures by weighting monthly values by cargo amounts.
Tools and Methods

Lead Author: Jamie Fischer, Georgia Institute of Technology
Additional Authors:

Adjo Amekudzi, Ph.D.
Michael Meyer, Ph.D., P.E.
Amy Ingles

The field of performance management in transportation is rapidly evolving and many-faceted. Guidance, case studies and tools representing the state of the field in performance measurement, targets setting and performance management are abundant, but also spread out across a wide range of literature. This presentation gives an overview of the Performance Management Resource Catalog (“the Catalog”), which is being developed to provide easier access to existing performance management resources. The Catalog is being developed by the Georgia Institute of Technology as part of a project on best practices in performance management sponsored by the Georgia Department of Transportation.

Thematic Sections:

The Performance Management Resource Catalog compiles and categorizes various resources on performance management into a collection of seven color-coded sections, each grouping and tabulating resources according to a common theme of performance management. Each section further categorizes resources by topic within its theme, and provides separate sections for (i) guidance, (ii) case studies, and (iii) tools according to topic. The seven thematic sections are as follows:

(1) Strategic Planning (Yellow)
Strong performance management programs are linked to strong strategic plans. Specifically, performance measures and targets are the tools with which an agency can track progress toward its strategic goals and objectives. This section lists resources for creating focused strategic plans. Its topics include definitions for performance-based planning, visioning, and how to set goals and objectives.

(2) Performance Measures (Orange)
Appropriate performance measurement will help an agency focus its data collection efforts on collecting the information that is most relevant to tracking progress toward strategic goals. This section table lists resources for the design of simple, measurable, and actionable performance measures. The topics of this section include how to select and organize measures step by step; specific measure formulations for outputs such as infrastructure condition and system efficiency, and outcomes such as accessibility, and environmental, economic and community impacts; and how to deal with “attribution issues,” that is the question of how much of a measured outcome can be attributed to agency actions. This is the largest section of the Catalog.

(3) Performance Targets (Red)
Performance targets provide short-term mile-markers along the road to achieving strategic goals. This section lists resources for setting targets that are both achievable and ambitious, thus helping an agency to make visible progress within a constrained budget.

(4) Funds Allocation and Programming (Green)
Performance-based resource allocation makes targets achievable; it lends consistency and accountability to agency processes. This section lists resources to help an agency make efficient use of a constrained budget. Topics include innovative funding sources and how to set priorities for project selection.

(5) Organizational Structure (Light Blue)
The success and longevity of a performance management program depends on an organizational context that supports and sustains it. This section provides resources for creating such a context, dealing with topics of both intra-agency structure and inter-organizational cooperation.

(6) Data (Dark Blue)
High quality performance measures can only be effective with high quality data. This section provides resources for developing robust data collection, analysis and management processes. Topics include how to structure data collection responsibilities, what types of data are needed for different types of measures, and how to link condition data to performance information.

(7) Communication with Stakeholders (Purple)
A successful performance management program will gradually increase the transparency and accountability of transportation decision making. This is accomplished primarily through the various means of communication with both internal and external stakeholders. Topics in this section include how to build relationships with legislators, how to strengthen trust with customers (system users), and how to increase employee buy-in to the performance management program.

The Performance Management Resource Catalog provides a tabulation of the various resources on transportation performance management. Each table entry provides information in four columns: (a) whether the resource offers guidance, case studies, or tools, (b) the topic within the theme, (c) the document where relevant information is found, and (d) the relevant page numbers within that document. One topic may have many relevant resources listed, in which case, the most recent resource is listed first. Also, the same resource may appear in several sections, if it is relevant to multiple topics. This method is used so that practitioners can easily search for resources by topic. Transportation agencies will be able to use the Catalog as a basis for accessing the appropriate resources as they refine their performance management programs.
Sustainable Communities: Measurement for Management

Lead Author: Frank Gallivan, *ICF International*
Additional Authors:

Jeff Ang-Olson
John Thomas

A new generation of transportation performance measures is taking root among regional and local government agencies, including MPOs, city, and county governments. This shift is driven by a broader interest in generating sustainable development outcomes. To manage growth and development sustainably, a comprehensive set of performance measures, along with a robust measurement approach, is required.

Whereas the previous generation of transportation performance measures was limited to traditional transportation objectives, including maximizing throughput and minimizing delay, the new generation is far broader. It includes measures related to environmental preservation (such as greenhouse gas emissions and land consumption), quality of life (such as bicycle and pedestrian level of service and location efficiency), and multi-modal access (such as access to employment and access to transit). The importance of sustainability in transportation decision making is highlighted by the HUD-DOT-EPA Interagency Partnership for Sustainability Communities. On June 16, 2009, EPA joined HUD and DOT in this partnership with a goal to improve access to affordable housing, provide more transportation options, and lower transportation costs while protecting the environment in communities nationwide. Subsequently, the Partnership announced the availability of $100 million in grant funding for regional integrated planning exercises. Grant recipients will be expected to adhere to the livability principles developed by the Partnership.

This poster provides an overview of four broad types of sustainable performance measures that support the objectives of the Interagency Partnership. Each measure can be represented in a variety of metrics. Some measures are appropriate for MPOs to use in designing and selecting long range transportation plan alternatives. Some metrics are appropriate for individual communities wishing to measure their progress toward sustainable goals.

The four measures presented are:

- Transit Accessible Homes and Jobs
- Household Transportation Costs
- Preserving Open Space
- Promoting Alternative Modes over Single Occupancy Vehicles

For each measure the poster provides several example metrics. Data needs and measurement challenges are also discussed. Calculation requirements, including modeling tools and input data, can vary substantially from metric to metric. Policies that can affect the outcome of metrics are described. For each measure, one or more examples of an MPO that has applied the measure in the long range transportation planning process are provided.

1
Measures of Effectiveness and Collection in the Simulated IntelliDrive Environment

Lead Author: Noah Goodall, Virginia Department of Transportation
Additional Authors:
Brian L. Smith, Ramkumar Venkatanarayana, Hyungjun Park, Jay Datesh

Wireless communication between vehicles and the transportation infrastructure will provide significantly more timely and comprehensive information about arterials and their performance. However, most measures-of-effectiveness were developed based on data available from traditional “point” sensors. The information made available with vehicle-to-infrastructure wireless communication, referred to here as “connected vehicles,” requires new metrics that can fully utilize the data.

This research identifies several new arterial performance metrics made available with connected vehicles, as well as several existing metrics that can be evaluated more accurately and frequently than before. The new metrics are person-delay, sudden deceleration, change in lateral acceleration, and aggregate regulation compliance. Person-delay measures a vehicle’s lost time multiplied by the number of passengers, and allows for more efficient movement of high-occupancy vehicles and sophisticated transit signal priority. Sudden deceleration and change in lateral acceleration measure activities such as unexpected braking and swerving, which may be leading indicators of unsafe conditions. Aggregate regulation compliance detects unsafe driving behavior that is difficult to collect in the field, such as speeding and illegal U-turns.

Engineers can address problem areas through signal timing changes traffic calming, and other measures. The proposed metrics all require high-resolution detection, and are difficult or impossible to measure with existing point detection. For each new metric, its compatibility with existing standards is discussed, and required SAE J2735 DSRC Message Set Dictionary data elements are identified.
Regional Mobility Corridor Atlas

Lead Author: Mike Hoglund, Metro
Additional Authors:
Matthew Hampton and Deena Platman

The Regional Mobility Corridors Atlas was conceived as a way to visually present the integrated mobility corridor concept developed for the Portland Oregon metropolitan region. This concept emerged from the region’s latest long-range transportation plan as a new approach for advancing multimodal mobility for people and goods in the region. A mobility corridor encompasses the network of freeways, arterials, high capacity transit lines, frequent service bus routes, freight/passenger rail lines and multi-use paths and the land uses they service. The function of these corridors is to facilitate travel between different parts of the region, and in some cases, connecting the region to the rest of Oregon and beyond.

The Atlas displays current land use and multi-modal transportation data for each of the region’s 24 mobility corridors. It was designed as a tool for decision-makers and planners to easily understand existing system conditions and identify needs for different parts of the region. For each corridor, the atlas provides a general overview that includes location in the region, primary transportation facilities, land use patterns, and an assessment of gaps and deficiencies for different modes of the travel. The structure of the atlas provides for comparison of data between mobility corridors and the ability to merge multiple corridors for a broader analysis. The Atlas also serves a tool for monitoring the effectiveness of different land use and transportation strategies in achieving desired outcomes over time.

The atlas presents a series of maps for each corridor showing its geographic location, transportation facilities, land use patterns and current operational attributes. The maps are accompanied by short explanatory narratives, data tables and a “quick facts” sidebar. Atlas data was generated from Metro’s Regional Land Inventory System (RLIS), Regional Travel Forecast Model, the Oregon Department of Transportation’s (ODOT) bridge inventory and the 2035 Regional Transportation Plan. An atlas user’s guide describes each map to facilitate usability for the reader.

Completed in spring 2010, the atlas document was broadly distributed to Metro’s regional partners to aid local planning activities. Metro designed a web page for easy viewing and downloading of atlas data - www.oregonmetro.gov.
Measuring the Impact and Performance of Transport Research Programs

Lead Author: David Kuehn, FHWA
Additional Authors:
none

Effective research is critical for meeting emerging transport challenges. Research, however, is difficult to measure. There can be significant time lags between the conduct of research and the return on the investment. Further impacts can be diffuse, accruing to unexpected parties who build on the work of others.

(1) The FHWA Exploratory Advanced Research (EAR) Program has been developing a suite of measures to monitor and improve overall Program portfolio performance and predict the potential impact of research. The EAR Program uses different measurements of performance to provide a balanced scorecard for day-to-day program management and communication of results to internal and public stakeholders. This brief paper provides information on EAR Program measures and background on the search for appropriate program measurements that could suggest approaches for other transport research programs. Many examples of transportation research program measurement are limited to process management, outputs measurement, and some indirect measurement of value or impact.

(2)(3) Common measurements include projects started, projects in progress, projects completed, products developed, adherence with budget, and adherence with schedules. Similarly, University Transportation Centers report process and output measures including projects funded, reports issued, papers presented, and personnel participating in research.

(4) Looking at research measurement outside or transportation still provides limited examples of effective measurement of program impact. Federal agencies and programs have been engaging in performance measurement at least since the passage of the Government Performance and Results Act of 1993. Research, however, has been a particularly difficult area for developing performance measurements.

(5) Federal guidance allow research programs a pass on quantitative performance and suggests that expert review continues to be the most effective method for assessing research. The guidance, however, does go further suggesting programs review performance in three areas.

One is relevance to agency mission using methods such as prospective and retrospective reviews by independent experts, regular review by primary customers, published multi-year program plans (or roadmaps) with clear goals and priorities and regular updates, clear articulation of potential public benefits, and stakeholder involvement throughout process;

Two is an assessment of research quality through retrospective reviews by technical experts and indirectly through competitive, merit-base allocation of funding; and
Three is performance, which could include annual retrospective documentation (performance report), cost-benefit analysis, benchmarking, and expressing the public benefits of results.

A federal research program that included a clear measure of impacts was the National Institute of Standards and Technology (NIST) Advanced Technology Program.

(6) The program, which was designed to accelerate private sector high risk and innovative research, conducted a retrospective survey of applications over the history of the program. The survey included both applicants that received awards and those that did not to assess if awards resulted in a new direction for the company, changed the company’s estimate of risk, or resulted in economic benefit including impact on revenue and size of the market. While certainly designed to assess the impact of the program, the retrospective survey started with around 900 potential companies that have been involved with the program over the course of more than five years, an evaluation effort both in cost and time that would be difficult for many transportation research programs to replicate.

For the EAR Program development of program measurement began by scanning commonly used measurements used by other transportation agencies research programs as well as measurements used in other federal programs with a focus on engineering research (which included NIST, Department of Energy, Environmental Protection Agency, and Army Corps of Engineers). The intent of program measurement was twofold: One, for reporting program value to critical stakeholders and, two, for improving program management. Like many research programs, measurement issues for the EAR Program included finding an appropriate scale of effort and maximizing use of available data. Discussions with internal and external stakeholders lead development of baseline and target measurements from an initial set of possible measures. The EAR Program currently is refining measurements that reflect quality and availability of program data.

To report results, the EAR Program adopted a Balanced Scorecard Approach, which aligns measures under four perspectives: Financial, Customer, Internal Business Process, and Innovation and Learning.

(7) Within the Financial perspective, the EAR Program sought measurements that could respond to, “How efficient does the program appear to Congress, leadership?” Congressional and leadership inquiries frequently focus on efficient and effective use of program resources. Two measures that demonstrate good stewardship of program resources are, one, percent of funds awarded to research and, two, amount of matching non-federal funds by sector. Neither measurement nor any other measurement that the EAR Program considered provides clear information on program impact from the financial perspective because of the long time scale and diffuse return on investment in research.

Within the Customer perspective, the EAR Program sought to answer, “How does the program appear to internal and external customers?” One important customer segment is the teams that have the ability to conduct the research, and they are interested in the yield rate, or percentage of applicants who receive awards. Other customers, both internal and external, are interested in how the Program supports research in different national strategic areas – safety, mobility, environmental stewardship – so the program is developing the measurement of project results be goal area. With the development of persuasive logic chain, the program should be able to
imply impact in advance of retrospective review that could not take place until five, 10, or more years after projects are completed.

From the perspective of the Internal Business Process, the EAR Program addressed the question, “In which process should the program excel?” One area of concern is overlooking potential areas of science or engineering that could have a dramatic impact on the transportation industry. Accordingly, the EAR Program promotes breadth with depth, scanning a large number of topics through initial stage investigations then filtering results to find a limited number of topics to invest in multi-year research. To monitor the breadth of the initial investigations, the Program developed and is refining a measure of initial stage investigations by Program focus areas. Another critical EAR Program element is ensuring access and use of research results. Rather than follow a typical outcome measurement such as papers published – which is important for providing information about the research results – the EAR Program is developing a measurement for tracking the percent of topics that gain follow on funding from other sources. The EAR Program believes that this is better validation that results are being used. For the final perspective of Innovation and Learning, the EAR Program asked “where should the program improve and change?” To answer this question, the EAR Program is tracking new personnel involved in program as in indication of increased internal research capacity and topics that involve multiple offices showing increased capacity to work across traditional disciplines. Under development, the EAR Program is seeking a measurement of projects that lead to closing persistent knowledge gaps, result in new fundamental data, or significantly change current understanding.

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Evaluating Investment Needs and Projecting System Performance with the Highway Economics Requirements System

Lead Author: David Luskin, FHWA
Additional Authors: Chris Chang

The Highway Economic Requirements System (HERS) projects the overall conditions and performance of the highway system at alternative potential levels of investment in highway preservation and capacity. The model is designed for use with data from the national sample of highway sections in the Highway Performance Monitoring System (HPMS). Potential improvements to individual sections are identified using engineering criteria and then evaluated with a cost-benefit analysis that considers potential savings in costs of travel time, vehicle operation, crashes, emissions, and highway maintenance. Analyses based on HERS inform Congressional deliberations on the highway federal-aid program and underpin the highway portion of the biennial report to Congress, Status of the Nation’s Bridges, Highways, and Transit: Conditions and Performance.

In the report’s 2008 edition, needs for investments in highway preservation and capacity were evaluated for the 20 years period, 2007-2026. In 2006 dollars, the investment required to implement all cost-beneficial improvements was estimated to average over this period $115.7 billion per year, compared to an actual investment in 2006 of $48.2 billion. The projected 20-year change in average delay per vehicle mile of travel is a decline of 8.5 percent at the higher of these investment levels versus an increase of 11.0 percent at the lower level.

The C&P report HERS analysis also indicated that implementation of economically efficient congestion pricing would substantially reduce preservation and capacity investment needs. The HERS model is continuously undergoing refinement, including work in progress to improve the prediction of pavement performance.

In response to the States’ needs for a data-driven tool to support “needs” assessment, performance management, and program development decisions, the FHWA developed a version of HERS for state and local agency use. During the development of the Highway Economic Requirements System – State Version (HERS-ST), the state agencies played a major role in making the tool more user-friendly and applicable for state use; subsequent HERS-ST upgrades have been done in partnership between the FHWA and selected state agencies.

Twenty-one state agencies and a number of local government agencies and planning organizations have used HERS-ST for various applications. The most common uses are reporting and evaluating highway system performance and estimating investment needs in highway preservation and capacity as an input to long-range planning. Transportation agencies also use the model to examine the impacts of the investment level on highway condition and performance; such analysis can support the setting of performance targets in a fiscally constrained environment. Though the data to HERS-ST must conform to the format in the HPMS sample, some transportation agencies supplement the HPMS required
sample with additional highway sections on which they collect data to support corridor- and regional-level applications of HERS-ST. Additionally, given HERS-ST’s cost-benefit analysis capability, some agencies use the tool to evaluate programmed projects. Like the HERS model, the HERS-ST is being refined to better serve the transportation agencies in supporting performance management and resource-allocation decisions. The new HPMS data input format is currently being incorporated into HERS-ST, and so will be the new pavement performance prediction models currently being developed for HERS.

In summary, the engineering and economic analytics in HERS/HERS-ST support the evaluation of highway system condition and performance, investment scenarios and programmed projects, and the development of performance targets.
Measuring Transportation Infrastructure Performance for the United States

Lead Author: Sue McNeil, University of Delaware
Additional Authors:
Qiang Li, University of Delaware,
Michelle Oswald, University of Delaware,
Susanne Trimbath, STP Advisory Services

U.S. transportation infrastructure is understood to be the foundation for economic health and competitiveness. However, no study has taken a comprehensive, quantitative look at infrastructure performance over time. Most of the past studies have focused on trying to correlate infrastructure expenditure rather than infrastructure performance with economic productivity. An ongoing project funded by the US Chamber of Commerce Foundation has developed a Transportation Infrastructure Performance Index and related the index to economic growth and productivity.

The index was constructed using publically available data for a representative sample of 36 Metropolitan Statistical Areas (MSA). An iterative process was used to identify and select the indicators. In the first iteration, a set of indicators was identified based on a literature review including reports and websites. The second iteration involved an in-depth evaluation of the available data and ease of data collection. The third iteration involved discussions with a small group of transportation academicians with expertise in air, freight and transit. The experts suggested additional data sets and alternative measures. They also stressed the value of initiating discussion rather than seeking perfect indicators. In the fourth iteration, stakeholders were recruited by the U.S. Chamber of Commerce to participate in half-day meetings. The meetings were held in Chicago, Atlanta, Houston and San Jose and focused on understanding what aspects of infrastructure performance are important to businesses. The fifth iteration involved experts from U.S. Chamber member organizations with transportation interests. These experts were asked to comment on the indicators and adjustments made as needed. Finally, the academic experts were invited to comment on the revised list, and further adjustments were made. Twenty one indicators representing supply, quality of service and utilization for highway, transit, air, rail and intermodal passenger and freight transportation were identified. Data for these 21 indicators were assembled for the period 1990 through to 2008. Although the process is replicable and transparent, there are significant limitations in the data. These include the varying levels of data aggregation, missing or incomplete and erroneous data, the challenges involved in prediction and forecasting, and institutional issues related to ownership and access to the data, changing data formats and changing jurisdictional boundaries and names (1).

The index itself is constructed by normalizing the data and developing weights derived from the relative importance of the indicator determined using the Analytic Hierarchy Process and the relative contribution to the economy of each of the sampled MSAs. The calculated Transportation Performance Index and 5-year moving average show relatively little change over the last two decades despite growing awareness of aging infrastructure, improved operations, and greater investment in infrastructure.
Relationships between per capita economic growth, and transportation infrastructure performance and foreign direct investment have also been demonstrated. Specifically, a one point change in the Transportation Performance Index increases gross domestic product per capita by 0.3%. The transportation index was also shown to correlate with the American Society of Civil Engineers report card for the period 1998-2008 – the period over which the two measures have similar inputs. Finally, the transportation performance index can play a role in communicating national needs, and the importance of infrastructure.

Additional details may be found in the technical report documenting the construction of the index and the analysis of the results (2).

References


Using Risk as Basis for Project Prioritization and Performance Target Setting

Lead Author: John O'Hare, Georgia Institute Of Technology
Additional Authors:

Adjo Amekudzi, Ph.D.
Associate Professor
Georgia Institute of Technology

This research examines risk assessment and risk management at transportation agencies as it applies to project prioritization and performance targets setting. Since Transportation Asset Management Systems (TAMs) are already in place at many transportation agencies, particularly at larger agencies, i.e., state Departments of Transportation (DOTs), they can be used as a platform to incorporate risk into project prioritization and performance targets setting. Transportation agencies are at various stages in the implementation of TAM systems. Some agencies are quite advanced, particularly several international agencies. For example, all of the international agencies examined in the Federal Highway Administration (FHWA)/AASHTO 2005 (1) international scan tour practice some degree of risk assessment in some areas of their TAM processes. Furthermore, all of the agencies used the concept of risk to establish investment priorities (1). A 2006 domestic scan tour in the United States identifies best practices in TAM (2). There was little evidence of risk being used in TAM at the time the domestic scan was conducted. Again, a number of the few agencies that have applied risk assessment methods have done so when conducting scenario analysis. Typically different scenarios are presented that are projected to result from different levels of funding.

Perhaps the most common use of the term risk when applied to transportation infrastructure refers to the risk of failure of a transportation infrastructure asset. However, this risk of failure is not well defined since performance targets for transportation infrastructure condition are not standardized (3). The objectives of this research are to review approaches being used to enhance TAM decision making and to demonstrate the value of addressing uncertainties by comparing the results of bridge prioritization where uncertainties are addressed versus ignored. This poster presents a discussion on risk approaches being used to enhance TAM decision making, and preliminary results on a comparative study on project prioritization with and without risk considerations. Some preliminary results of this research use data from the National Bridge Inventory (NBI) and the Georgia Department of Transportation (GDOT) to develop prioritization scenarios using multi-attribute decision making (MADM) methods. A final product of this research will be a case study in which several scenarios incorporating uncertainty are compared to deterministic scenarios to demonstrate impacts of addressing uncertainty on the prioritization outcomes.

Risk-based decision making typically describes a systematic process that evaluates uncertainties, develops policies based on these uncertainties, and addresses the possible consequences of these policies (4). Risk is defined as the probability that a negative event occurs, and the severity of the consequences of this negative event are estimated (5;1). Although closely related to risk, uncertainty...
carries a different meaning. Uncertainty is an inherent component of the decision making process when choices are made based on incomplete knowledge (5).

Risk assessment, which refers to the scientific process of measuring risks in a quantitative and empirical manner, usually precedes risk management (4;5). Risk management is a qualitative process that involves judging the acceptability of risks (4) within any applicable legal, political, social, economic, environmental, and engineering considerations (5). Decision making for various engineered systems will benefit from risk assessment and risk management. Safety factors applied to various engineered facility designs are an attempt to address uncertainties.

In a paper, Atkan and Moon (6) emphasize the importance of performance monitoring in an effective asset management system. They go on to present specific steps that are necessary for performance-based asset management. In this sort of asset management framework, prioritization is driven by the risk of failure, or non-performance. Ultimately these steps would provide an asset management framework that identifies critical assets; the risk of non-performance of these assets should be minimized.

Scenario analysis, scenario planning methods, or scenario assessment is a collection of tools that can be used to evaluate risk and uncertainty (7;5). The alternative that provides the greatest benefit, is the most cost effective, and has minimal risk is usually the best alternative. A scenario analysis serves as a means to evaluate different alternatives in project development. It is not a forecast, nor does it calculate the specific probability that a given event will occur (5).

Program optimization, also referred to as project prioritization, is another component of the asset management process that typically incorporates some level of risk assessment techniques. These prioritization techniques can be used at a number of different levels in the asset management process, ranging from a broader network level to a more specific project level. Project programming, or project selection, involves analyzing a range or combination of alternatives to determine which alternative(s) is the best investment. This process usually involves scenario analysis, which presents decision makers with tradeoffs between different alternatives (7).

Probabilistic models account for risk by taking uncertainty into account (5;7). These models use statistical methods in which mathematical functions of decision-making factors are developed. Uncertainties of the model inputs are calculated using probability distributions and statistical parameters, such as coefficient of variation and mean. In order to conduct a probability-based risk assessment the uncertainties associated with the input variables, such as variation in user demand, need to be estimated.

In the United States and Canada there are several local, state, and national level examples of risk applications in TAM systems. For example, the City of Edmonton places infrastructure assets into various risk severity zones (8). Another example includes an analysis of past NBI ratings to predict bridge system preservation needs that was done for the Louisiana Department of Transportation and Development (9). Dabous and Alkass (10) developed a method to rank bridge projects based on Multi-attribute Utility Theory (MAUT).

Several different methods can be used to prioritize bridge projects, including benefit cost ratio analysis, the California Department of Transportation’s Health Index (11), and FHWA’s Sufficiency Rating (SR) formula (12). Another example is a framework developed by Cambridge Systematics that can be used to
prioritize bridge inspections or to minimize the risk of service interruption (13). Risk can be incorporated into TAM in various areas and to achieve different objectives. Another feature of the frameworks highlighted above is that decision-maker input is a factor. This is valuable, since as mentioned in the international scan, risk assessment can be used a way to inform and garner support from elected officials (2).

References
Use of Maintenance Investment Needs Assessment Tool to Incorporate Performance Measures into Budget Decision Making in the Virginia Department of Transportation

Lead Author: Jeff Price, VDOT
Additional Authors:
Wenling Chen
Larrie Henley

1. INTRODUCTION

A Maintenance and Operations (M&O) needs assessment tool was recently developed at VDOT to support budget decision making for traffic signal and ITS assets. The tool estimates M&O funding needs based on service level performance targets. Specifically, use of the tool allows linking varying funding levels to the corresponding work performance measures such as frequency of preventive maintenance, response rate to repair calls, and the extent of delays in lifecycle based replacement. The tool provides an analytical framework for users to compare various funding scenarios with different work performance targets. This framework also allows users to quantify and better understand the performance consequences of different maintenance investment strategies or decisions, especially under the current financially constrained environment.

2. VDOT'S SYSTEM AND PERFORMANCE BASED BUDGETING APPROACH

Virginia has approximately 57,000 centerline miles of roads and 20,000 structures. VDOT is responsible for over 33,000 signal and ITS devices. In FY2011, VDOT’s M&O budget for signals and ITS assets was about $90million. Since FY2006, VDOT has adopted a performance based approach to identify M&O needs of many assets based on inventory and condition. The improved data on inventory, condition and performance based needs led to a 10% increase ($97.4million) in FY06 M&O funding over the original planned allocation. The new approach has allowed shifting from an M&O allocation based on historical expenditure to an objective, quantified needs and data driven method for many assets. The tool developed recently for traffic signals and ITS assets allows linking funding requirements to the corresponding work performance measures such as:

- frequency or extent of preventive maintenance,
- rate of responses to repair calls, and
- the extent of delays in lifecycle based replacement

Figures 1 through 5 in the poster provide details on the analytical framework. Specifically, the tool calls three types of inputs to determine needs: (1) Asset characteristics: component, quantity of a component per device, age, life expectancy, and replacement cost; (2) M&O work: work category, work definitions, frequencies, resource requirements, unit cost of work; and (3) Performance criteria: objectives or targets behind the needs. The tool allows assessing needs related to the following work categories:
• Preventive maintenance,
• Repair,
• Replacement,
• Operating needs, and
• Miscellaneous needs such as payment to the localities, which maintain their assets at VDOT’s cost.

3. INCORPORATION OF WORK PERFORMANCE MEASURES IN BUDGETING

The tool provides an analytical framework to link different levels of work performance targets with their corresponding funding requirements. Typical performance targets incorporated in the tool include:

• frequency or extent of preventive maintenance,
• response rate to repair calls, and
• the extent of delays in lifecycle based replacement

Figures 6a and 6b in the poster provide an example of two signal needs scenarios, where different targets for the extent of PM performed, the extent of delays in life cycle replacement and optimization frequencies lead to different funding implications. Conversely, in a funding constrained environment, the tool may also be used to demonstrate potential work performance consequences associated with a reduced funding scenario.

The tool has allowed users to compare funding scenarios with different performance targets. It has also allowed decision makers to better understand the performance consequences of funding decisions.

CAVEAT

All opinions are the responsibility of the authors and do not necessarily reflect the official views of VDOT.
Applying Sustainability Through Performance Measurement

Lead Author: Tara Ramani, Texas Transportation Institute
Additional Authors:
Josias Zietsman, Texas Transportation Institute
Virginia Reeder, Joanne Potter, and Joshua DeFlorio, Cambridge Systematics

This poster will showcase ongoing research under the National Cooperative Highway Research Program project (NCHRP 08-74) titled “Sustainability Performance Measures for State Departments of Transportation and Other Transportation Agencies.” The goal of this project is to develop guidance for state departments of transportation and other agencies to understand and apply concepts of sustainability through performance measurement.

There is increasing attention being given to the topic of “sustainability”; broadly speaking, sustainability is concerned with providing a balanced approach to social, economic, and environmental issues, while considering both present and future needs of society. Transportation, as a major consumer of fossil fuels and a major generator of emissions, is an important concern from a sustainability perspective. However, the application of the concept of sustainability by transportation agencies is often limited by agencies’ understanding of what sustainability means and how it can be integrated into their regular functions. The concept of performance measurement can help transportation agencies understand and apply sustainability. Understanding what sustainability means is the first step in being able to apply a framework for sustainability.

This research posits that the concept of sustainability goes beyond the transportation sector, and that it is reflected in general, non-negotiable principles of sustainability. Then, goals are used to operationalize the general sustainability principles within the transportation sector. The general principles of sustainability are made operational with respect to the transportation sector in the form of 11 goals that cover a range of sustainability concerns within the sphere of influence of transportation agencies. The goals developed in the framework are broad and generally applicable to the entire transportation sector. Goal-specific objectives are used to define how the goal can be applied to different aspects of the transportation agency’s functions. Objectives are more specific and measurable, and lay the foundation for performance measurement, with measures that can be tied directly to objectives. This framework uses a set of “focus areas” to classify and describe the broad functions of a transportation agency in support of its core mission/functions. The objectives for each goal are developed based on the focus area. The development of performance measures is closely linked to the development of objectives, and many of them are a small shift to help quantify each objective. Ideal performance measures are easily understood, provide clear indication of moving toward an established goal, and can be tracked using accessible and available data. The implementation of performance measurement is the final step in applying the framework, and involves refining selected performance measures, and quantifying or applying the measures for various purposes such as description, evaluation, decision-support, accountability and communication.

The research products include a user-friendly guidebook, a detailed project report, and an electronic “compendium” of performance measures. These can be applied/adapted for use in a range of
transportation agencies, including state departments of transportation, metropolitan planning organizations, and other agencies, and can help further the use of performance measures for a difficult-to-measure area like sustainability.

This poster presentation will include:

1. Highlights of case studies conducted and other general findings
2. The framework for sustainability performance measurement developed as part of this research
3. Mock-ups of the user-friendly guidebook
4. Demonstration of an electronic application containing a compendium of performance measures with various usability features.
Measures of Effectiveness and Collection in the Simulated IntelliDrive Environment

Lead Author: Brian Smith, University of Virginia
Additional Authors:

Lindsay M. Marfurt  
Simona E. Babiceanu

Travel time-based congestion measures are often presented at the national or state level. While these measures are important indicators of overall driving behavior, they do not reflect the everyday experiences of travelers. Travelers and local decision makers require mobility indicators which compare facilities within one state or metropolitan area, and which are understandable to both audiences. Recent advances in ITS technology have provided sufficiently comprehensive data sets for generating travel time-based mobility measures. These techniques rely on “probe vehicles” which report travel time data in real time, and usually drive for purposes other than travel time data collection. These methods more closely approximate “ground truth” by collecting data from multiple vehicles at a place and time.

The “Regional Analysis and Reporting of Travel Time-Based Congestion Measures” study identifies travel time-based performance measures which represent the commuter experience; proposes a reporting method which uses GIS; and applies the measures and the method to a case study of “real-world” data. Potential benefits of this study for transportation agencies are enabling communication with decision makers and the traveling public; identifying appropriate algorithms and aggregation levels for meaningful data presentation; and demonstrating the potential for inter- and intra-regional comparison.

General criteria for identifying good performance measures in transportation are: cost-effectiveness to generate, relevancy to travelers, ease of understanding, ease of quantifying benefits of current operation programs, and ease of incorporating into the decision-making process. In addition to these, the following travel time-specific criteria were considered: relevancy at commute level, usefulness in ranking travelers’ experience on different commutes, and ability to illustrate trends.

Based on these criteria, three indicators were chosen: (1) extent of congestion, measuring spatial comparison of congestion among metro areas, (2) travel time index, for quantifying congestion intensity, and (3) buffer index, for quantifying congestion reliability. All these measures are computed for weekdays by meteorological season, excluding special events (holidays, weather, and political). The extent of congestion is computed by time of day and by metropolitan region (Northern Virginia, Richmond, and Fredericksburg). It is defined as the percent of congested roadway miles and is the Congested Roadway measure presented by NCHRP 618 divided by the total road miles. A road segment is flagged as congested if its average speed is 45 mph or less.

The travel time index and buffer index measures are computed for the “peak hour” (the 60-minute period during which the extent of congestion was highest) and for “commutes” (commonly-traveled units understandable to a traveler, representative for the region, and which can be recombined into different travel routes). The study showed that the AM peak hour is 8:00 – 9:00 and the PM peak hour is
17:30 – 18:30 and was chosen because it was found to be stable across the seasons and represents the “worst of the worst” traffic. Travel time index is defined by NCHRP as the actual travel rate divided by the free-flow or posted speed limit travel rate. In this project, the early-morning (2:00 – 3:00) speed is used instead of posted speed limit. Buffer Index is also defined by NCHRP, as the difference between 95th percentile travel time and average travel time divided by the average travel time.

To be effective, performance measures must advance beyond the numbers, to be presented so they are meaningful to decision makers. This poster introduces GIS as a spatial data presentation tool, allowing for visual identification of bottlenecks and patterns. GIS presentation is used for segment-level analyses of travel time index and buffer index. For data with a geographical component, a map display has the highest information density while also being immediately comprehensible to a traveler or decision maker. Maps can display not only the individual segment measures, but also the location of “good” and “bad” conditions, the spatial extent of each condition, and the status of alternate routes. ArcGIS also allows for overlaying of different datasets; for example, a transit map could be overlaid on a map of congestion intensity to determine whether transit is serving the most congested areas.

This study uses travel time data supplied by Inrix, a private sector travel time date provider, from the I-95 Corridor (Interstate 95 and alternate routes) in Virginia. Inrix reports data at 2 minute intervals for pre-defined logical roadway segments called “TMC segments”. The case study shows how segment-level and commute-level analyses reveal regional patterns not seen in current congestion reports. Northern Virginia is found to experience a much greater spatial extent of congestion than the regions of Richmond or Fredericksburg. Within Northern Virginia, travel time index and buffer index are weakly linearly correlated with R2 = 0.461 for the AM peak hour and R2 = 0.395 for PM peak hour. Non-radial routes experience congestion comparable to inbound or outbound routes. Seasonal trends from Fall 2009 to Spring 2010 are also studied, and potential travel time index interpretation problems are identified: for seven of the top ten commutes ranked by travel time index, both free flow and peak hour travel times changed seasonally.

Further research is needed to identify ways of incorporating the measures into local decision making and funding allocation. Additional work could refine the definition of travel time index and other measures that rely on changing reference data. Error analysis for different aggregation orders would identify methods with least error and greatest rankings stability. Finally, future research into the graphical side of this work could identify ways for periodic reports to convey both temporal and spatial variation.

References
Freeway Performance Initiative Traffic Analysis

Lead Author: Jin Wang, Atkins
Additional Authors:
Guillaume Shearin, Brad Lane

The poster will illustrate the Freeway Performance Initiative (FPI) methodology, an example of performance-based decision making to analyze the existing and future operating conditions of freeway corridors, and to identify and prioritize improvement strategies. The Metropolitan Transportation Commission (MTC) in Oakland, California, developed this methodology to assess major highway corridors throughout the nine-county region.

The poster will describe the performance measures used to analyze the corridors, such as the following:

- Travel time / speed
- VMT/VHT
- Delay
- Reliability (buffer index)
- Length of queues
- Safety

The poster will show how these measures are used to determine the causes of existing and future recurrent traffic congestion problems in the corridor and identify the locations of freeway bottlenecks. It will summarize the analytical tools used, which include sketch planning tools, travel demand models, Highway Capacity Manual (HCM) based tools, traffic signal optimization tools, macroscopic simulation models, mesoscopic simulation models, and microscopic simulation models. Methodology steps will be outlined, as follows:

- Calibration of the simulation models to existing conditions and use with travel demand models to project horizon year conditions.
- Development of mitigation strategies to alleviate the identified congestion problems. The proposed mitigation measures are segregated into short-term and long-term implementation timelines. Mitigation measures include the following:
  - Capacity improvements, such as widening, and HOV lanes
  - Operational improvements, such as auxiliary lanes and interchange modifications
  - Transportation management strategies, such as ramp metering, changeable message signs, closed circuit TV
  - Assessment of the identified strategies individually, or as “packages” with multiple strategies and projects grouped together.
  - Development of planning-level cost estimates of each strategy, broken out by capital and operations and maintenance costs.
  - Evaluation of the proposed congestion mitigation strategies and projects using benefit/cost analysis, leading to a prioritized list of recommended strategies.
The FPI methodology was developed by MTC. It has been successfully applied in the San Francisco Bay Area to identify improvement strategies for multiple freeway corridors. The poster will include results for an example corridor.
Performance-Based Metrics: The Riders' Perspective

Lead Author: Janice Wells, Permanent Citizens Advisory Committee to the MTA
Additional Authors:

Ellyn Shannon

This research by the Permanent Citizens Advisory Committee to the MTA (PCAC) investigates performance metrics presented by the operating agencies of the MTA and makes recommendations for improvement or adjustment with an eye to better capturing the impact on riders. The PCAC represents the interests of the riders of the nation's largest public transportation system and is comprised of three rider councils which were created by the New York State Legislature in 1981: the Long Island Rail Road Commuter Council (LIRGCC); the Metro-North Railroad Commuter Council (MNRCC); and, the New York City Transit Riders Council (NYCTRC).

The genesis of this study arose from commuters expressing skepticism at some of the on-time metrics presented by the Long Island Rail Road (LIRR). The PCAC began investigating data used in the computations and it became clear that “trains” had impressive on-time percentages while the time delay that “riders” experienced from canceled trains was not being captured. A three-month analysis of the LIRR delay data revealed that while a canceled train was counted as “late”, the added 20–30 minute delay to a rider, forced to wait for the next available train, was never captured. In order to inform Board members, riders and the general public on the frequency and passenger impacts of delayed and canceled trains, PCAC asked the LIRR and the Metro-North Railroad (MNR) to place these statistics in their MTA Board Committee Book and on the MTA website in a searchable databases. The railroads implemented this request in September 2010.

In light of these initial “canceled train” findings, the PCAC decided that a more in-depth study on metrics at all three MTA Agencies might lead to:

•Development of true passenger on-time performance (OTP) measures;
•Identification of the magnitude of passengers impacted by delays and canceled trains; and
•Better linkage of capital investments to improvement in passenger service.

This inquiry included a literature review; a review of the history of metrics at the MTA and current performance measures; a comparison of metrics at other leading transit agencies which are displayed on their websites; and a discussion on how the Capital Program relates to better service.

Findings

The MTA and its Operating Agencies provide some of the most transparent and detailed operational metrics among U.S. transit agencies; and this information is readily available on the MTA website. With respect to MNR and LIRR, no major commuter railroad comes close to their level of operational performance disclosure. In addition, the NYCT is to be lauded for the improvement of its performance indicators over the last 15 years, particularly with the implementation and refinement of its Wait Assessment metric.
Yet, a true passenger based on-time metric still eludes the MTA. Further, the effect of terminated and canceled trains on the commuter railroads — the magnitude of riders that are affected by delays and the resulting economic impact of lost work time — has yet to be captured.

Finally, despite the high level of disclosure, the MTA’s operational metrics are often omitted in discussions of capital investments and the impact they will have on reducing slow, delayed and canceled trains. The average rider doesn’t necessarily understand what new interlockings, switches and signals are, let alone appreciate how their improvement will enhance their commute.

Recommendations

1. The MTA should continue to foster investment in operational and measurement technology, as new technology is providing the means to refine and improve both performance and performance measurement.

2. The LIRR and MNR should place their ridership book, which contains average train ridership by specific train, on the MTA website in a searchable database. Thus, the number of LIRR and MNR passengers onboard each delayed and canceled train could be estimated. Researchers should be encouraged to use this data to model the economic impacts of delayed and canceled trains on workers and employers.

3. For improved transparency, the LIRR and MNR should change their “Categories of Delay” in the MTA Board Committee Book from categories that relate to departments responsible (as is currently done) to the actual reason for the delay.

4. In the same vein, NYCT should define what factors constitute a “major delay” in the subway system and identify them in the Transit Committee Book each month by line(s), cause, and number of trains and length of time they were delayed. Currently, there is no major system delay information provided to the public.

5. Performance databases for NYCT subways and buses on the web should be searchable and available to software application developers. Currently, there are no searchable subway or bus performance databases on the MTA website that provide information on Wait Assessment.

6. The NYCT should consider describing the Wait Assessment metric to the general public in more user friendly terms. As currently presented, the NYCT’s Wait Assessment percentage means little to the average rider.

7. The LIRR and MNR should strive to develop a canceled train “delay factor”, i.e., time until the next train arrives or actual wait time for a “rescue” train or bus. This factor should be included in the "average minutes late" metric. What happens to riders in the case of a canceled train should be a matter of record. If in-house resources are not available, outside sources, such as academic researchers, should be utilized to develop a methodology for capturing the true impact of a canceled or terminated train.

8. The LIRR and MNR should strive to develop a true passenger-based OTP metric, for the AM Peak period to terminals, incorporating a canceled train delay factor. Again, if in-house resources are not available, outside academic researchers would be an excellent potential to tackle this analysis.