U.S. Department of Transportation
Federal Highway Administration

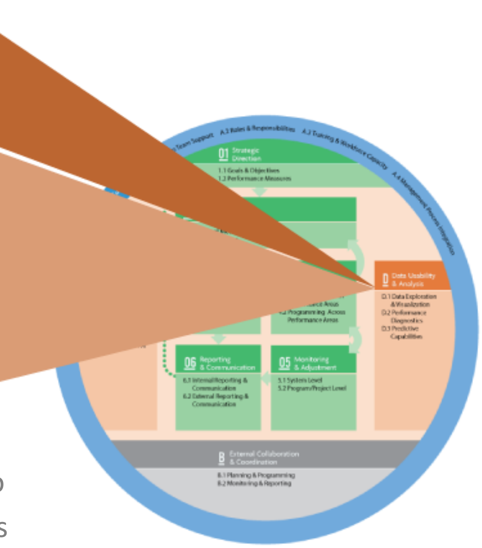
COMPONENT D

DATA USABILITY AND ANALYSIS

This chapter provides assistance to transportation agencies with the "Data Usability and Analysis" component of Transportation Performance Management (TPM). It discusses how data usability and analysis fit within the TPM Framework, describes how this component interrelates with the other nine components, presents definitions for associated terminology, and includes an action plan exercise. Key implementation steps are the focus of the chapter. Guidebook users should take the TPM Capability Maturity Self-Assessment (located in the TPM Toolbox at www.tpmtools.org) as a starting point for enhancing TPM activities. It is important to note that federal regulations for data usability and analysis may differ from what is included in this chapter.

D Data Usability & Analysis

D.1 Data Exploration & Visualization
D.2 Performance Diagnostics
D.3 Predictive Capabilities



Data Usability and Analysis is the existence of useful and valuable data sets and analysis capabilities available in accessible, convenient forms to support transportation performance management. While many agencies have a wealth of data, such data are often disorganized, or cannot be analyzed effectively to produce useful information to support target setting, decision making, monitoring or other TPM practices.

INTRODUCTION

As illustrated in Figure D-1, each of the framework components depend on the existence of relevant data sets, provided in usable, convenient forms to support transportation performance management. This chapter covers steps that can be used to systematically assess data and analysis requirements, select tools, implement analysis capabilities, and develop and improve these capabilities over time.

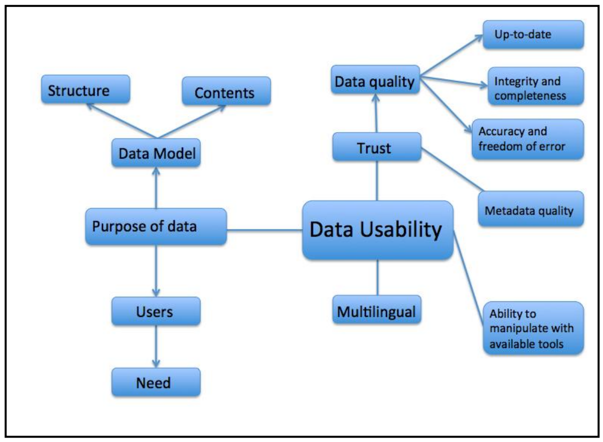
Data *usability* considers the ability of a user to derive useful information from data. Data provided in a series of text files that require weeks of complex processing to be in a form suitable for analysis are not very usable. On the other hand, data delivered on a performance dashboard that can be immediately interpreted would be highly usable. Data usability is one of the key criteria included in the data value assessment process featured in NCHRP Report 814: Data to Support Transportation Agency Business Needs: A Self-Assessment Guide (see pages 38-39 and 42-43 of this reference for data usability assessment criteria and examples).

There are multiple dimensions to data usability:

- **Relevance:** data must address an information need
- **Quality:** data must be of acceptable quality for the intended purpose
- **Coverage and Granularity:** data must have adequate coverage and be structured at the right level of granularity
- **Accessibility and Documentation:** data must be accessible, with sufficient metadata for potential users to understand their derivation and meaning
- **Ease of Analysis:** appropriate tools must be available to manipulate the data (e.g., filtering, sorting, and aggregating) and viewing the data (e.g., mapping and charting). In some cases, specialized methodologies and tools are needed to perform statistical analysis or predictive modeling

Figure D-1: Elements of Data Usability

Source: Adapted from Directions Magazine[1]



A proactive approach to data usability can ensure that available data are put to good use for TPM. Agencies should examine not only the data and tools that are available for performance monitoring and reporting but also the backgrounds and capabilities of the staff who will be analyzing and using the data. For example:

- Do they know what questions to ask about the data?
- Do they understand how the data were collected?
- Do they understand the data's level of accuracy and precision?
- Do they understand the precise definitions of the data elements?
- Are they familiar with changes that may have occurred over time in data collection methods and definitions?
- Do they understand how variations in filter conditions may impact results?
- Are they familiar with tools and techniques for presenting data in a useful way?

[1] Dr. Iain Cross and Joana Palahi. Evaluating the Usability of Aggregated Datasets in the GIS4EU Project. (2010). Glencoe, IL. http://www.directionsmag.com/entry/evaluating-the-usability-of-aggregated-datasets-in-the-gis4eu-project/122329

- Do they have access to specialized expertise in data integration, data manipulation and statistical analysis that may be required for performance trend analysis, diagnostics, and prediction?

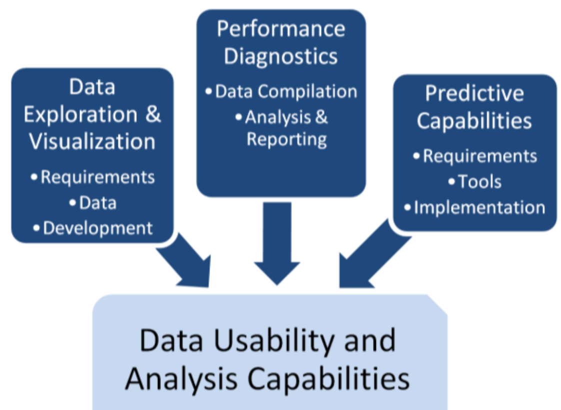
A transportation performance management skills assessment can include these questions in order to recognize and understand potential challenges that will need to be addressed to ensure a strong transportation performance management capability. There may be a need to build staff capacity in data analysis methods through recruiting, training, and mentoring. Collaboration within the agency can be used to leverage available expertise internally. For example, staff within an agency data management unit can be tapped to provide advisory services to staff within an operations performance function. Outsourcing can be used as a strategy for gaining specialized skills and providing internal staff with exposure to new techniques. See subcomponent A.3 Training and Workforce Capacity for further discussion.

External collaboration can be pursued to help provide the necessary capabilities when partner agencies share common performance monitoring and reporting needs. In this situation, available staff resources can be pooled to take advantage of complementary skill sets across agencies. Staff roles and responsibilities can be negotiated as part of data-sharing agreements. See External Collaboration and Coordination (Component B), subcomponent B.2 Monitoring and Reporting.

SUBCOMPONENTS AND IMPLEMENTATION STEPS

Figure D-2: Subcomponents for Data Usability and Analysis

Source: Federal Highway Administration



Data Usability and Analysis is defined here as: the existence of useful and valuable data sets and analysis capabilities available in accessible, convenient forms to support transportation performance management. While many agencies have a wealth of data, it may not be in the right form to allow for visualization or analysis to support target setting, decision-making, monitoring, or other TPM practices. Agency efforts to process data into convenient forms, provide useful visualization and analysis tools, and build staff capacity will directly impact an agency's ability to understand and improve performance.

Ensuring usability of data for transportation performance management involves considering three types of capabilities (Figure D-2):

- **Data Exploration and Visualization:** availability and value of data, tools, and reports for understanding performance results and trends.
- **Performance Diagnostics:** availability and value of data, tools, and reports that allow an agency to understand how influencing factors affected performance results both at the system and project levels.
- **Predictive Capabilities:** availability and value of analytical capabilities to predict future performance and emerging trends.

These three capabilities are interrelated. Data exploration and visualization capabilities build a foundation for performance diagnostics by allowing agencies to explore variations in performance over time, across the network, and for other subsets of interest. Through this process, questions intuitively arise about reasons for performance variations. These questions lead to identification of additional data sets and views that could be helpful for performance diagnostics. Performance diagnostics capabilities contribute to establishment of predictive capabilities. Once causal factors behind performance results are understood, models can be created based on relationships between independent variables (such as funding levels, programmed projects, VMT, growth patterns, etc.) and performance measures of interest.

As illustrated in Table D-1, Table D-2, and Table D-3 these interrelated capabilities contribute to each of the fundamental TPM activities of target setting (Component 02), performance-based planning (Component 03), performance-based programming (Component 04), monitoring and adjustment (Component 05), and reporting and communications (Component 06). For example, the process of setting a performance target for pavement condition is facilitated by the ability to visualize and explore pavement condition trends across geographic areas, road network subsets, and pavement types. This data exploration capability could be used to inform further analysis of major contributing factors to pavement performance (i.e., performance diagnostics). The diagnostic analysis would then support predictive modeling of future pavement performance under varying assumptions.

Table D-1: TPM Activities Requiring Data Usability and Analysis, Subcomponent D.1

Source: Federal Highway Administration

TPM Component	Sample TPM Activities Requiring D.1 Exploration and Visualization Capabilities
02: Target Setting	Visualize trends
03: Performance-Based Planning	Visualize deficiencies and needs to inform strategy development Visualize impacts of alternative investment scenarios
04: Performance-Based Programming	Track locations of programmed projects against deficiencies
05: Monitoring and Adjustment	Understand timing of programmed project completion
06: Reporting and Communication	Tailor performance reports to different audiences

Table D-2: TPM Activities Requiring Data Usability and Analysis, Subcomponent D.2

Source: Federal Highway Administration

TPM Component	Sample TPM Activities Requiring D.2 Performance Diagnostics
02: Target Setting	Identify factors that have impacted performance trends
03: Performance-Based Planning	Understand impacts of implemented strategies
04: Performance-Based Programming	Understand program effectiveness
05: Monitoring and Adjustment	Diagnose reasons for delays and take appropriate action Identify factors contributing to performance results
06: Reporting and Communication	Explain reasons for performance results

Table D-3: TPM Activities Requiring Data Usability and Analysis, Subcomponent D.3
Source: Federal Highway Administration

TPM Component	Sample TPM Activities Requiring D.3 Predictive Capabilities
02: Target Setting	Assess future ability to achieve targets under varying assumptions
03: Performance-Based Planning	Identify strategies based on projected performance
04: Performance-Based Programming	Predict impacts of programmed projects on multiple performance areas
05: Monitoring and Adjustment	Adjust predictions of program outcomes based on project delivery status Update revenue projections to assess program delivery risk
06: Reporting and Communication	Communicate future implications of investment decisions

It is important to keep in mind that most agencies already have capabilities for data analysis in place. The processes defined in this guidebook can be viewed as a way to build on existing capabilities in order to strengthen the value of data for transportation performance management. Table D-4 outlines implementation steps for each of these capabilities that will be further explored in this chapter.

Table D-4: Data Usability and Analysis Implementation Steps
Source: Federal Highway Administration

Data Exploration and Visualization	Performance Diagnostics	Predictive Capabilities
1. Understand requirements	1. Compile supporting data	1. Understand requirements
2. Assess data usability	2. Integrate diagnostics into analysis and reporting processes	2. Identify and select tools
3. Design and develop data views		3. Implement and enhance capabilities

CLARIFYING TERMINOLOGY

Table D-5 presents the definitions for the data usability and analysis terms used in this Guidebook. A full list of common TPM terminology and definitions is included in Appendix C: Glossary.

Table D-5: Data Usability and Analysis: Defining Common TPM Terminology
Source: Federal Highway Administration

Common Terms	Definition	Example
Data Exploration and Visualization	Presentation of data in a graphical form to enable interactive analysis and facilitate understanding and communication.	Common TPM data visualizations include maps showing highway links with poor performance, trend lines showing average crash rates, and dashboards showing charts with key performance indicators.

Common Terms	Definition	Example
Data Usability	The ease with which user information needs can be met with available data, tools, and skills.	A data feed of highway travel speeds is not usable in its raw form. Data processing, summarization and presentation are required to make this data feed usable.
Imputation	Substitution of estimated values for missing or inconsistent data element values.	A probe data set consisting of speeds by five-minute period for each section of an Interstate may have missing data due to insufficient observations for some periods/sections. Data for these periods/sections may be imputed based on values for nearby sections.
Performance Diagnostics	Analysis of root causes for performance results.	Correlating traffic incidents with travel speed data; breaking down crash data by contributing factors recorded in crash records or highway inventories.
Transportation Performance Management	A strategic approach that uses system information to make investment and policy decisions to achieve performance goals.	Determining what results are to be pursued and using information from past performance levels and forecasted conditions to guide investments.

RELATIONSHIP TO TPM COMPONENTS

As noted above, Data Usability and Analysis are an integral part of TPM and are touched upon in the other chapters of this guidebook. Table D-6 summarizes how each of the nine other components relate to Component D.

Table D-6: Data Usability and Analysis Relationship to TPM Components

Source: Federal Highway Administration

Component	Summary Definition	Relationship to Data Usability and Analysis
01. Strategic Direction	The establishment of an agency's focus through well-defined goals/objectives and a set of aligned performance measures.	Establishing performance measures that can realistically be tracked requires consideration of data and analysis requirements.
02. Target Setting	The use of baseline data, information on possible strategies, resource constraints and forecasting tools to collaboratively establish targets.	Establishing performance targets requires analysis and interpretation of available trend data, as well as capabilities for predicting future performance under varying assumptions.
03. Performance-Based Planning	Use of a strategic direction to drive development and documentation of agency strategies and priorities in the long-range transportation plan and other plans.	Data usability and analysis support evaluation of alternative mid and long-range scenarios.

Component	Summary Definition	Relationship to Data Usability and Analysis
04. Performance-Based Programming	Allocation of resources to projects to achieve strategic goals, objectives and performance targets. Clear linkages established between investments made and their expected performance outputs and outcomes.	Performance-based programming requires application of analysis capabilities for evaluation of the performance outcomes of candidate projects for programming.
05. Monitoring and Adjustment	Processes to monitor and assess actions taken and outcomes achieved. Establishes a feedback loop to adjust programming, planning, and benchmarking/target setting decisions. Provides key insight into the efficacy of investments.	Data usability and analysis are integral to performance monitoring–they are needed to support the process of understanding patterns, identifying key performance drivers, and pinpointing areas for improvement.
06. Reporting and Communication	Products, techniques, and processes to communicate performance information to different audiences for maximum impact.	Data visualization capabilities are essential for effective communication of performance information to different audiences.
A. TPM Organization and Culture	Institutionalization of a TPM culture within the organization, as evidenced by leadership support, employee buy-in, and embedded organizational structures and processes that support TPM.	Data visualization capabilities enable a shared picture of performance that supports an agency performance culture.
B. External Collaboration and Coordination	Established processes to collaborate and coordinate with agency partners and stakeholders on planning/ visioning, target setting, programming, data sharing, and reporting.	Data visualization capabilities enable a shared picture of performance that supports external collaboration.
C. Data Management	Established processes to ensure data quality and accessibility, and to maximize efficiency of data acquisition and integration for TPM.	Data management practices are essential for strengthening data usability for TPM.

IMPLEMENTATION STEPS

D.1 DATA EXPLORATION AND VISUALIZATION

Data Exploration and Visualization is defined here as the presentation and/or manipulation of data in a graphical form to facilitate understanding and communication. The process of improving exploration and visualization capabilities begins by identifying the questions that the agency would like to answer. Once this is done, gaps in data and analysis can be assessed, and improvements can be designed.

> "You can have data without information, but you cannot have information without data."
>
> - Daniel Keyes Moran, Programmer

1. Understand requirements
2. Assess data usability
3. Design and develop data views

> "Above all else, show the data."
>
> - Edward R. Tufte, Data Visualization Thought Leader

STEP D.1.1	Understand requirements

Description	To assess data usability, agency staff must first identify what questions need to be answered, and what data sources are needed to address these questions. Once this is done, the agency can evaluate data adequacy and define data exploration and visualization requirements. While the specific questions will depend on the performance area, the following types of questions will generally be applicable:
	• What is the current level of performance?
	    o How does it vary across types of related measures (pavement roughness, rutting, cracking)?
	    o How does it vary across transportation system subsets (district, jurisdiction, functional class, ownership, corridor)?
	    o How does it vary by class of traveler (mode, vehicle type, trip type, age category)?
	    o How does it vary by season, time of day, or day of the week?
	• Is observed performance representative of "typical" conditions or related to unusual events or circumstances (storm events or holidays)?
	• How does performance compare with peers and the nation as a whole?
	• How does current performance compare with past trends?
	    o Are things stable, improving, or getting worse?
	    o Is current performance part of a regularly-occurring cycle?
	• What factors have contributed to the current performance?
	    o What factors can the agency influence (hazardous curves, bottlenecks, pavement mix types)?
	    o How do changes in performance relate to general socio-economic or travel trends (economic downturn, aging population, lower fuel prices contributing to increase in driving)?
	• How effective have past actions to improve performance been (safety improvements, asset preventive maintenance programs, incident response improvement)?
	
	Based on these questions, agencies can create a chart similar to that in Table D-7 to identify data sources and understand analysis requirements. Because agencies typically will not have

STEP D.1.1	Understand requirements
	all desired data, it is helpful to prioritize requirements to begin rolling out basic data exploration and visualization capabilities and have a plan for future expansion of these capabilities.
Examples	**Auto Report Generator: Utah Department of Transportation**[2] Utah DOT's Auto Generator allows users to enter project limits on a straight-line diagram and generate a spreadsheet that can be used to prepare an engineer's estimate. This is an example of building a tool that presents existing data (asset data collected via LiDAR) in a form that is immediately useful for addressing a specific business question: what is the cost of replacing existing assets within a given location? The summary spreadsheet provides data related to pavements, pavement markings, barriers, and signs. Engineers can then use this information to verify measurements and other details (e.g., sign damage, non-standard barriers) in the field.

Table D-7: Safety Data Requirements Analysis (Examples)

Source: Utah Department of Transportation[3]

Question	Data Elements	Coverage	Granularity
How does the current level of highway safety performance compare with past trends?	Fatality Rate–based on number of highway fatalities and vehicle miles of travel	Spatial: All public roads statewide Temporal: 1995-2015	Spatial: by road class and jurisdiction Temporal: Annual Other: Age Category
What factors have contributed to the current level of performance?	Crash record attributes (first harmful event, etc.) Road inventory attributes Emergency Medical Response Attributes	Linkage to crash records to provide same coverage as dependent variable (fatality rate)	Linkage to crash records to provide same granularity as dependent variable (fatality rate)

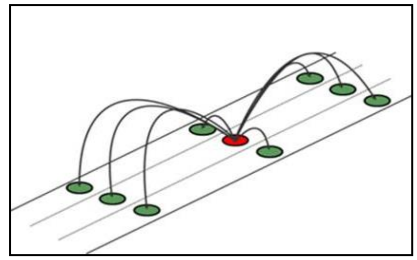
Linkages to Other TPM Components	Component 02: Target Setting Component 03: Performance-Based Planning Component 04: Performance-Based Programming Component 05: Monitoring and Adjustment Component 06: Reporting and Communication Component B: External Collaboration and Coordination	(See TPM Framework)

[2] Utah Department of Transportation, "Auto-generated summary sheets" (June 18, 2014), http://blog.udot.utah.gov/2014/06/auto-generated-summary-sheets/.

[3] Utah Department of Transportation, "Auto-generated summary sheets" (June 18, 2014), http://blog.udot.utah.gov/2014/06/auto-generated-summary-sheets/.

STEP D.1.2	Assess data usability
Description	Once data requirements are identified, the next step is to examine the available data and determine its usability. **Questions to ask in assessing data usability include:** • Are relevant data available, i.e., that can provide answers to the applicable questions? • Are the data of sufficient quality for the purpose–are they sufficiently accurate, complete, consistent and current? • Do the data have sufficient coverage to meet business needs–both spatially and temporally? • Are the data available at the right level of granularity to meet business needs? • Where multiple overlapping sources of data are available, is it clear which is authoritative? Inevitably there will be gaps in the existing data. Some gaps can be filled through new data collection or acquisition initiatives. Because acquisition of new data comes at a cost, it is necessary to consider the value that the new data would bring and whether existing data could suffice. Other gaps will not be possible to fill through acquisition of new data–for example, a trend data set might be missing data for certain years, or historical data may be based on a different measurement method than current data. These types of gaps need to be addressed on a case-by-case basis. In some cases, imputation methodologies can be used to fill in missing data. In addition, data transformation methods can be applied to convert across measures (where statistically reliable relationships can be established). In other cases, the agency can decide to just live with the missing data.
Examples	**Crash Data Quality Assessment** The University of Massachusetts UMassSafe program, with participation from the Massachusetts Traffic Records Coordinating Committee (TRCC) conducted an audit of data quality issues in the Massachusetts Crash Data System (CDS). **Key issues discovered included:** • High rate of missing injury severity data: injury severity is missing for approximately 25% of cases. • Poor location information: location information collected on the crash form varies greatly. • Poor data quality for engineering-related fields: while injury severity is perhaps the most substantial field with a high percentage of missing information, there are other fields that share similar problems.[4]

[4] UMassSafe Traffic Safety Research Program. Crash Data Quality Audit. http://www.ecs.umass.edu/masssafe/cdqa.htm. Retrieved 15 July 2016.

STEP D.1.2	Assess data usability
	Figure D-3: Imputation Model Source: Transportation Research Board[5]  Each of these types of errors impacts usability of data for tracking highway safety performance. Missing injury severity data impacts the ability to meaningfully track serious injuries. Poor location information impacts ability to summarize the data by geographic area and to visualize the data on a map. Poor quality data for other crash record fields impacts the ability to understand causal factors. **Traffic Speed Data—Addressing Missing Values** Travel time data sets based on vehicles acting as "probes" may have missing values for certain locations and time periods due to gaps in traffic at that place and time. Imputation methods are used by vendors of these data sets to fill in these missing values based on the surrounding data.[6]
Linkages to Other TPM Components	Component B: External Collaboration and Coordination Component C: Data Management (See TPM Framework)

STEP D.1.3	Design and develop data views
Description	After relevant data has been compiled, capabilities for data exploration and visualization can be designed and developed. Data exploration and visualization techniques take sets of individual data records and transform them into a form that facilitates interpretation and analysis. The design of these capabilities should be based on the requirements identified in step D.1.1. **Common data exploration techniques include:** • **Grouping:** organizing data into categories for analysis (e.g., corridors or districts) • **Filtering:** looking at a subset of the data meeting a specified set of criteria (e.g., run off the road crashes on rural roads involving fatalities) • **Sorting:** ordering data records based on a specified set of criteria (e.g., sort transit routes by daily ridership) • **Aggregating:** summarizing groups of records by calculating sums, averages, weighted averages, or minimum or maximum values (e.g., calculating the length-weighted average pavement condition index for Interstate highways in District 1)

[5] *Figure 3.5 Imputation of traffic data* from page 54 of the *Strategic Highway Research Program (SHRP 2) Report S2-L02-RR-2: Guide to Establishing Monitoring Programs for Travel Time Reliability*

[6] Strategic Highway Research Program (SHRP 2). (2009). Report S2-L02-RR-2: Guide to Establishing Monitoring Programs for Travel Time Reliability Washington, DC. http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_S2-L02-RR-2.pdf

STEP D.1.3	Design and develop data views
	• **Disaggregating:** viewing individual records that comprise a data subset (e.g., view the individual projects for the current fiscal year that are not on time or on budget) Pivot tables and increasingly sophisticated data analysis features in desktop spreadsheet software can perform many of these functions, as can various other commercially available reporting and business intelligence tools. For some types of visualizations, specialized software development may be required. Work may be needed to prepare the data so that it utilizes common, consistent categories and includes valid data for elements that will be used for grouping, filtering sorting and aggregating. **Common data visualizations include:** • Charts that summarize current performance, trend lines and peer comparisons–these may be bar (simple, stacked, or clustered), line, and pie charts, scatter or bubble charts, bullet graphs, histograms, radar charts, tree maps, heat maps, or combinations. • Maps that show performance by location or network segment, or allow for examination of detailed information such as condition of individual assets or characteristics of individual crashes. Maps are a useful tool for integrating multiple data sets with a spatial component in order to better understand results. They are also useful for communicating performance information to both internal and external audiences. • Dashboards that utilize a variety of charts to show high-level performance indicators. Dashboards may be interactive–enabling drill down from categories to sub-categories and individual records. • Infographics developed to facilitate understanding of a specific performance area. Some agencies have been able to leverage external resources for developing useful data visualizations. They make an open data feed available, and encourage app developers to present the data in useful forms (e.g., interactive maps).
Examples	**Sample Visualizations from Washington State DOT** Washington State DOT's Gray Notebook provides several examples of effective data visualizations. The donut chart displayed in Figure D-4 demonstrates the relative magnitudes of different reasons for cancelling ferry trips. The stamp graphs in Figure D-5 depict differences in congestion, both temporally (by period of the day, and by year) and geographically. The spiral graph in Figure D-6 shows where and when delay is greatest along a corridor. A fourth image shown in Figure D-7 from WSDOT (but not from the Gray Notebook) shows a screenshot of a tool that can be used in the field to review and validate different components of the pavement condition index along a specified road segment.

STEP D.1.3 — Design and develop data views

Figure D-4: WSDOT Data Visualization Example 1

Source: The Gray Notebook Volume 58[7]

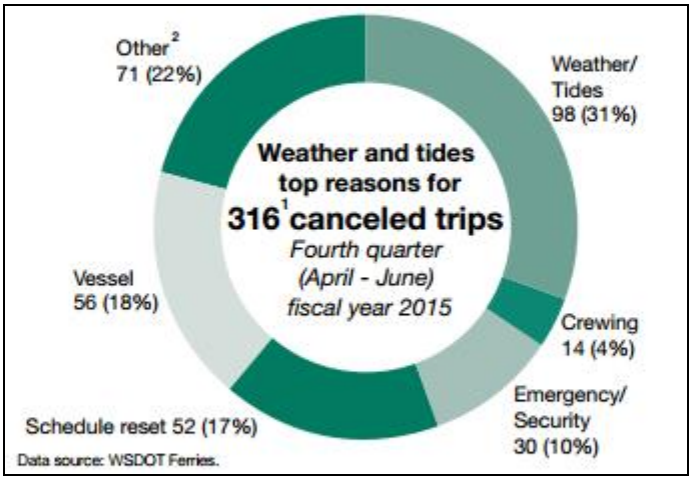
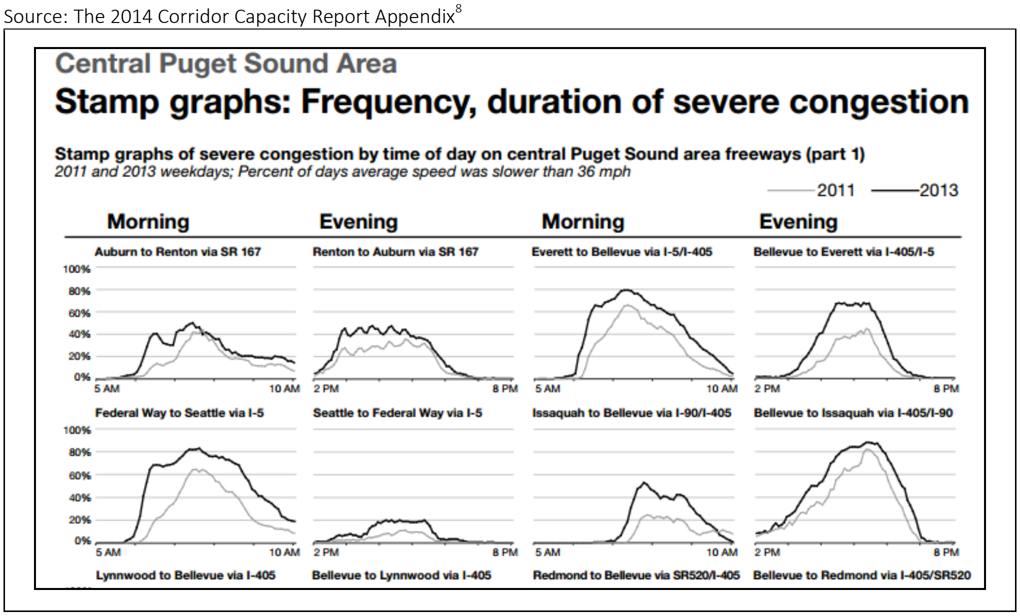


Figure D-5: WSDOT Data Visualization Example 2

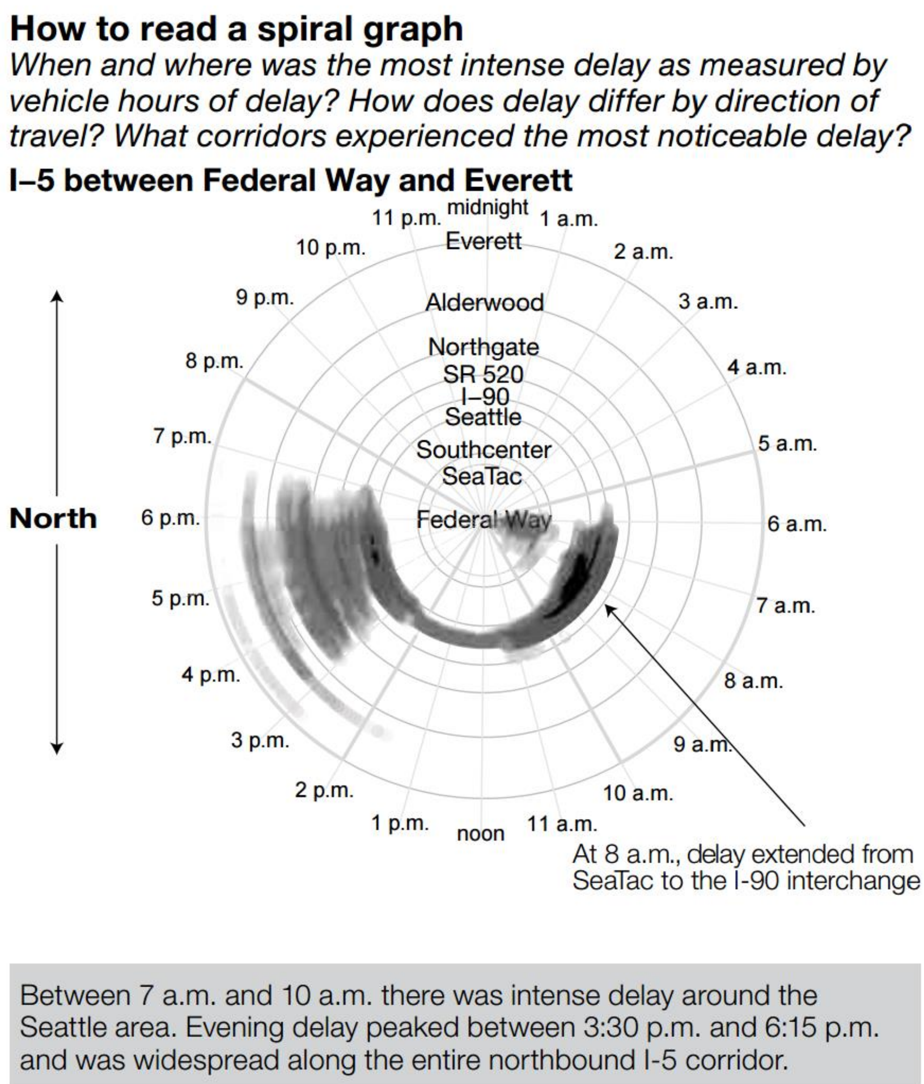
Source: The 2014 Corridor Capacity Report Appendix[8]



[7] Washington State Department of Transportation. (2015). The Gray Notebook: WSDOT's Quarterly Performance Report on Transportation Systems, Programs, and Department Management (June 30, 2015). Olympia, WA. http://wsdot.wa.gov/publications/fulltext/graynotebook/Jun15.pdf

[8] Washington State Department of Transportation. (2014). The 2014 Corridor Capacity Report Appendix. Olympia, WA. http://wsdot.wa.gov/publications/fulltext/graynotebook/CCR14_appendix.pdf#page=8

STEP D.1.3	Design and develop data views
	Figure D-6: WSDOT Data Visualization Example 3 Source: The 2014 Corridor Capacity Report Appendix[9]

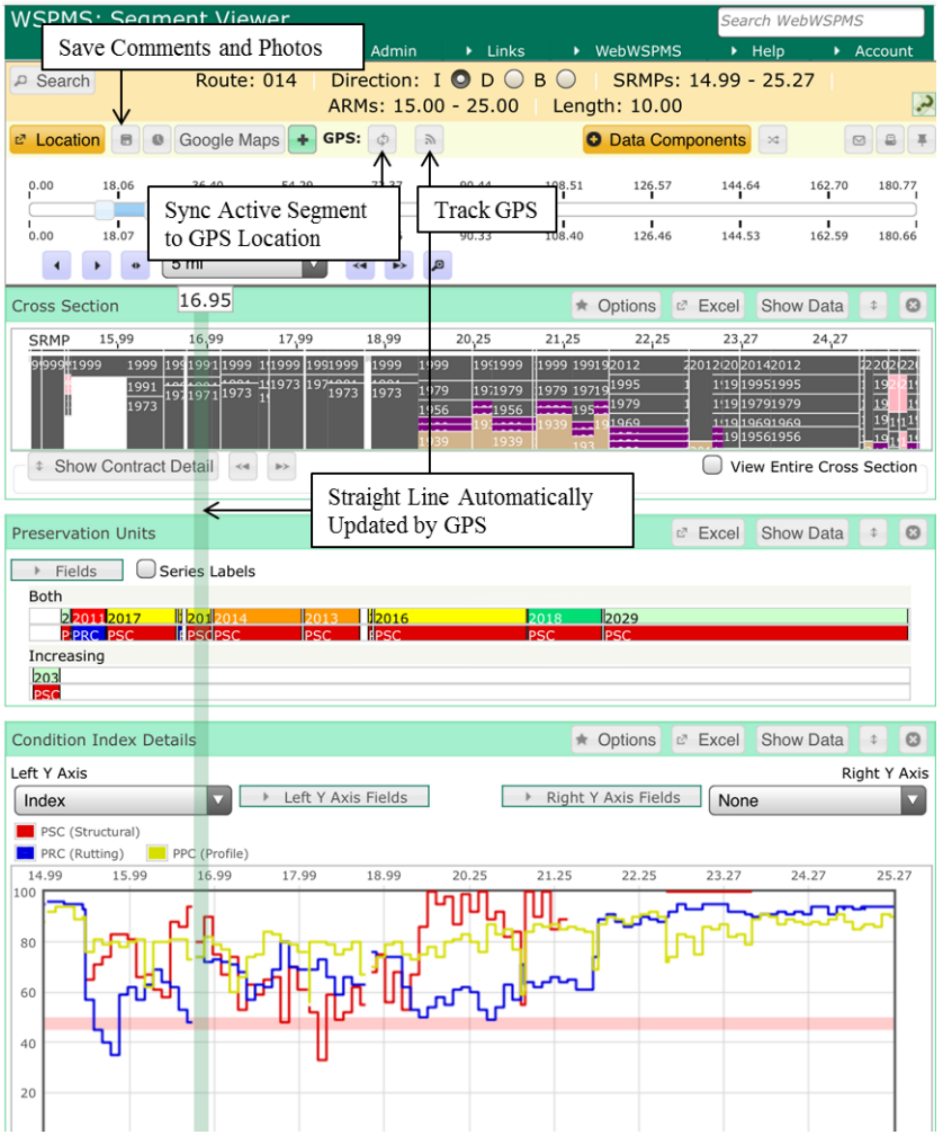


[9] Washington State Department of Transportation. (2014). The 2014 Corridor Capacity Report Appendix. Olympia, WA. http://wsdot.wa.gov/publications/fulltext/graynotebook/CCR14_appendix.pdf#page=10

STEP D.1.3	Design and develop data views

Figure D-7: WSDOT Data Visualization Example 4

Source: Visualizing Pavement Management Data[10]



[10] Washington State Department of Transportation. (2015). Visualizing Pavement Management Data at the Project Level. Olympia, WA. https://www.wsdot.wa.gov/NR/rdonlyres/D77C2653-25AD-4AD3-A0D6-A1B268073E09/0/VisualizingPavementManagmentDataattheProjectLevel.pdf

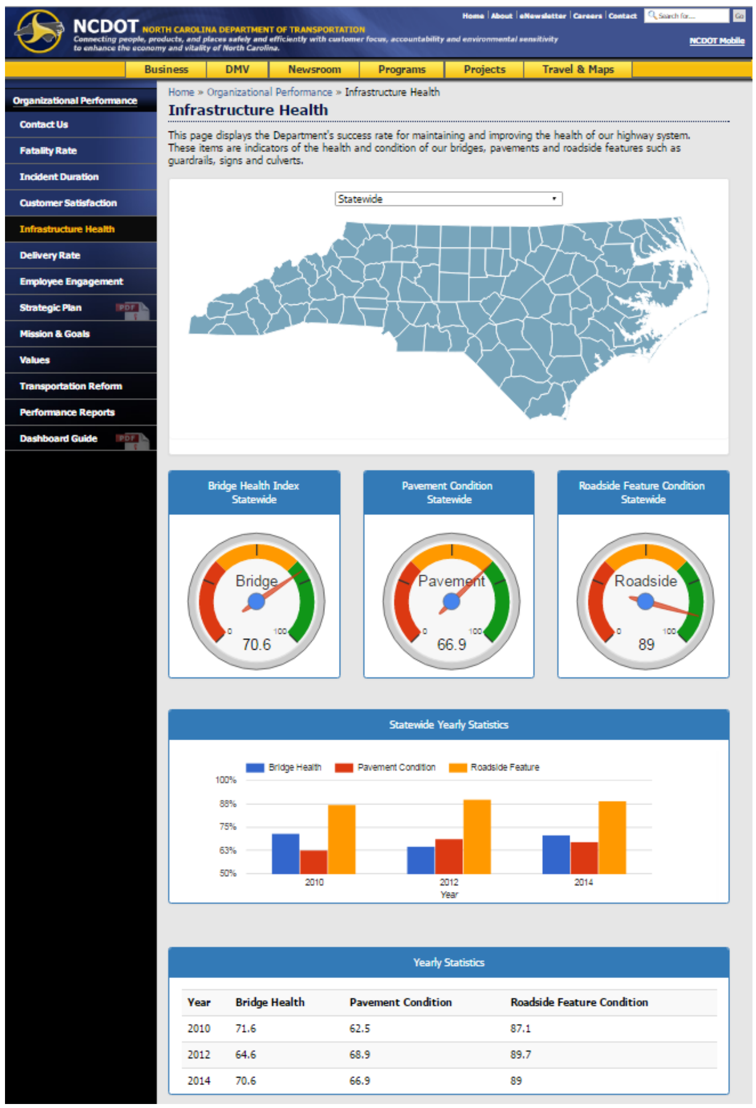
STEP D.1.3	Design and develop data views

Organizational Performance: North Carolina Department of Transportation[11]

North Carolina DOT allows users to quickly compare performance statewide or for specific counties on its website. The example below demonstrates infrastructure health statistics (bridge health index, pavement condition, and roadside feature condition) at the statewide level, but the clickable map allows users to easily explore performance across counties. The data view also displays historical data at the annual level.

Figure D-8: NCDOT Performance Data for Public Consumption

Source: Infrastructure Health[12]



[11] North Carolina Department of Transportation, "Organizational Performance: Infrastructure Health," http://www.ncdot.gov/performance/InfrastructureHealth.html. Retrieved June 6, 2016.

[12] North Carolina Department of Transportation, "Organizational Performance: Infrastructure Health. http://www.ncdot.gov/performance/InfrastructureHealth.html. Retrieved June 6, 2016.

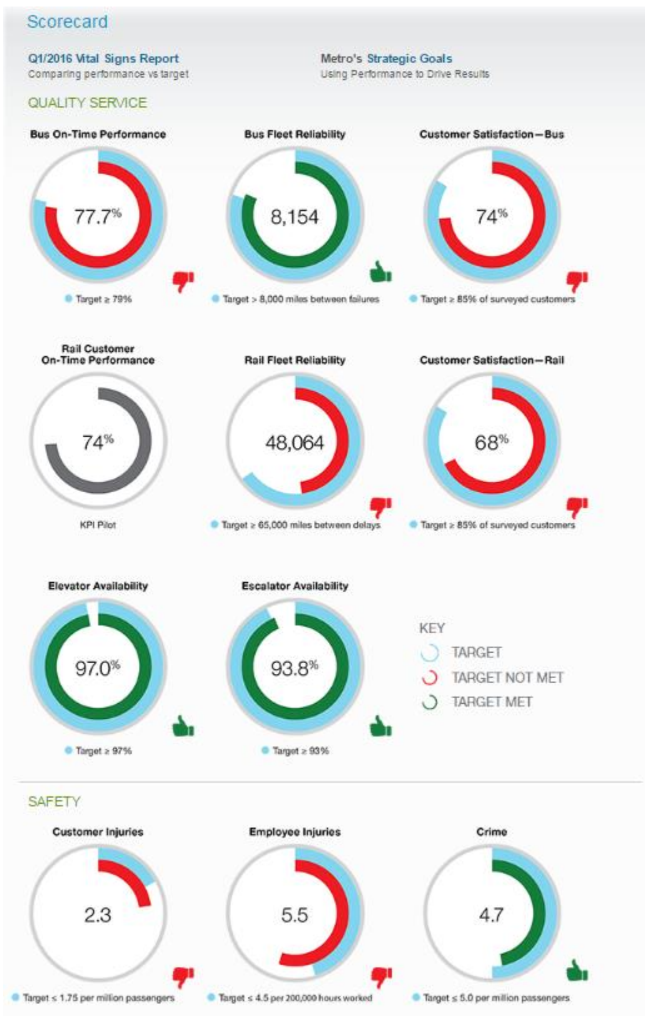
STEP D.1.3	Design and develop data views

Performance Scorecard: Washington Metropolitan Area Transit Authority[13]

Washington Metropolitan Area Transit Authority (WMATA)'s Scorecard dashboard shows high-level performance indicators across a number of categories, displaying a total of 14 performance measures related to service quality, safety, and people and assets. The dashboard displays WMATA's performance in the given period along with the target performance for the period. Indicators are color-coded in green and red so that it is instantly clear to the user whether WMATA met its target for each performance indicator. An accompanying "Vital Signs Report" is available that provides further details on each of the performance indicators, including historical performance, reasons for historical change, and key actions to improve performance.

Figure D-9: WMATA Scorecard Dashboard

Source: WMATA[14]



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[13] Washington Metropolitan Area Transit Authority, "Scorecard" (2016 Q1), https://www.wmata.com/about_metro/scorecard/.

[14] Washington Metropolitan Area Transit Authority, "Scorecard" (2016 Q1), https://www.wmata.com/about_metro/scorecard/

STEP D.1.3	Design and develop data views
	37 Billion Mile Data Challenge: Massachusetts Department of Transportation, Metropolitan Area Planning Council, and Massachusetts Technology Collaborative[15] MassDOT, the Metropolitan Area Planning Council (MAPC), and the Massachusetts Technology Collaborative (MassTech) collaborated to hold a data challenge where the agencies provided the public with vehicle census data and asked the public to provide policy insights. The vehicle census data was produced using anonymized State Vehicle Registry data, and included data on vehicle characteristics, annual mileage, and aggregate spatial data. The data challenge encouraged participants to consider specific questions, such as, "What factors make a neighborhood more likely to have high car ownership and mileage," and "Where might investments in walking, biking and transit have the biggest impact in reducing how much people drive"? Award-winning entries included a split-screen mapping tool comparing any two of a set of emissions metrics, visualization tools made available to other entrants, and an infographic on driving facts.
Linkages to Other TPM Components	Component A: Organization and Culture Component C: Data Management

(See TPM Framework)

[15] Massachusetts Department of Transportation, "Data Rules the Road: Massachusetts Driving Habits Revealed in Data Challenge" (May 2, 2014), http://www.massdot.state.ma.us/main/tabid/1075/ctl/detail/mid/2937/itemid/432/Data-Rules-the-Road----Massachusetts-Driving-Habits-Revealed-in-Data-Challenge---.aspx.

D.2 PERFORMANCE DIAGNOSTICS

The following subcomponent outlines implementation steps for agencies to develop performance diagnostics capabilities. This process allows an agency to examine performance changes and understand how factors affected performance.

1. Compile supporting data
2. Integrate diagnostics into analysis and reporting processes

> "All truths are easy to understand once they are discovered; the point is to discover them."
>
> - Galileo Galilei

STEP D.2.1	Compile supporting data
Description	The steps described above for subcomponent D.1 should result in identification of additional data that would be helpful for root cause analysis. Much of the data needed for performance diagnostics will already be compiled as part of agency planning and performance data gathering activities (see Component C, Data Management). However, it may or may not be in a form that is useful for analysis. For example, crash records will typically contain a wealth of information for understanding causal factors. However, linking road inventory or incident data to the crash records requires additional effort. In some instances agencies will find that they need to undertake data quality improvement efforts to ensure consistent spatial referencing across crash and inventory data sets, and to ensure that inventory data are available that match the specific time of the crash. It will be important to distinguish causal factors that are within the agency's control from those that are external. While both types of factors should be considered in developing predictive capabilities, agencies will gain the most value through identifying things that they can do to "move the performance needle."
Examples	Examples of explanatory variables for each of the TPM performance areas are identified below. To diagnose performance in each TPM area, it would be necessary to compile data on some or all of the explanatory variables.

Table D-8: Explanatory Variables (Examples)

Source: Federal Highway Administration

TPM Area	Explanatory Variables
General	Socio-economic and travel trends
Bridge Condition	Structure type and design Structure age Structure maintenance history Waterway adequacy Traffic loading Environment (e.g., salt spray exposure)
Pavement Condition	Pavement type and design

STEP D.2.1	Compile supporting data

	Pavement age Pavement maintenance history Environmental factors (e.g., freeze-thaw cycles) Traffic loading
Safety	Socio-economic and land use factors (e.g., population and population density, age distribution, degree of urbanization) Traffic volume and vehicle type mix Weather (e.g., slippery surface, poor visibility) Enforcement Activities (e.g., seat belts, speeding) Roadway capacity and geometrics (e.g., curves, shoulder drop off) Safety hardware (barriers, signage, lighting, etc.) Speed limits Availability of emergency medical facilities and services
Air Quality	Stationary source emissions Weather patterns Land use/density Modal split Automobile occupancy Traffic volumes Travel speeds Vehicle fleet characteristics Vehicle emissions standards Vehicle inspection programs
Freight	Business climate/growth patterns Modal options–cost, travel time, reliability Intermodal facilities Shipment patterns/commodity flows Border crossings State regulations Global trends (e.g., containerization)
System Performance	Capacity Alternative routes and modes Traveler information Signal operations/traffic management systems Demand patterns Incidents Special events

STEP D.2.1	Compile supporting data
Linkages to Other TPM Components	Component 06: Reporting and Communication Component A: Organization and Culture Component C: Data Management (See TPM Framework)

STEP D.2.2	Integrate diagnostics into analysis and reporting processes

Description

Once data are compiled that can provide diagnostic information (see Component C, Data Management), the data must be integrated into the agency's analysis and reporting tools and processes.

Several different approaches to integration can be considered, depending on the nature of the data:

- Direct linkage to the elemental unit of performance–enabling the analyst to "slice and dice" data by causal factors or conduct statistical analysis. Using this method, a value associated with the causal factor is associated with each elemental performance record (e.g., pavement section, bridge, crash, system performance location/time slice, etc.)
- Trend data overlays–enabling the analyst to view trend information for the causal factor together with the primary performance trend (e.g., show VMT growth in a corridor along with changes in average speed)
- Spatial overlays–enabling the analyst to view data for geographic areas or network links for the causal factors as an overlay on the primary performance data (e.g., overlay climate zones on a map of pavement deterioration)
- High level consideration–separate trend or pattern investigation for the causal factor that assists the analyst to draw conclusions about the primary performance data (e.g., understanding shifts in patterns of global trade for understanding changes in freight flows)

Each of these approaches implies different processes for data preparation. The direct linkage approach can require a data conversion or mapping exercise where the causal data set has been independently assembled, and identifiers for location, time, event, or asset are not consistent with those used for the primary performance data set.

The trend data overlay approach requires that the causal data set and the primary performance data sets cover the same time frame (or overlap sufficiently to provide for meaningful trend comparison). If time units vary (e.g., fiscal versus calendar years), some degree of conversion may be needed.

The spatial overlay approach requires at a minimum that both data sets have spatial referencing that can be utilized within the agency's available GIS. However, some level of data processing may be needed to display different data sets for the same set of zones or network sections. For example, if one data set has population by census tract and another has average pavement condition by district, both could be displayed on a map, but a data conversion

STEP D.2.2	Integrate diagnostics into analysis and reporting processes
	process would be required to aggregate the census tract information to be displayed by district. Data standardization and integration is covered in more detail in Data Management (Component C). Once an integration approach is selected and implemented, a repeatable process to support root cause analysis on an ongoing basis can be implemented. This will require effort, but can save future analysts from having to "reinvent the wheel" later on. The results can take the form of automatically generated views, which can be made available to a wider audience beyond the primary data analyst. Regularly obtaining feedback on the value of the data diagnostic views can result in continued improvements.
Examples	**Minnesota Strategic Highway Safety Plan: Focus Area Priorities**[16] The Minnesota Strategic Highway Safety Plan 2014-2019 was intended to reduce traffic-related crashes. It presents a set of focus areas with strategies for improving statewide road safety. In selecting safety strategies, the state begins by reviewing crash data and analyzing for frequency, patterns, and trends across the focus areas, regions, roadway types, and conditions. As a result, diagnostics are integrated into reporting through the Strategic Highway Safety Plan, and impact the selection of strategies to effect change in future performance. For example, the state combined crash data with road design data to determine if road design had any explanatory power in lane departure crashes, and found that rural two-lane roads with high speed limits account for 49% of severe lane departure crashes. This information is useful for development of key strategies such as: "Provide buffer space between opposite travel directions," and "Provide wider shoulders, enhanced pavement markings and chevrons for high-risk curves."

[16] Minnesota DOT. (2015). *Minnesota Strategic Highway Safety Plan, 2014-2019*. http://www.dot.state.mn.us/trafficeng/safety/shsp/Minnesota_SHSP_2014.pdf

STEP D.2.2	Integrate diagnostics into analysis and reporting processes

Figure D-10: MnDOT Investment Prioritization

Source: Minnesota Strategic Highway Safety Plan[17]

Relationship to Road Parameters

Road design type and speed limit distribution of severe lane departure crashes in **rural** areas

	<30 mph		30 mph		35 mph - 40 mph		45 mph +		All Speed Limits	
Freeway/Ramps	0	0%	2	<1%	0	0%	128	4%	130	4%
Other Divided Highway	0	0%	2	<1%	0	0%	117	4%	119	4%
4-6 Lanes	0	0%	2	<1%	0	0%	15	<1%	17	1%
3-Lane and 5-Lane	0	0%	0	0%	0	0%	7	<1%	7	<1%
2-Lane Roadway	10	<1%	86	3%	35	1%	**1563**	**49%**	1694	53%
One-Way Street	0	0%	1	<1%	0	0%	0	0%	1	<1%
Other	5	<1%	7	<1%	2	<1%	85	3%	99	3%
All Roadways	15	<1%	100	3%	37	1%	1915	60%	2067	65%

Road design type and speed limit distribution of severe lane departure crashes in urban areas

	<30 mph		30 mph		35 mph - 40 mph		45 mph +		All Speed Limits	
Freeway/Ramps	0	0%	7	<1%	6	<1%	150	5%	163	5%
Other Divided Highway	0	0%	6	<1%	24	1%	95	3%	125	4%
4-6 Lanes	0	0%	80	3%	59	2%	49	2%	188	6%
3-Lane and 5-Lane	0	0%	6	<1%	11	<1%	6	<1%	23	1%
2-Lane Roadway	9	<1%	239	7%	64	2%	155	5%	467	14%
One-Way Street	1	<1%	19	1%	1	<1%	1	<1%	22	1%
Other	7	<1%	10	<1%	5	<1%	15	<1%	37	1%
All Roadways	17	1%	367	11%	170	5%	471	15%	1025	32%

65% of Minnesota's severe lane departure crashes occur in rural areas, compared to 32% in urban areas.

2-lane roads with high speed limits (45+ mph) in rural areas account for 49% of severe lane departure crashes; alternatively, 76% (1563 of 2067) of severe lane departure crashes in rural areas occur on 2-lane roadways with high speed limits.

The severe lane departure crashes that occur in urban areas are more distributed among both facility type and speed limit than those in rural areas.

[17] Minnesota Department of Transportation. (2014). Minnesota Highway Safety Plan. St. Paul, MN. http://www.dot.state.mn.us/trafficeng/safety/shsp/Minnesota_SHSP_2014.pdf

STEP D.2.2	Integrate diagnostics into analysis and reporting processes

Minnesota DOT: Crash Mapping Analysis Tool[18]

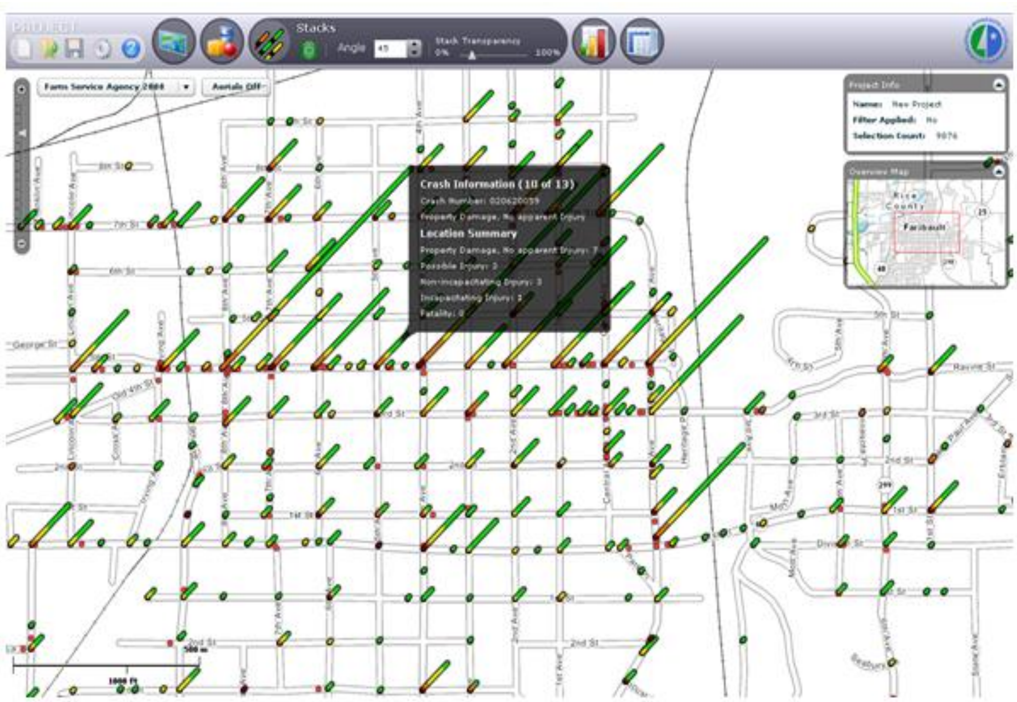
Minnesota DOT also created the Minnesota Crash Mapping Analysis Tool (MnCMAT), which allows approved users to visually examine data compiled and integrated from multiple sources through a GIS-based mapping tool. The MnCMAT has drill down and selection capabilities, and can create various outputs.

The basic analysis process consists of:

1) Selecting the area to be analyzed
2) Applying filtering criteria (e.g., location, contributing factor, time period, crash severity, crash diagram, driver information, road design, speed limit, system class, surface conditions, weather, type of crash, number of fatalities, number of vehicles)
3) Generating output in the form of maps, charts, reports, and date files

Figure D-11: MnDOT Crash Mapping Analysis Tool

Source: Minnesota Crash Mapping Analysis Tool – MnCMAT Material PowerPoint[19]



[18] Vizecky, Mark and Sulmaan Khan, Minnesota Department of Transportation, "Minnesota Crash Mapping Analysis Tool (MnCMAT) & Crash Data" (Feb. 2015). http://www.dot.state.mn.us/stateaid/trafficsafety/mncmat/material.ppt & http://www.dot.state.mn.us/stateaid/crashmapping.html

[19] Minnesota Department of Transportation. (June 2015). Minnesota Crash Mapping Analysis Tool - MnCMAT Material PowerPoint. St. Paul, MN. http://www.dot.state.mn.us/stateaid/crashmapping.html

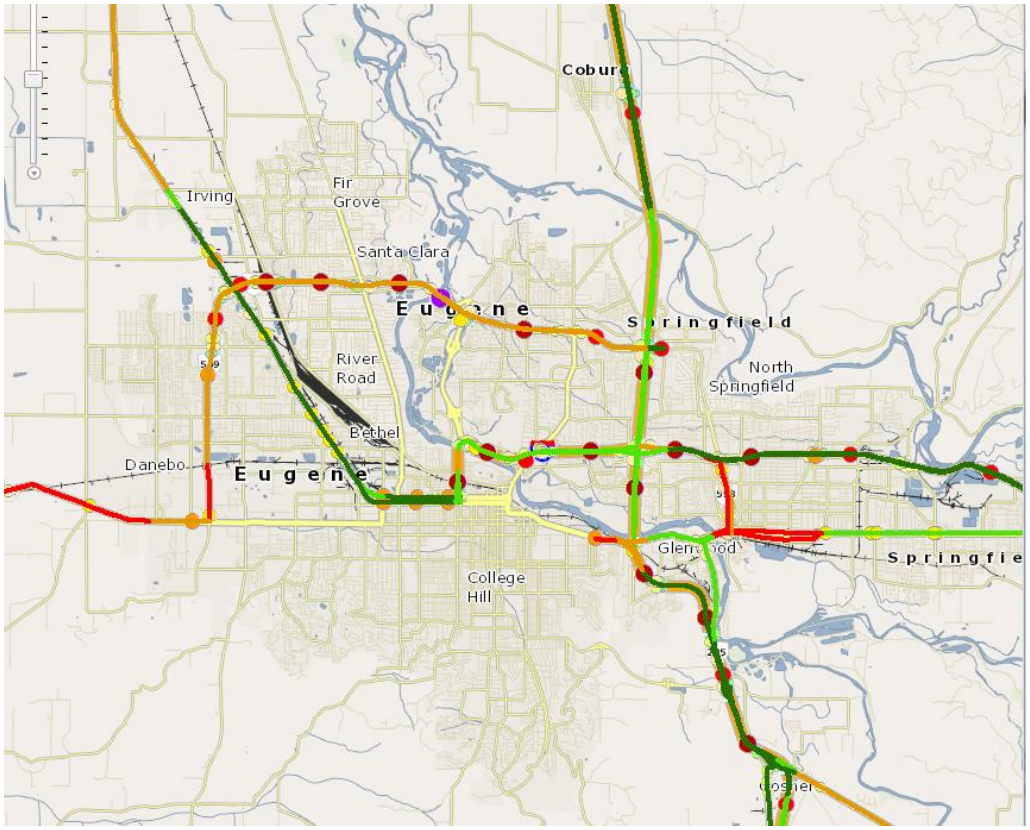
STEP D.2.2	Integrate diagnostics into analysis and reporting processes

Oregon DOT: TransGIS[20]

Oregon DOT's TransGIS web mapping application integrates a variety of data into a user-friendly GIS interface. This enhances the ability for ODOT staff and other users to overlay different data layers to explore and analyze data interrelationships.

Figure D-12: OregonDOT Web Mapping and GIS Integration

Source: ODOT [21]



Linkages to Other TPM Components

Component 05: Monitoring and Adjustment

Component 06: Reporting and Communication

Component A: Organization and Culture

Component C: Data Management

(See TPM Framework)

[20] Oregon Department of Transportation, "ODOT TransGIS." https://gis.odot.state.or.us/transgis/ (restricted link).
[21] Oregon Department of Transportation, "ODOT TransGIS." https://gis.odot.state.or.us/transgis/ (restricted link).

D.3 PREDICTIVE CAPABILITIES

Predictive capabilities enable agencies to anticipate future performance and emerging trends. The following section outlines implementation steps for agencies to develop predictive capabilities. Agencies must first establish a methodology for predicting future performance, then evaluate, acquire, and configure analysis tools to support that methodology. Continual review and improvement of tools is an important and ongoing activity.

1. Understand requirements
2. Identify and select tools
3. Implement and enhance capabilities

> "The reality about transportation is that it's future-oriented. If we're planning for what we have, we're behind the curve."
>
> - Anthony Foxx, U.S. Secretary of Transportation

> "The most reliable way to forecast the future is to try to understand the present."
>
> - John Naisbitt, Author of Megatrends

STEP D.3.1	Understand requirements
Description	Predictive capabilities enable agencies to systematically analyze future performance given (1) implementation of performance improvement projects and programs, and (2) changes in other factors that the agency does not control. Performance predictions are useful for setting defensible future performance targets, for planning-level evaluation of the potential effectiveness of alternative strategies to improve performance, and for assessing likely performance impacts of alternative short and mid-range program bundles. Performance predictions can be made at the system-wide, subnetwork, corridor, or facility level. Performance analysis methods can range in complexity–based on the number and type of factors considered, and the technical modeling approach used. A methodology that is intended for network-level predictions is not typically appropriate for site-specific applications. Requirements for performance prediction capabilities can be established by clarifying how these capabilities will be used for target setting, planning, site-specific strategy development, and programming. **In general, predictive capabilities should:** • Allow agencies to analyze the "do nothing" scenario–to predict how performance would change if no improvements were implemented • Allow agencies to estimate the potential impacts of individual strategies for performance improvement • Allow agencies to predict how the value of a performance measure will change based on implementation of plans or programs Ideally, predictive capabilities should allow for convenient testing of a variety of assumptions. A scenario analysis approach to prediction recognizes inherent uncertainties and ensures that recipients of the analysis understand these uncertainties. Prior to establishing requirements, it is a good idea to do some research into the state of the

STEP D.3.1	Understand requirements
	practice in different areas for performance prediction (see step D.3.2). This can help to identify what is possible given available data and tools – and the level of effort required to implement and maintain a modeling capability.
Examples	**Safety Performance Functions (SPF)** have been developed as a simple method for predicting the average number of crashes per year at a location, as a function of exposure and site characteristics. **SPFs can be used in different contexts:** • Network Screening: Identify sites with potential for safety improvement by determining whether the observed safety performance is different from that which would be expected based on data from sites with similar characteristics. • Countermeasure Comparison: Estimate the long-term expected crash frequency without any countermeasures and compare this to the expected frequency with a set of countermeasures under consideration. SPFs can be calibrated to reflect specific locations and time periods. However, an agency may choose to use additional predictive tools to supplement or update SPFs. For further information, see: http://safety.fhwa.dot.gov/tools/crf/resources/cmfs/pullsheet_spf.cfm **Crash Prediction Modeling: Utah Department of Transportation**[22] Utah DOT calibrated the Highway Safety Manual's crash prediction models for statewide curved segments of rural two-lane two-way highways over three-year and five-year periods. The calibration used LiDAR data on highway characteristics in combination with historical crash data. The model incorporated safety performance functions, crash modification factors, and a jurisdictional calibration factor. Utah DOT developed this model to meet requirements for a predictive safety tool that accounts for local conditions and specific roadway attributes.
Linkages to Other TPM Components	Component 02: Target Setting (See TPM Framework) Component 03: Performance-Based Planning Component 04: Performance-Based Programming Component C: Data Management

STEP D.3.2	Identify and select tools
Description	A variety of tools are available for predicting performance. Some tools are simple and don't require specialized software. Others are more complex and can be obtained from FTA, FHWA,

[22] Mitsuru Saito, Casey S. Knecht, Grant G. Schultz, and Aaron A. Cook, "Crash Prediction Modeling for Curved Segments of Rural Two-Lane Two-Way Highways in Utah," UDOT Research Report No. UT-15.12 (October 2015), http://ntl.bts.gov/lib/56000/56800/56825/15.12_Crash_Prediction_Modeling_for_Curved_Segments_of_Rural_Two_Lane_Two_Way_Hwys_in_UT.pdf.

STEP D.3.2	Identify and select tools
	peer agencies, or through purchase or licensing of software from commercial entities. **Prior to selection of any tool, agencies should conduct an evaluation that includes the following considerations:** • Match with agency business needs; • Experience of other agencies with the tool (other client/user references); • Availability of sufficient data to meet tool requirements; • Ease of integration with existing systems that may supply inputs; • Ease of integration with existing agency reporting and mapping tools; • Availability of technical documentation describing methodology and assumptions; • Availability of user documentation describing steps for tool application; • The time and complexity of implementation; • The ability to customize the tool to the agency, both during implementation and on an ongoing basis; • Tool acquisition and support costs; • Likelihood of ongoing support and upgrades; and • Availability of internal staff resources to understand and productively make use of the tool. In order to ensure that a tool under consideration meets agency requirements, a pilot application can be pursued. This provides an opportunity to test the tool's capabilities with real data for a limited application.
Examples	**Table D-9: Example Analysis Tools and Methods by TPM Performance Area** Source: Federal Highway Administration

Table D-9: Example Analysis Tools and Methods by TPM Performance Area

Source: Federal Highway Administration

TPM Area	Available Tools
Bridge Condition	Bridge Management Systems (commercial, AASHTOWare, and custom built)
Pavement Condition	Pavement Management Systems (commercial and custom built)
Safety	SafetyAnalyst IHDSM Crash Modification Factors See others at: http://safety.fhwa.dot.gov/tsp/fhwasa13033/appxb.cfm
System Performance and Freight	SHRP-2 TravelWorks Bundle Commercial and custom travel demand modeling tools: trip and activity-based (for person travel and freight movement) Traffic Simulation and Analysis Models (see: http://ops.fhwa.dot.gov/trafficanalysistools/ FHWA's Freight Analysis Framework: forecasts Economic Input-Output Models: commercial and custom

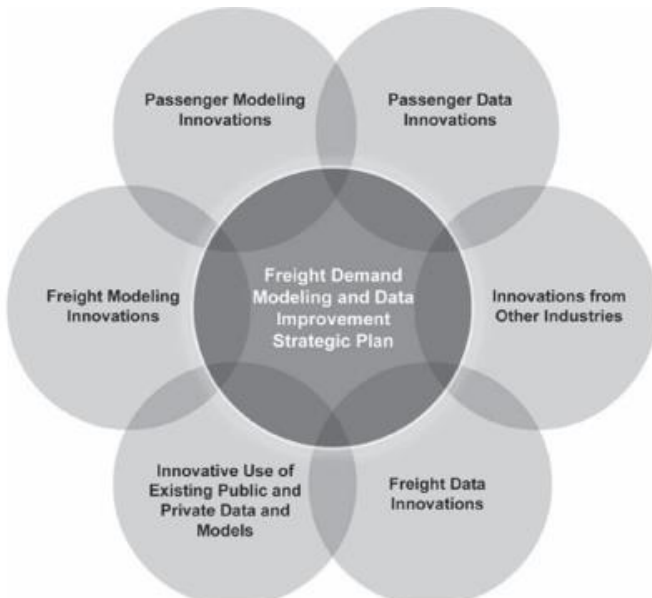
STEP D.3.2	Identify and select tools

Freight Demand Modeling: Wisconsin DOT[23,24]

As part of the second Strategic Highway Research Program (SHRP2) Product C20 Implementation Assistance Program, Wisconsin DOT piloted a proof of concept to develop a hybridized model for freight demand, with the goal of integrating it with regional travel demand models in order to quantify the effects of different scenarios on freight transportation in the region. WisDOT is currently reviewing the modeling effort. Outside of the Wisconsin DOT example, the SHRP2 Product C20 as a whole built a strategic plan with a long-term set of strategic objectives for freight demand modeling and data innovation going forward.

Figure D-13: Integrating Freight Demand Modeling

Source: Transportation Research Board[25]



MPO Congestion Forecasting: Nashville Area MPO[26]

Like many MPOs, the Nashville Area MPO forecasts roadway congestion. The MPO uses a land use model as a tool to predict residential and employment distributions. It then uses a travel demand model as a tool to predict travel patterns. The congestion forecasts then use this travel demand model to identify congested routes in horizon years. The MPO notes that historically, Nashville regional congestion followed a radial commuting pattern into and out of

[23] Federal Highway Administration, "A strategic roadmap for making better freight investments," SHRP2 Project C20. http://www.fhwa.dot.gov/goshrp2/Solutions/All/C20/Freight_Demand_Modeling_and_Data_Improvement

[24] Transportation Research Board. (2013). Freight Demand Modeling and Data Improvement. Washington, DC. http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_S2-C20-RR-1.pdf

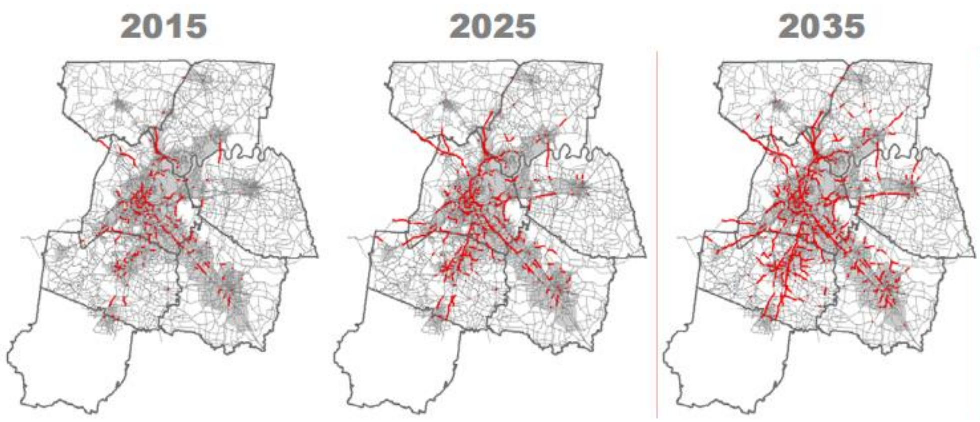
[25] *Figure 2.1 Innovations Considered in the SHRP 2 C20 Freight Demand Modeling and Data Improvement Strategic Plan* from page 19 of the report, *Strategic Highway Research Program (SHRP 2) Report S2-C20-RR-1: Freight Demand Modeling and Data Improvement*

[26] Nashville Area Metropolitan Planning Organization. (2015). *2035 Nashville Area Regional Transportation Plan*. http://www.nashvillempo.org/docs/lrtp/2035rtp/Docs/2035_Doc/2035Plan_Complete.pdf

STEP D.3.2	Identify and select tools
	downtown CBDs, but that recently congestion has also occurred near suburban commercial clusters (Regional Activity Centers) and in circumferential commuting patterns. This existing scenario serves as a foundation to forecasting future congestion.

Figure D-14: MPO Congestion Forecasting Visualization

Source: Nashville Area MPO[27]



Linkages to Other TPM Components	Component 03: Performance-Based Planning Component 04: Performance-Based Programming Component 06: Reporting and Communication Component A: Organization and Culture Component C: Data Management	(See TPM Framework)

STEP D.3.3	Implement and enhance capabilities
Description	Once the selected predictive tools are in place, an agency can focus on implementing and enhancing its analysis–and integrating use of the tool within agency business processes. This may involve: • Validating and improving model parameters and inputs. Over time, default values for model parameters can be validated and replaced with improved parameters that better match with actual agency experience. • Utilizing the models to analyze risk factors that may impact achievement of strategic goals and objectives. This can be accomplished through scenario analysis that tests the impacts of varying assumptions. • Communicating the value and the limitations of the tools to stakeholders to ensure proper use. Communicating the value can generate support for the tools and future enhancements, while communicating limitations can lead to an understanding of (and possibly support for) how the tool can be approved.

[27] Nashville Area Metropolitan Planning Organization. (2010). 2035 Nashville Area Regional Transportation Plan. Nashville, TN. http://www.nashvillempo.org/docs/lrtp/2035rtp/Docs/2035_Doc/2035Plan_Complete.pdf

STEP D.3.3	Implement and enhance capabilities

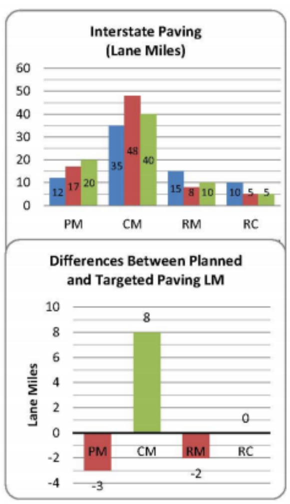
Examples

Pavement Management Analysis: Virginia DOT

Virginia DOT uses a commercial Pavement Management System (PMS) to predict future network-level pavement performance as part of its annual maintenance and operations programming process. The agency sets pavement performance targets at the statewide and district levels. It uses its PMS, together with a companion pavement maintenance scheduling system (PMSS) tool to provide early warning of targets not being reached. This analysis is based on the status of planned paving projects, the most recent pavement condition assessments, and predicted pavement deterioration based on PMS performance models. The pavement management tools allow VDOT to use multi-constraint optimization to predict future needs and performance, and to inform agency business processes (e.g., budgeting and programming). The figure below illustrates one of the reports used to summarize planned versus targeted work by highway system class and treatment type.

Figure D-15: VDOT Comparative Pavement Analysis

Source: Virginia DOT[28]



<u>Hampton Roads Interstate Paving Summary</u>

Preventative Maintenance (PM)	
2011 Awarded (PMSS):	16 LM
2012 Planned (PMSS):	17 LM
2012 Targeted (PMS Optimized):	20 LM
Difference (Planned – Targeted):	**-3 LM**
Corrective Maintenance (CM)	
2011 Awarded (PMSS):	35 LM
2012 Planned (PMSS):	48 LM
2012 Targeted (PMS Optimized):	40 LM
Difference (Planned – Targeted):	**+8 LM**
Restorative Maintenance (RM)	
2011 Awarded (PMSS):	15 LM
2012 Planned (PMSS):	8 LM
2012 Targeted (PMS Optimized):	10 LM
Difference (Planned – Targeted):	**-2 LM**
Reconstruction / Major Rehab (RC)	
2011 Awarded (PMSS):	10 LM
2012 Planned (PMSS):	7 LM
2012 Targeted (PMS Optimized):	7 LM
Difference (Planned – Targeted):	**0 LM**

Given planned 2012 Interstate paving, Hampton Roads District:

- **<u>Is not</u>** predicted to achieve its 20 lane mile paving target for Preventative Maintenance on the Interstate system.
- **<u>Is</u>** predicted to achieve its 40 lane mile paving target for Corrective Maintenance on the Interstate system.
- **<u>Is not</u>** predicted to achieve its 10 lane mile paving target for Restorative Maintenance on the Interstate system.
- **<u>Is</u>** predicted to achieve its 7 lane mile paving target for Reconstruction / Major Rehabilitation on the Interstate system.

[28] Virginia Department of Transportation. (2014). Use of VDOT's Pavement Management System to Proactively Plan and Monitor Pavement Maintenance and Rehabilitation Activities to Meet the Agency's Performance Target. Richmond, VA. https://vtechworks.lib.vt.edu/bitstream/handle/10919/56388/ICMPA9-000321.PDF?sequence=2&isAllowed=y)

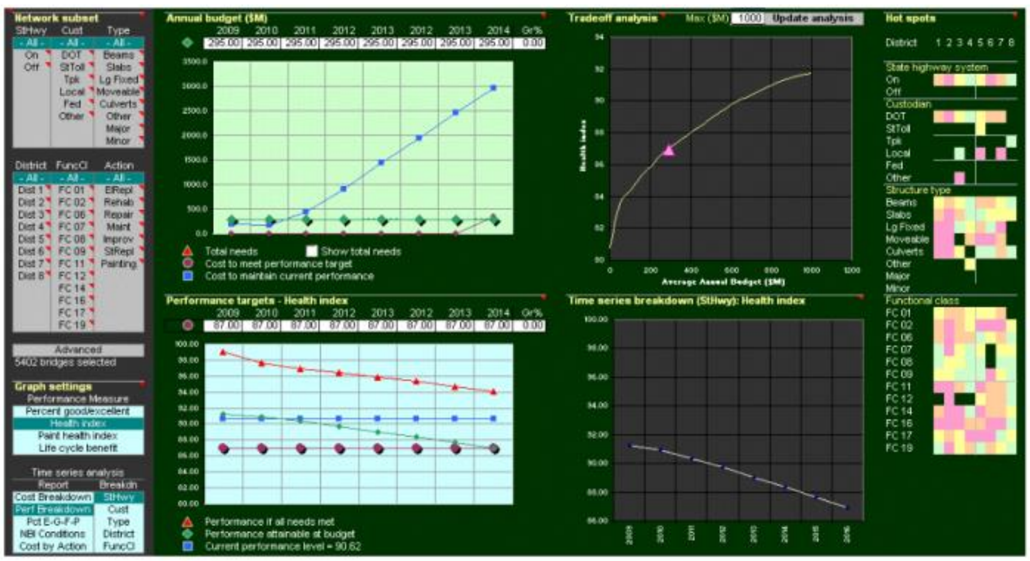
STEP D.3.3	Implement and enhance capabilities

Bridge Management System Enhancements: Florida DOT[29]

Florida DOT implemented the AASHTO Pontis Bridge Management System as part of an effort to improve its asset management information quality, and support decision-making at the network and project levels. Since its initial implementation, Florida DOT has made a number of customized enhancements, such as improving its deterioration and cost models, and implementing multi-objective optimization. Florida DOT uses the outputs of the bridge management system to forecast life cycle costs for planning of maintenance, repair, rehabilitation, and replacement work, and to forecast National Bridge Inventory bridge condition measures. This is helpful for resource allocation, as the software predicts bridge performance levels given different funding scenarios.

Figure D-16: FDOT Pontis Bridge Management System

Source: Florida Department of Transportation[30]



Linkages to Other TPM Components

Component 03: Performance-Based Planning

Component 04: Performance-Based Programming

Component A: Organization and Culture

Component C: Data Management

(See TPM Framework)

[29] Sobanjo, John O. and Paul D. Thompson. (2011). *Final Report: Enhancement of the FDOT's Project Level and Network Level Bridge Management Analysis Tools*. Prepared for Florida Department of Transportation. http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_MNT/FDOT_BDK83_977-01_rpt..pdf

[30] Florida Department of Transportation. (2011). Enhancement of the FDOT's Project Lvel and Network Level Bridge Management Analysis Tools. Tallahassee, FL. http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_MNT/FDOT_BDK83_977-01_rpt..pdf

RESOURCES

General Resources	Year	Link
TPM Toolbox	2016	www.tpmtools.org
AASHTO Asset Management Guide, Volume 2	2013	https://www.fhwa.dot.gov/asset/pubs/hif13047.pdf
NCRHP Report 666: Target Setting Method and Data Management to Support Performance-Based Resource Allocation by Transportation Agencies	2010	http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_666.pdf
NCHRP Report 800: Successful Practices in GIS-Based Asset Management	2015	http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_800.pdf
NCHRP Report 814: Data to Support Transportation Agency Business Needs: A Self-Assessment Guide	2015	http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_814.pdf
Data Systems and Asset Management Including 2014 Thomas B. Deen Distinguished Lecture	2014	http://trrjournalonline.trb.org/toc/trr/2460

Pavement Resources	Year	Link
AASHTO Pavement Management Guide, 2nd Edition	2012	https://bookstore.transportation.org/collection_detail.aspx?ID=117
Pavement Health Track (PHT) Analysis Tool, Summary Report	2013	https://www.fhwa.dot.gov/pavement/healthtrack/pubs/technical/technical.pdf
FHWA Long Term Pavement Performance (LTPP) Website	2015	http://www.fhwa.dot.gov/research/tfhrc/programs/infrastructure/pavements/ltpp/
NCHRP Synthesis 335: Pavement Management Applications Using Geographic Information Systems	2004	http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_335.pdf
Database Development for an HMA Pavement Performance Analysis System	2008	http://wisdotresearch.wi.gov/wp-content/uploads/06-13hmadatabase-f.pdf

Bridge Resources	Year	Link
NCHRP Report 590: Multi-Objective Optimization for Bridge Management Systems	2007	http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_590.pdf
FHWA Long Term Bridge Performance Website	2015	https://www.fhwa.dot.gov/research/tfhrc/programs/infrastructure/structures/ltbp/

Bridge Resources	Year	Link
Creation of Long-Term Bridge Performance (LTBP) Bridge Portal: A Web-based Application with Advanced Visualization and Analysis Tools		

Safety Resources	Year	Link
Highway Safety Manual, First Edition, with 2014 Supplement	2014	https://bookstore.transportation.org/collection_detail.aspx?ID=135
NCHRP Research Results Digest 329: Highway Safety Manual Data Needs Guide	2008	http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rrd_329.pdf
AASHTOWare Safety Analyst Website		http://www.safetyanalyst.org/
Development of a Visualization System for Safety Analyst	2014	http://trrjournalonline.trb.org/doi/10.3141/2460-19
Crash Modification Factors Clearinghouse	2015	http://www.cmfclearinghouse.org/about.cfm
FHWA Highway Safety Information System, Safety Analysis Tools Website	2015	http://www.hsisinfo.org/hsis.cfm?type=6
Exploring Clusters of Contributing Factors for Single-Vehicle Fatal Crashes Through Multiple Correspondence Analysis	2014	http://trid.trb.org/view/1286022

System Performance and Freight Resources	Year	Link
FHWA Traffic Monitoring Guide	2013	https://www.fhwa.dot.gov/policyinformation/tmguide/
FHWA Freight Analysis Framework	2015	http://ops.fhwa.dot.gov/FREIGHT/freight_analysis/faf/index.htm
NCFRP Report 8: Freight Demand Modeling to Support Public Sector Decision Making	2010	http://onlinepubs.trb.org/onlinepubs/ncfrp/ncfrp_rpt_008.pdf
SHRP 2 Report S2-L02-RR-2: Guide to Establishing Monitoring Programs for Travel Time Reliability	2014	http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_S2-L02-RR-2.pdf
SHRP 2 Report S2-L05-RR-2: Guide to Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes	2014	http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_S2-L05-RR-2.pdf
SHRP 2 Report S2-L04-RR-1: Incorporating Reliability Performance Measures into Operations and Planning Modeling Tools	2014	http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_S2-L04-RR-1.pdf

System Performance and Freight Resources	Year	Link
SHRP 2, EconWorks Wider Economic Benefits Analysis Tools		https://planningtools.transportation.org/75/analysis-tools.html
SHRP 2 Report S2-C20-RR-1: Freight Demand Modeling and Data Improvement	2013	http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_S2-C20-RR-1.pdf
Wide-area Congestion Performance Monitoring Using Probe Data	2013	http://trid.trb.org/view/1238533
NCHRP Synthesis 406: Advanced Practices in Travel Forecasting	2010	http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_406.pdf
NCHRP Synthesis 384: Forecasting Metropolitan Commercial and Freight Travel	2008	http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_384.pdf

ACTION PLAN

1. Of the TPM subcomponents discussed in this chapter, which one would you like to work on?

- ❑ D.1 Data Exploration and Visualization
- ❑ D.2 Performance Diagnostics
- ❑ D.3 Predictive Capabilities

2. What aspect of the TPM process listed above do you want to change?

3. What "steps" discussed in this chapter do you think could help you address the challenge noted above?

Data Exploration and Visualization

- ❑ Understand requirements
- ❑ Assess data usability
- ❑ Design and develop data views

Performance Diagnostics

- ❑ Compile supporting data
- ❑ Integrate diagnostics into analysis and reporting processes

Predictive Capabilities

- ❑ Understand requirements
- ❑ Identify and select tools
- ❑ Implement and enhance capabilities

4. To implement the "step" identified above, what actions are necessary, who will lead the effort and what interrelationships exist?

Action(s)	Lead Staff	Interrelationships

5. What are some potential barriers to success and what solutions did this guidebook provide?

6. Who is someone (internal and/or external) I will collaborate with to implement this action plan?

7. How will I know if I have made progress (milestones/timeframe/measures)?

FIGURE INDEX

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