



U.S. Department of Transportation  
Federal Highway Administration



# Showcasing Visualization Tools in Congestion Management



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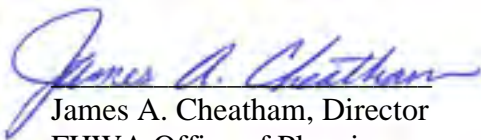
Dear Colleague:

The Federal Highway Administration's (FHWA) Office of Planning, Environment, and Realty, in collaboration with the FHWA Office of Operations and the Federal Transit Administration's (FTA) Office of Planning and Environment, has developed two new products to advance the Congestion Management Process (CMP). These two products, *The Congestion Management Process: A Guidebook* and a summary report *Showcasing Visualization Tools in Congestion Management*, have been developed to act as a companion package of documents and reflect strong, continuing collaboration among FHWA, FTA, and professionals in metropolitan transportation planning processes nationwide.

These documents stand as products of FHWA's and FTA's on-going effort to provide assistance in implementing key provisions of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users. These documents do not create new requirements, but merely provide suggested approaches for integrating the CMP into metropolitan transportation planning processes.

We look forward to receiving your feedback, reactions, and experiences in implementing these concepts and utilizing these resources. Please direct any comments, questions, and suggestions to Egan Smith at [egan.smith@dot.gov](mailto:egan.smith@dot.gov) or (202-366-6072); or John Sprowls at [john.sprowls@dot.gov](mailto:john.sprowls@dot.gov) or (202-366-5362).

Sincerely yours,



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<b>16. Abstract</b> This publication is a summary report describing visualization practices used as part of the congestion management process (CMP), and is a supplement to the CMP Guidebook. These visualizations include maps, charts, graphs, photographs, videos, and computer illustrations and simulations. The report is organized both in terms of the type of visualization and the type/source of data, and includes many examples of visualizations used in CMPs around the nation.			
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# Table of Contents

<b>1–Introduction.....</b>	<b>1</b>
The role of visualizations in the Congestion Management Process.....	1
Visuals for Specific Audiences .....	2
<b>2–Data Types Used in Visualizations .....</b>	<b>3</b>
Types of data and use of data .....	3
<b>3–Visualization Methods Used in CMP Activities .....</b>	<b>5</b>
Displays of measured congestion based on observed data.....	5
Displays of forecasted or modeled conditions .....	15
Displays of congestion trends and variability observed over time.....	21
Displays of reliability data .....	24
Displays of multimodal and transit data .....	25
Displays of recommended strategies for implementation .....	26
Charts, graphs, and tables .....	27
Use of visuals to differentiate among CMP strategy options .....	29
Use of video or animation in visuals.....	31
<b>4–Visualizations Used in Related Transportation Activities .....</b>	<b>32</b>
<b>5–Conclusion .....</b>	<b>32</b>
Lessons learned and future directions.....	33





# 1—Introduction

This report showcases approaches to visualization that are used in the Congestion Management Processes (CMP) conducted by metropolitan planning organizations (MPOs). This report has been prepared as one of the inputs to the development of an updated guidebook on the CMP for the Federal Highway Administration (FHWA) and Federal Transit Administration (FTA). It highlights effective visualization practices that are currently in use by MPOs, noting examples of these practices, and the purpose, primary audience, and data and analysis requirements of the visualizations.

The use of visualizations to display information about the congestion of transportation systems is evolving, and may occur both within and outside of the CMP. Applications of the evolving techniques to CMPs can lead to an improved understanding of congestion issues by transportation planning staff preparing the CMP, to more informed decision making by the appointed and elected officials, and finally to the implementation of more effective congestion management solutions.

## ***The role of visualizations in the Congestion Management Process***

Clear, concise visuals—such as annotated maps, graphs, photos, illustrations, and videos—can allow the audience to quickly understand an important topic more effectively than through statistics and numerical tables. Consequently, visualization can be a very effective tool for presenting transportation performance data and information in ways that can be understood and absorbed by various audiences, including technical staff, transportation decision-makers, and the general public.

Visualization serves three essential functions within an MPO's CMP, from the information gathering that occurs at the beginning of the process to the dissemination of information at the end. Visualization:

- Facilitates analysis of congestion problems by technical staff through the “mining” of data sources for pertinent information about congestion, such as location, extent, intensity, duration, and causality, and through organization of congestion-related data, as maps, graphs, and charts, for analysis purposes;
- Enables the professional staff involved in the CMP to more effectively discuss congestion problems and develop solutions with a mutual and more informed understanding of the congested conditions throughout the region; and
- Provides a means to effectively communicate that information to decision-makers and public about the status of congestion and the need for congestion management strategies in the metropolitan area.

These three functions are related, but differentiated primarily by the intended use (helping with the detailed technical analysis, developing a staff consensus, or decision-support and public education). Many CMPs have visualizations with components of each of these broad purposes. Typically information needs drive analysis and data—and in the reverse, the availability of data, analysis methods, and display techniques impact the information available for decision making.

Several MPOs develop materials that are intended to present the information collected and analyzed through the CMP to the public, and disseminate these either through reports or websites. While these materials are generally broad in scope, they often include visuals such as maps of congested locations or bar graphs of changes in transportation system use over time, which are intended to convey a simple message about congestion in the area, and how it relates to other parts of the planning process. For example, if a major

project was recently implemented in an effort to mitigate congestion in an area, a before-and-after visualization (such as a color-coded map of level of service, a graph of vehicle delay, or a series of photographs of actual conditions) could be used to convey the impact the project had. Similarly, if one location within an MPO stood out as a result of the CMP analysis as an area most in need of congestion mitigation, a visual could be used to express that to the public. The primary concern in developing visualizations for the public is to ensure that they are easy to understand and that the intended message is clear.

Visualizations, especially map-based, can also serve as a valuable tool in organizing data and making it easier to analyze on a technical level. Some visualizations are more schematic in their representations of data patterns, or blend schematic with map-based formats. The fact that much of the data collected for the CMP is geographically-based (tied either to an area, a corridor or a spot location) makes mapping especially important for practitioners, both within an MPO and at partner agencies outside the MPO. Mapping can be done on paper, through a GIS program, or through an online mapping service, depending on the data and the MPO's capabilities. Graphs and photographs can also be effective tools in helping practitioners analyze and apply the large volumes of data that are often collected or gathered as part of a CMP effort. If kept relatively simple and easy to read, these display maps of technical data with concise annotations can also be an effective tool for reaching the general public.

### ***Visuals for Specific Audiences***

MPOs create visualizations geared specifically toward different audiences. These visualizations are accessible to everyone, but may be most useful for specific sectors of the population. Some visualizations are more technical and are most practical for internal use as opposed to public consumption. For instance, visualizations depicting detailed level-of-service likely are most valuable for decision-makers and planners in determining where to focus congestion management efforts. For example, Puget Sound Regional Council uses a geodatabase with shapefiles showing land use attributes, congestion and level-of-service at points in the region in order to help planners better identify regional needs based on multiple factors.

Conversely, visualizations that show “before and after” alternatives are constructive for the public and stakeholders without expertise in transportation planning or analysis, since these visualizations clearly and visually lay out the results of different congestion management options. Scenario development can also be used to educate the public on the impacts of different land use decisions on transportation needs in a region. MPOs such as the Wilmington Area Planning Council house interactive maps developed using Google Maps, which allow viewers to pan and zoom so they can see the data on either a regional or a detailed scale. For example, people can zoom to the street level within their community or neighborhood to find the specific data for that area. The Atlanta Regional Council uses “travel time shed” diagrams to show policymakers how long it takes to travel from the downtown area outward.

There are no cut-and-dried rules for determining which visualization types are most useful for specific audience types. However, it is clearly necessary to consider the intended audience and use in determining the best visualization approach to use.

## 2–Data Types Used in Visualizations

Visualizations are tools to summarize an extensive amount of data into a more easily comprehensible set of information. This data can come from multiple sources. Data may be directly *collected* by the MPO utilizing in-house staff and resources or temporary personnel, or through consultants. For instance, many MPOs conduct travel time studies, traffic counts, or intersection studies. Data may also be *gathered* by the MPO from external, secondary sources that collect data for a different main purpose. For instance, data may include transit operations data from transit providers or archived ITS data from traffic flow detectors used by transportation operations organizations. Some of these sources may actually be more useful, easier to gather, more detailed, or less costly than directly-collected data would be.

It is also important to note another distinction in the information used in creating visualizations. Most MPOs use *observed data* while some also use *simulated or forecasted information*. Observed data may not always be available for the desired analysis but there may be similar or related types of information from the travel demand modeling system, which can lead an MPO to rely on modeled information instead of observed data. When the CMP is dealing with future scenarios, modeling of information is necessary. When dealing with recent or past conditions, observed data is often more accepted by decision makers. Many of the visualization tools can be used either with observed data or modeled information, but it is important to be aware that the public or decision-makers may mistake modeled data for visualizations of “observed” data.

At many MPOs the collection and gathering of data lies at the heart of CMP activities. These data activities take many forms, ranging from the manual collection of speed data through travel-time runs to the gathering of vast data repositories available through Intelligent Transportation System (ITS) and Advanced Transportation Management System (ATMS) activities. In many cases, data is gathered from existing data sources at partner agencies, such as crash databases from the state police or state DOT. As noted above, MPOs also tend to use results from modeling simulations as part of the CMP, due in part to the fact that historically, the communication of the results of forecasts of future congestion conditions has been a major part of the activities of MPOs. There can sometimes be a very large amount of such modeled information, depending on the complexity of the model and the number of scenarios tested using the model. One major challenge for MPOs is how to organize, interpret, and use the large volumes of data and processed information that are available for use. Visualization can be an effective tool for doing this, and then for presenting the most pertinent information to the public. This section focuses on the different data types that are used in CMP visualizations.

### ***Types of data and use of data***

There are many types of data that can be used in visualizations as part of the CMP process. Data types are often differentiated or categorized according to the source or underlying nature of the data. The following list is not exhaustive, but includes several common types of data that are used in CMP-related visualizations by MPOs.

- **Volume-based data on the quantity of system use:** Volume, expressed either as Annual Average Weekday Daily Traffic (AAWDT) or Vehicle-Miles-of-Travel (VMT), is a widely-available dataset at most MPOs around the nation. Volume per se is not a true measure of congestion; rather it is a measure of the *quantity* of use, while congestion is a measure of the *quality* of use of the system. Nevertheless, volume can, in certain circumstances, be an effective proxy measure of congestion. This is the type of data typically

used in summary analyses of regional congestion. Some MPOs also collect detailed traffic counts—including such items as vehicle classification, time-of-day (typically in 15 minute increments), and turning movements—as part of detailed CMP analyses at problem locations.

- **Aerial photography data:** Aerial photographs can be used as a source of data showing the number and density of vehicles along a corridor at any given time. When conducted iteratively, the photographs can provide data on average conditions in the corridor. This information is typically used for corridor-level analyses of recurring congestion. For freeway uninterrupted flow conditions, the density of traffic (the number of vehicles per mile per lane) is the preferred measure of congestion in accordance with the Highway Capacity and Quality of Service Manual. Several MPOs contract with private sector vendors to periodically carry out such corridor sampling, as well as to prepare region-wide summaries that aggregate the observed data from the individual corridors.
- **Speed and travel time data:** Travel time and speed samples are conducted by many MPOs as part of the CMP process to directly observe congested conditions. These are generally conducted using GPS technology to measure link-speeds rather than spot speeds as spot speeds have considerable variation, particularly on arterials. The use of GPS technology also allows easy transfer of the data into a Geographic Information System (GIS) program. Such speed data studies can also be conducted using on-board diagnostics programs (necessary in some locations with poor GPS reception) or manually using a stopwatch and tape recorder and/or pencil and paper. This information is typically used for corridor-level analyses of recurring congestion. In addition, some MPOs prepare region-wide summaries that aggregate the observed data from the individual corridors.
- **Archived ITS data:** Various operations-related data can be gathered and obtained from Intelligent Transportation Systems (ITS), such as information on combinations of spot-speeds, volumes, and percent lane-occupancy. The particular information available depends on the detector technology and installation set-up. Estimates of vehicle lengths and lane-occupancy can be used to calculate average spot-speed for short-duration time intervals, sometimes as short as every 20 to 30 seconds. Probe-based data from monitoring the flow of electronic toll-tags are also used in some MPO areas. In addition, data on incident response and the impact of such non-recurring congestion is often used as a source of data on travel time reliability.

ITS data is typically only available on a subset of roads within an area, usually a portion of the freeway network. Some arterial-based data is beginning to become available. There are several private-sector companies that have recently begun using various types of probe vehicles to estimate link travel times and speeds every two to three minutes in many metropolitan areas. These companies are marketing that data source to governmental agencies; some MPOs are beginning to experiment with the use of that type of data to visualize congestion patterns, including variability and reliability. These purchased data sources are also beginning to provide much more widespread coverage of the freeway system as well as major and some minor arterial roads

- **High-Occupancy Vehicle (HOV)/High-Occupancy Toll (HOT) lane data:** Some HOV and HOT networks, especially on HOT lanes that use variable congestion pricing, have data on lane usage and the peak-period congestion characteristics of the facility. The data may be gathered from ITS flow detectors or directly collected by a MPO from their own sampling of traffic on those facilities.
- **Transit data:** A wide range of transit data may be available from transit agencies, including boarding and alighting statistics, total ridership, on-time performance, and transit vehicle capacity. Archived Automatic

Vehicle Location (AVL) data can be especially useful for examining the impact congestion has on on-time performance. Several MPOs also track the usage of park-and-ride facilities as part of the CMP.

- **Bicycle/pedestrian data:** Many MPOs collect data on the location and condition of bicycle/pedestrian facilities, such as sidewalks, bicycle lanes, and off-road paths. Some MPOs are also beginning to collect data on bicycle and pedestrian facility usage, through both manual and automated count methods.
- **Crash data:** Many MPOs use crash data as a method of determining locations where non-recurring congestion due to incidents is more likely to occur. The data is typically provided by the state police or state DOT, but is sometimes also from local sources. Displays and tabular and chart summaries of such data can be a useful supplement to the congestion-based displays.

Data types are often differentiated or categorized according to the underlying nature of the data. One such important aspect of each of these data types to make note of is the distinction between spatial data (what happens at a given location) and temporal data (what happens at a given time or over a period of time). It is generally understood that congestion of component parts of our transportation systems is often very site- or “spatial-specific” as well as time- or “temporal-specific”. Visualization can be an effective means of integrating spatially- and temporally-based data features into a single more understandable display of congestion.

Micro-simulation models used by some MPOs in their analyses of congestion conditions can generate animated simulations that represent the spatial-temporal extent of the build-up and then the dispersion of congestion over an area or along a corridor, as well as the concurrent duration of the congested conditions over time. Static displays, such as time-distance congestion contour displays based upon observed data have long been used in operational planning and are beginning to be used by MPOs in CMP activities.

### 3—Visualization Methods Used in CMP Activities

The following section of this report provides specific examples of different types and methods of visualizations that are utilized by MPOs around the country as part of their CMP activities. These examples range from simple graphs and color-coded maps to complex location-time-delay diagrams, travel time contour maps, photographic simulations, and hybrid combinations of maps and tables.

#### ***Displays of measured congestion based on observed data***

One common type of visualization used as part of the CMP is the mapping of data collected during CMP system monitoring. There are several types of data that are collected by MPOs as part of this monitoring, and there are several ways in which to display the data.

Several examples of visualization techniques are presented in the following section, through a series of graphic examples, in order of increasing complexity. There are examples from other MPOs that could have also been selected, as some of the same techniques are used by different MPOs. For example, the schematic maps of freeway level of service shown in Figure 5 for the Washington area could also have used displays prepared for the North Central Texas COG, the Atlanta Regional Commission, or the East-West Gateway Coordinating Council, all of which have similar displays that have been tailored to their MPO area and needs.



**Figure 1:** Many MPOs collect speed and delay data for corridors as part of their CMP activities. These are often collected by conducting travel time samples, sometimes using GPS technology. These types of data can be displayed on both corridor-level maps and region-wide maps. Corridor maps can be simple color-coded displays, such as those used in the Metroplan CMP for the Little Rock, Arkansas region.

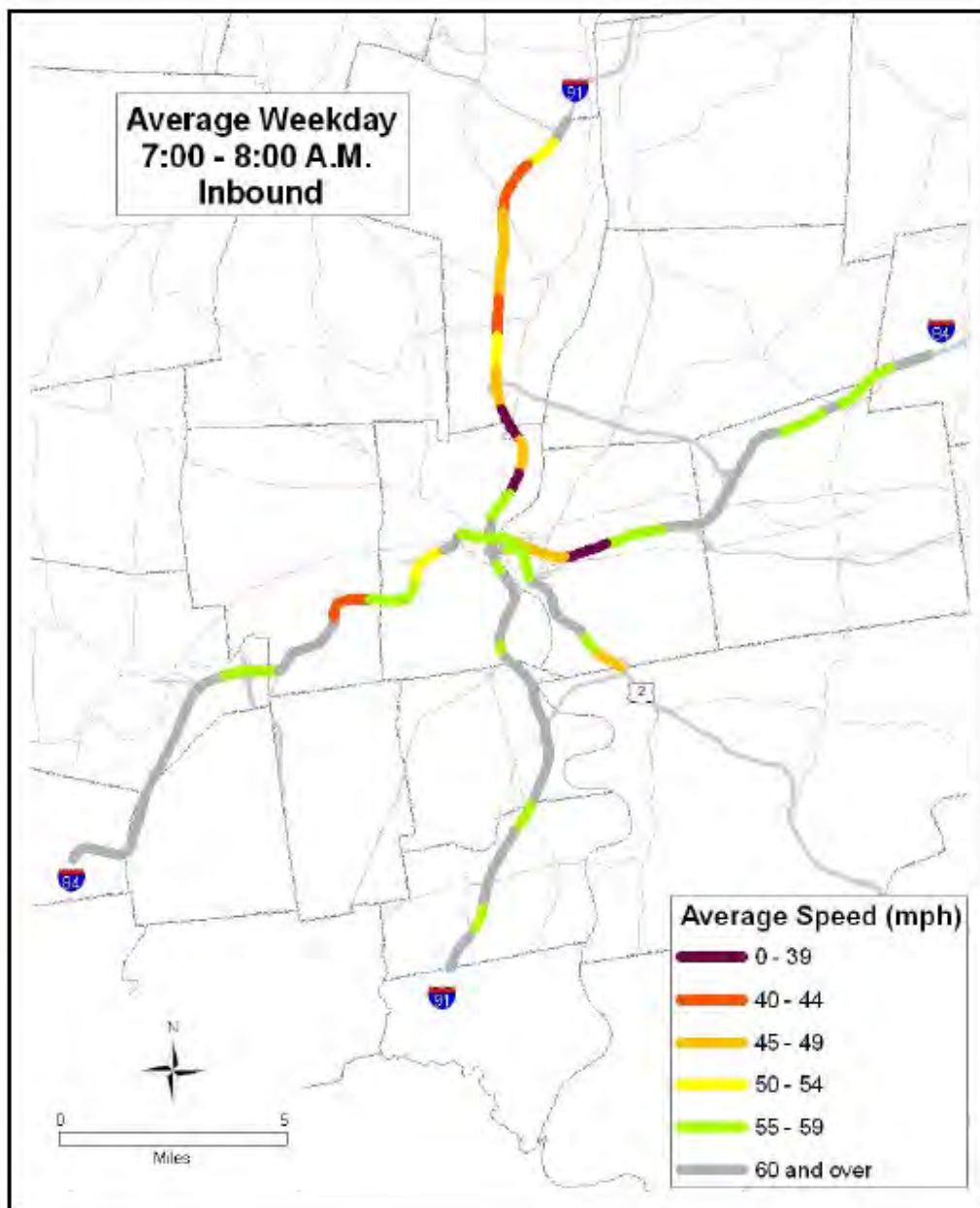
Metroplan utilizes detailed congestion/speed maps such as these in their CMP in order to assess likely sources of congestion and location-specific congestion mitigation strategies for each segment. These strategies may include implementing operational improvements or capacity-adding projects, applying access management (AM) techniques, or using intelligent transportation systems (ITS) technologies.



Source: "2008 CMS Report", Metroplan (Little Rock, AR), 2008

**Figure 2:** This example from the Capitol Region Council of Governments (CRCOG) in Hartford, Connecticut uses similar color-coded schematic maps to display data collected as part of the regional freeway ITS system. The basic color-coded maps are a simple, easily-comprehended method of visualizing this information. More complex maps, such as speed-time-location visuals, are more effective at showing detailed information available from ITS, such as the locations of bottlenecks, the extent of backups, and the duration of congestion, but may be more difficult for non-practitioners to understand.

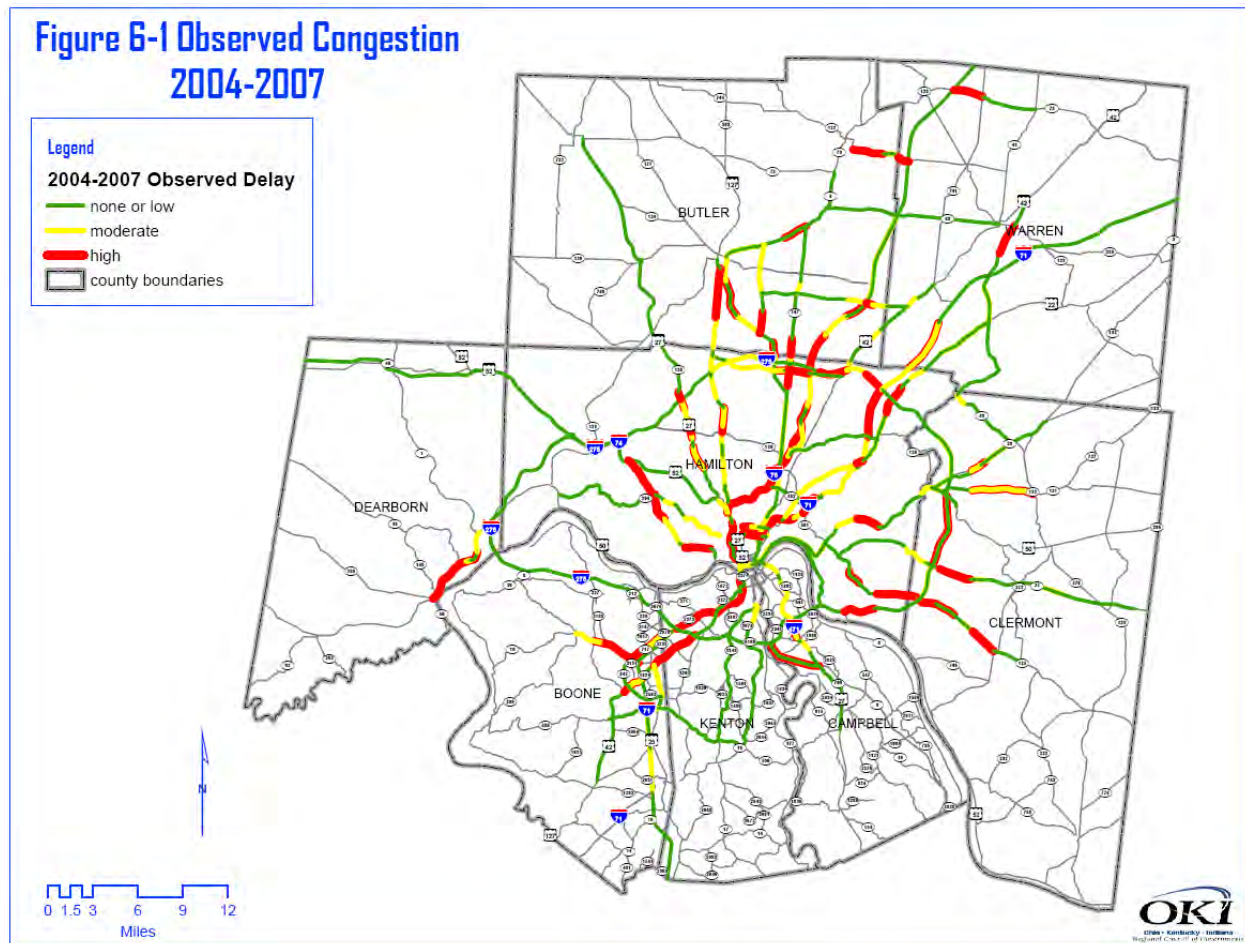
This map allows CRCOG planners to assess segment-level performance and determine how conditions vary within each corridor; ultimately, specific areas can be pinpointed that require attention.



Source: "Transportation Monitoring and Management Report: Metropolitan Hartford Area, 2005", Capitol Region Council of Governments, 2007.

**Figure 3:** This is an example of using regional-scale maps with color-coding to display measured speed and congestion data and metrics derived from these data. This example from the Ohio-Kentucky-Indiana Regional Council of Governments for the Cincinnati, Ohio region uses data derived from travel-time surveys conducted throughout the region over a period of three years.

This map is useful in terms of providing a large picture, generalized depiction of delay: planners can focus in on the most concentrated areas of red, or high delay areas, and determine sources of congestion and methods to minimize it.

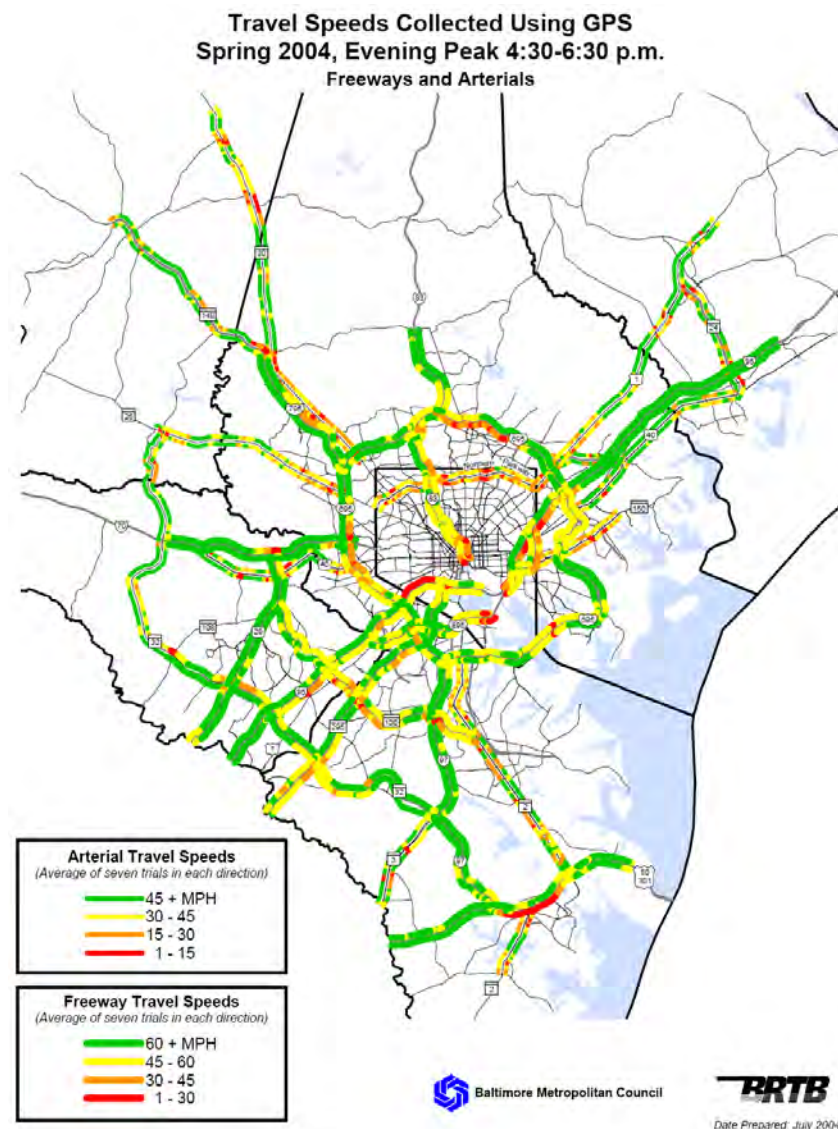


Source: “OKI Congestion Management Process Findings and Analysis”, Ohio-Kentucky-Indiana Regional Council of Governments, 2007



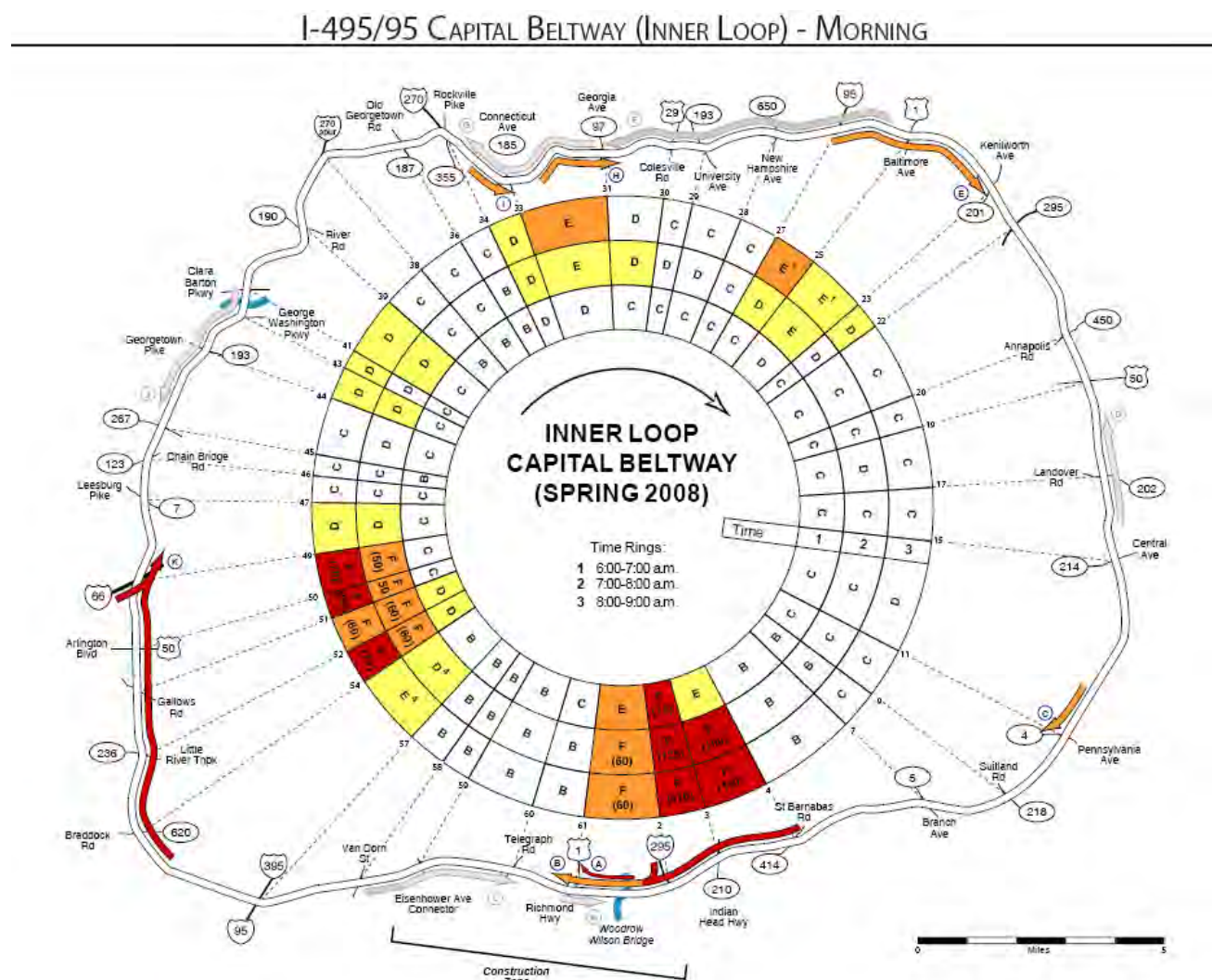
**Figure 4:** This is an example of a region-wide congestion visualization from the Baltimore Metropolitan Council that uses a color-coded palette to display travel time data and metrics. The data source for this display used seven GPS-based travel time samples for the PM peak-period for each corridor, for both directions. Data was averaged across the samples every 1/10<sup>th</sup> of a mile, or about every 500 feet in both directions, using a GIS-based database management system, which also prepared the display. Data for freeways and arterials are shown on the display but different speed ranges are used to reflect differences in link-speed performance for freeways and arterials.

The data collected and the map below allowed the Baltimore Metropolitan Council (BMC) to conduct an analysis highlighting particular segments of roadways in areas that show severe congestion during the evening commute. The observed conditions and causes of congestion on each severely-congested segment are then discussed, enabling segment-specific mitigation to be proposed when BMC decides to act.



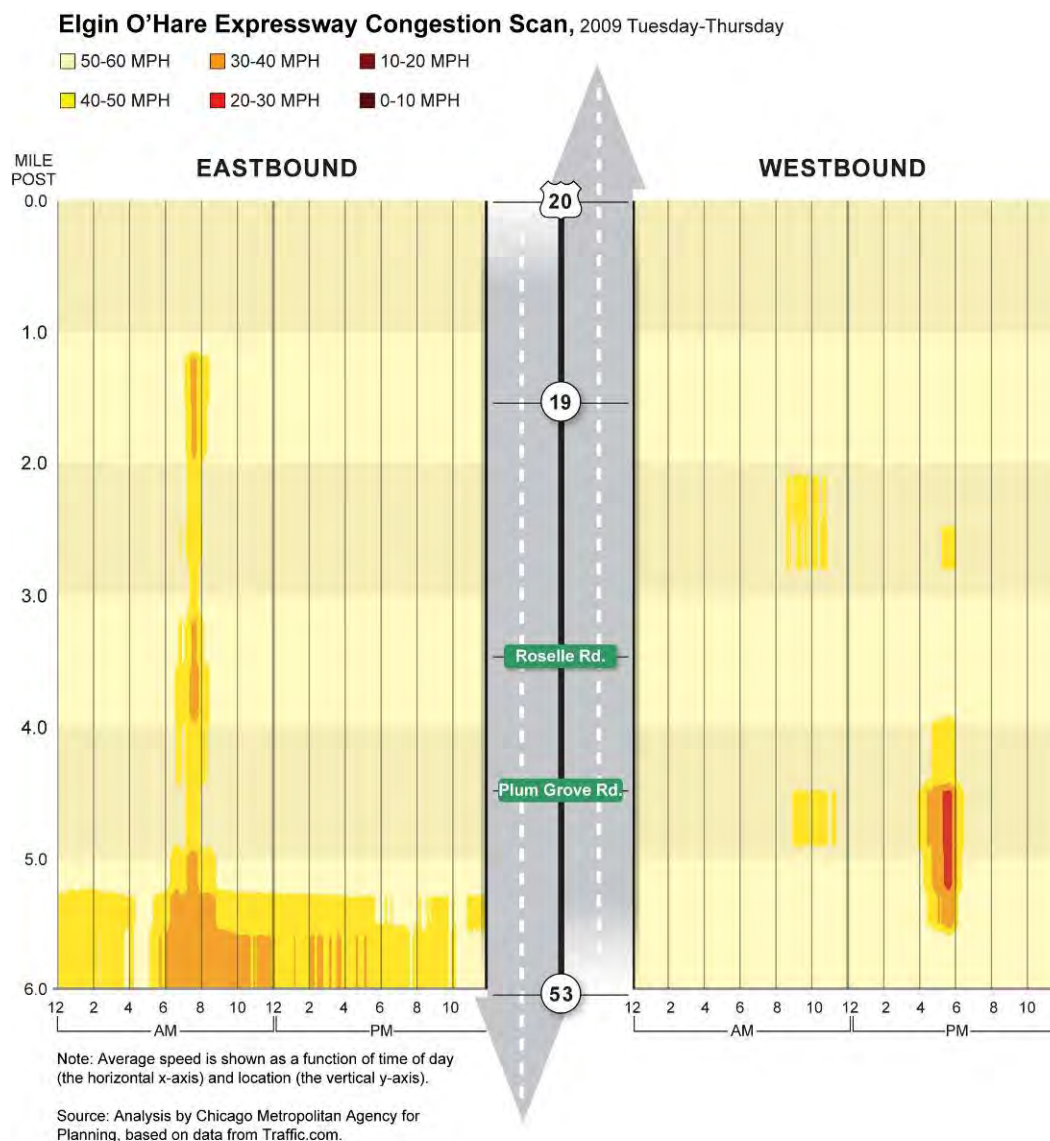
Source: "Congestion Monitoring Using GPS in the Baltimore Region: Travel Speeds in the Evening Peak, Spring 2004", Baltimore Metropolitan Council, 2004

**Figure 5:** At the Metropolitan Washington Council of Governments (MWCOG) in the Washington, DC region, the CMP uses data that is generated from low-level aerial photographic surveys of major corridors. Several passes are made on each photograph run, collecting longitudinal data through each three-hour peak period. The photographic data are then converted into a measure of level-of-service, which can be mapped schematically. Schematic maps are developed to show the congested areas along each corridor, supplemented with level-of-service data in the unique tabular format presented here in Figure 5. An advantage of this technique is that it presents the main message (highly-congested segments of the freeway network) in a clear, easy-to-understand format, while also conveying aspects of the detailed technical information. This is also an example of a combined spatial-temporal display as it shows the variation in congestion by three hourly time periods within the morning 3-hour peak-period. A similar graphic is also available for traffic traveling in the opposite direction around the Capital Beltway. This map allows MWCOG to break apart each congestion location, and define the type of congestion, frequency, direction, estimated speed, and speculated cause of congestion in their CMP.



Source: "Traffic Quality on the Metropolitan Washington Area Freeway System", National Capital Region Transportation Planning Board, Prepared by Skycomp, Inc., May 2009.

**Figure 6:** This example from the Chicago Metropolitan Agency for Planning is a detailed display of a travel speed contour based on archived ITS detector data from a private sector data provider. The graph shows average directional speed by location along the expressway corridor as well as by time of day throughout a selected sample day. This display shows, for example, that the westbound PM congestion conditions occurred over a two hour period between 4 and 6 PM, and were concentrated between about milepost 4.0 and milepost 5.5, with the most concentrated congestion being between mileposts 4.5 and 5.0. This display enables planners to focus in on the most densely congested areas and assess the extent and seriousness of congestion around each area.



Source: Chicago Metropolitan Agency for Planning CMP Performance Measurement Website (2009 data)



**Figures 7a-c:** In the Wilmington Area Planning Council (WILMAPCO) CMP, a wide range of congestion-related measures is displayed in a series of maps, of which three are included here. These displays show observed data, such as travel time and speed in Figure 7a, derived data, such as roadway and intersection level of service in Figure 7b, and gathered data, such as archived crash location/crash rate data in Figure 7c. The regional-scale maps are consistent from metric to metric and from year to year, making them easy to read and making patterns and trends easy to identify.

On WILMAPCO's website, users can click on each of the maps below to view data collected for the CMP through Google Maps technology. These links allow users to explore the details regarding the materials analyzed in determining the CMP corridors and their possible mitigation strategies.

**Figure 7a: Collected Speed Data**

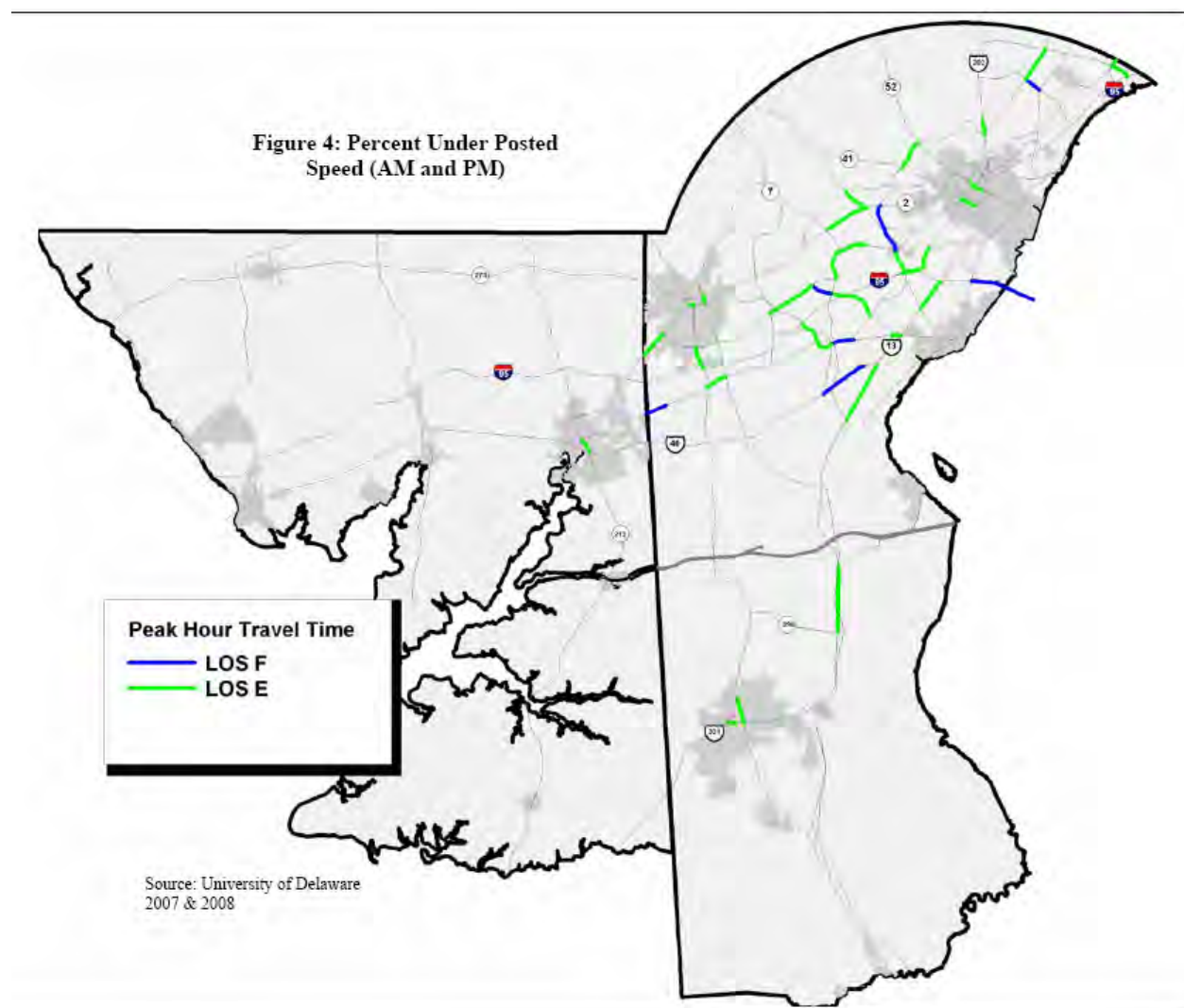


Figure 7b: Derived Level of Service Data

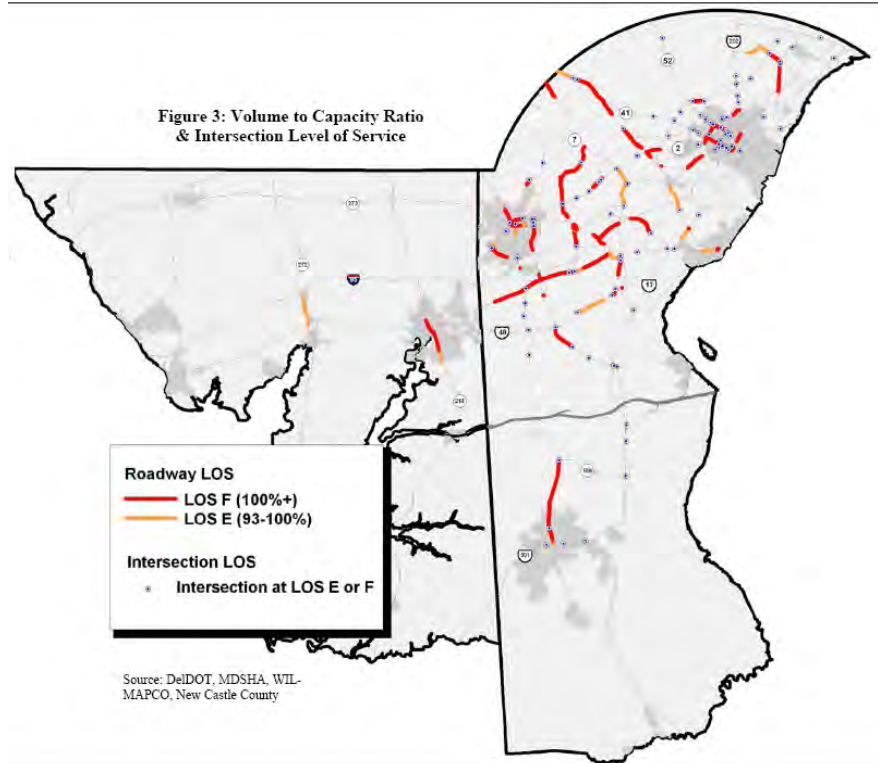
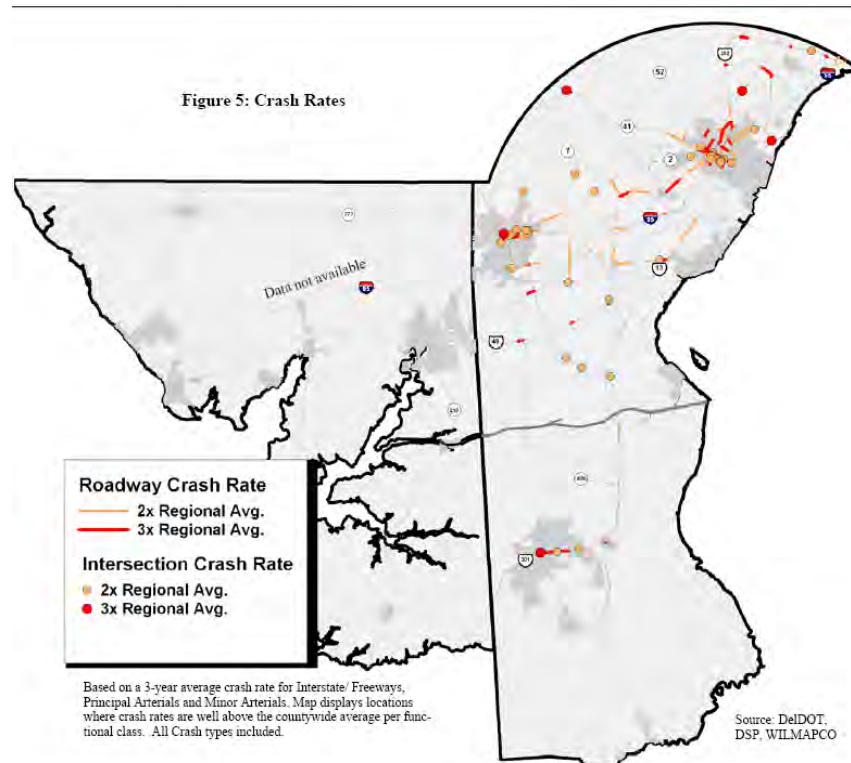


Figure 7c: Gathered Crash Data



Source: WILMAPCO CMS Website: <http://www.wilmapco.org/cms/>

**Figure 8:** The Baltimore Metropolitan Council (BMC) uses interactive mapping to make available map-linked information on the Baltimore region, allowing users to navigate, explore, manipulate, and customize BMC spatial data. The maps are designed to provide information about a particular topic, such as projects in the Transportation Improvement Program, crashes, or traffic counts. This image below overlays BMC color-coded data on level of service (based on observed travel speeds on regional highways) with an image from Google Earth mapping service.

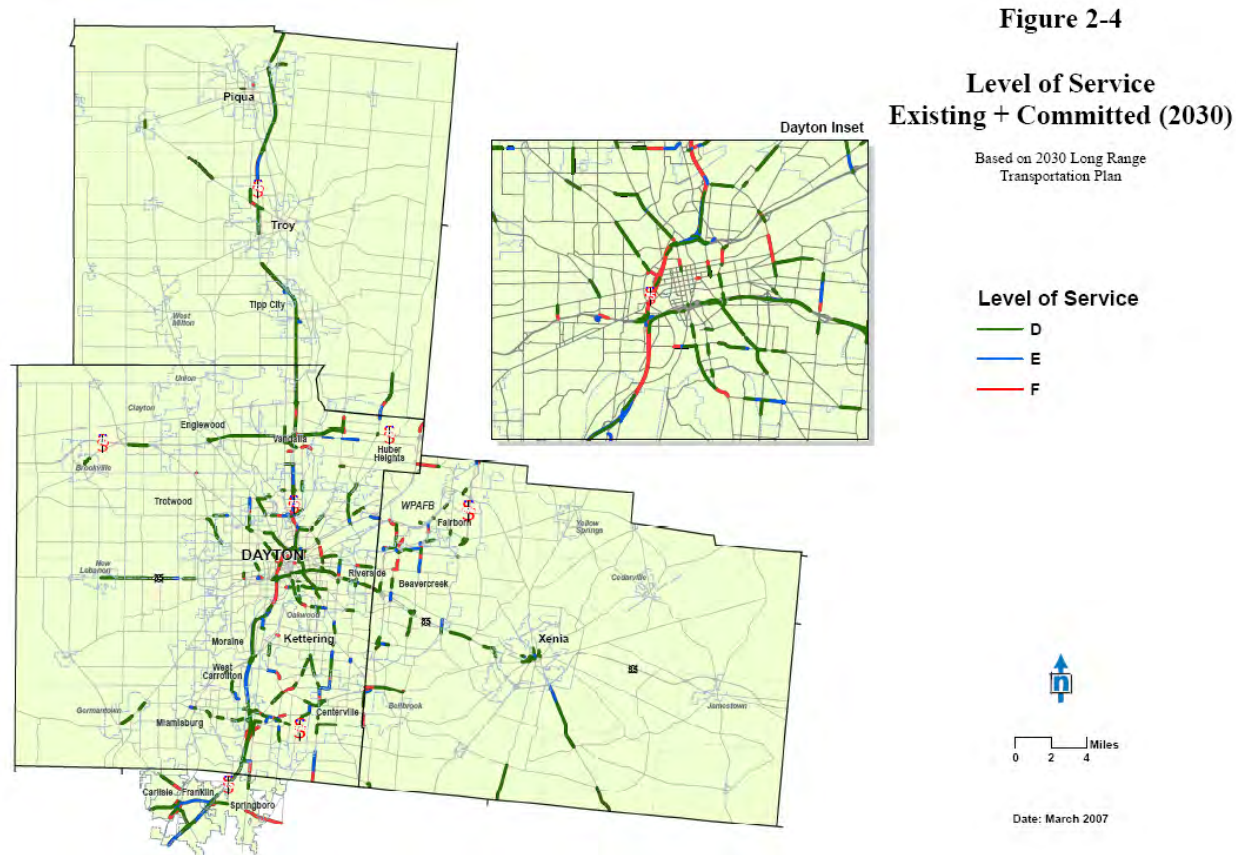


Source: BMC Website: <http://www.baltometro.org/content/view/726/496/>

### Displays of forecasted or modeled conditions

One common analysis approach in many CMPs is to use model results (whether current or forecasted) as a primary information source. Since models themselves are built using geographic data, this information can be easily displayed graphically in the form of maps. There are several ways that modeled results can be shown, including color-coded maps rating corridors and facilities by performance measures, travel time contour maps, maps using model area-based features (such as traffic analysis zones) to display the resulting forecast information, and time-space diagrams. Figures 9 through 13 provide examples of these types of visualizations.

**Figure 9:** The Miami Valley Regional Planning Commission (MVRPC) in the Dayton, Ohio region uses model results of both current and future forecasted conditions as part of its CMP analysis. The results of this analysis are displayed in simple color-coded maps showing the performance of the facilities as measured against several performance measures. This figure shows an example of a map developed by MVRPC, showing level of service for the year 2030, highlighting those areas anticipated to be congested. This allows MVRPC planners time to determine where they need to prepare for minimizing future congestion before it overwhelms the area. They can do this through targeting strategies at certain segments with an “F” level of service in 2030 in a proactive instead of responsive way.

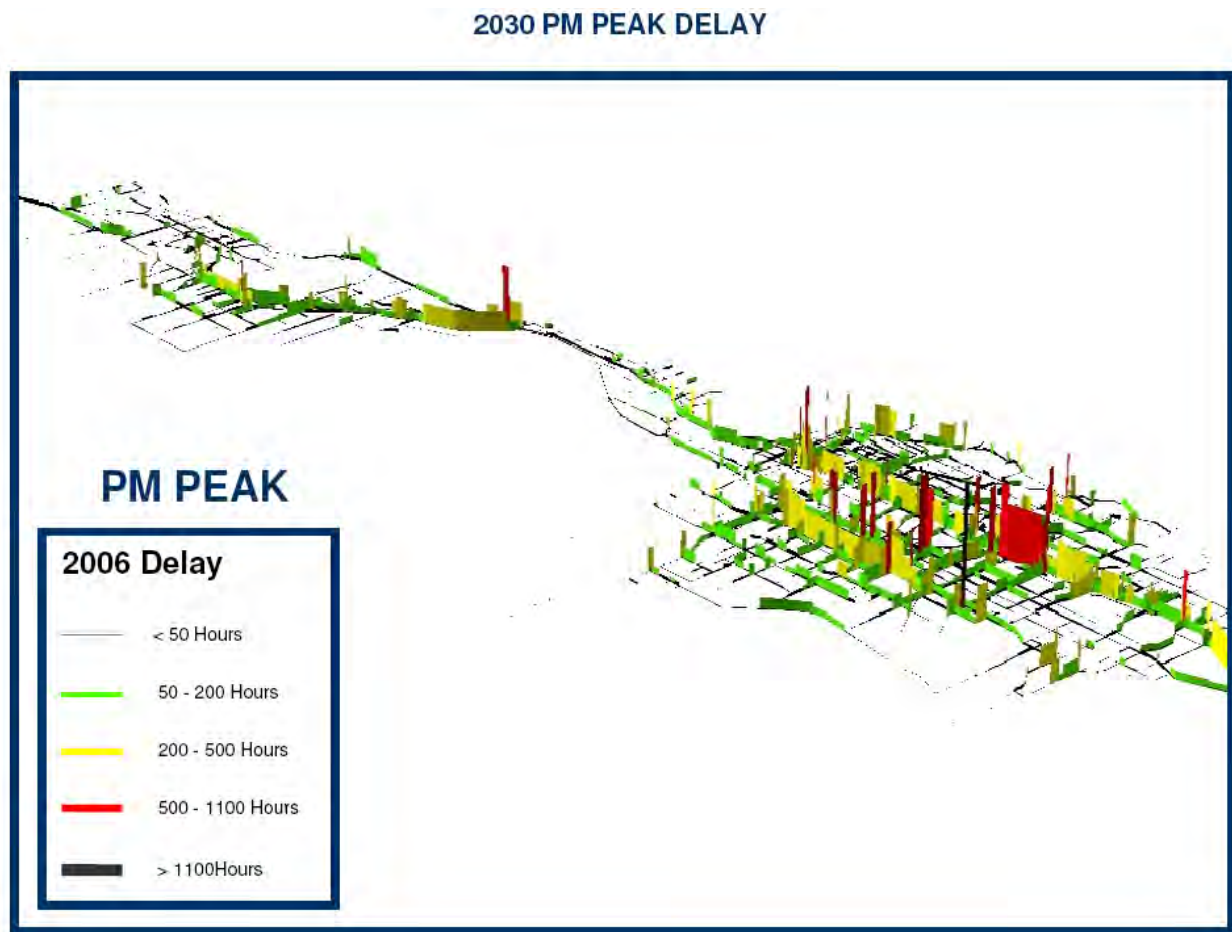


Source: “Congestion Management Process Technical Report”, Miami Valley Regional Planning Commission, 2007.



**Figure 10:** The Wasatch Front Regional Council (WFRC) in the Salt Lake City region uses 3-D graphics as a method of communicating additional information, beyond simple color-coded line maps. This figure is an example of a graphic using both color and vertical height to display regional delay patterns in modeled 2006 and 2030 information, creating an effective visual representation of the locations with significant delay estimates.

Maps quantifying future travel demand such as this one calculate how the existing transportation system would perform in the horizon year 2030, and allow WFRC to identify future transportation system needs, and act now to address them.



Source: "Adopted 2007-2030 Regional Transportation Plan", Wasatch Front Regional Council, 2007.



**Figure 11a:** Travel time contour maps can be made using any type of speed/travel time data, but are typically made using modeled results rather than observed data (or sometimes with a combination of the two) to ensure full coverage of the region. Figure 11a from the Atlanta Regional Commission shows the travel time during the peak period between downtown Atlanta and all points within the MPO area, as well as the non-congested free-flow condition, using 15-minute color-coded bands. This provides a quick snapshot of the effects regional congestion have on regional travel times.

Figure 5-4: PM Period Travel Time Contours (15 minutes) from Downtown-Midtown Activity Center (2005)

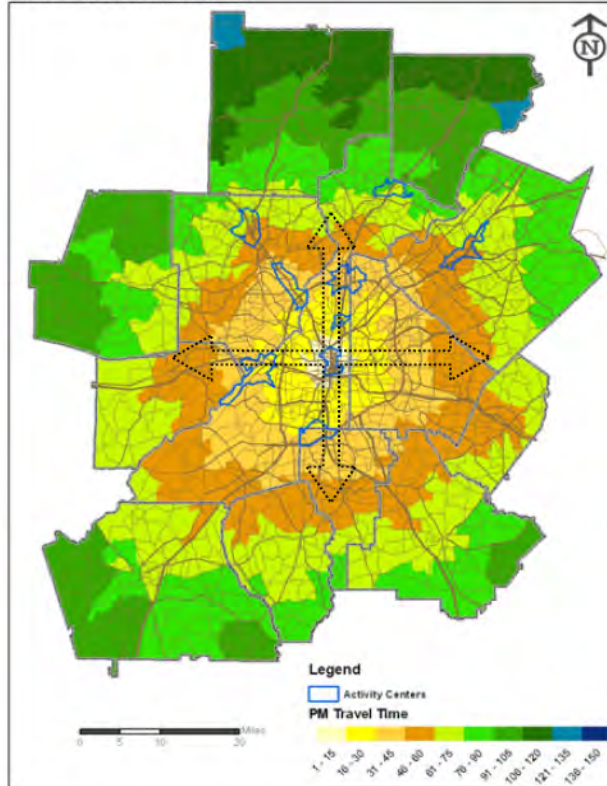
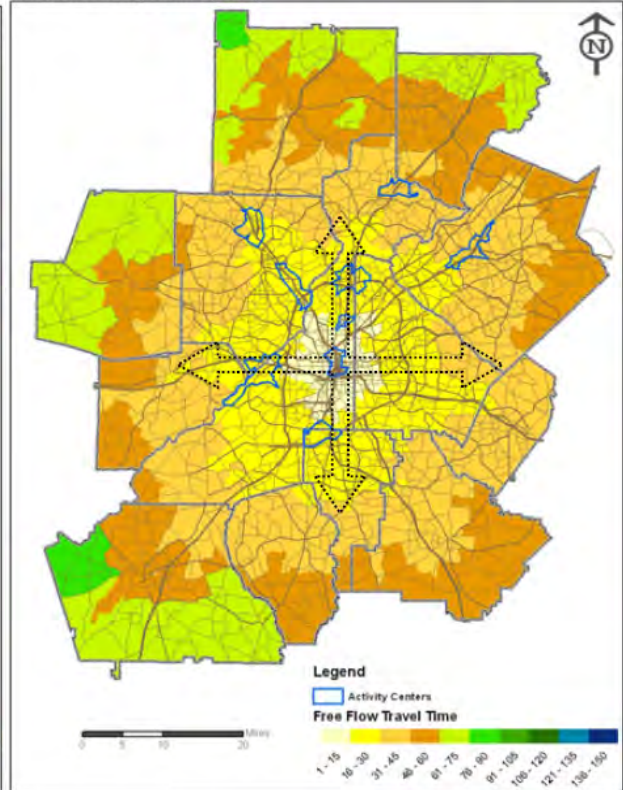
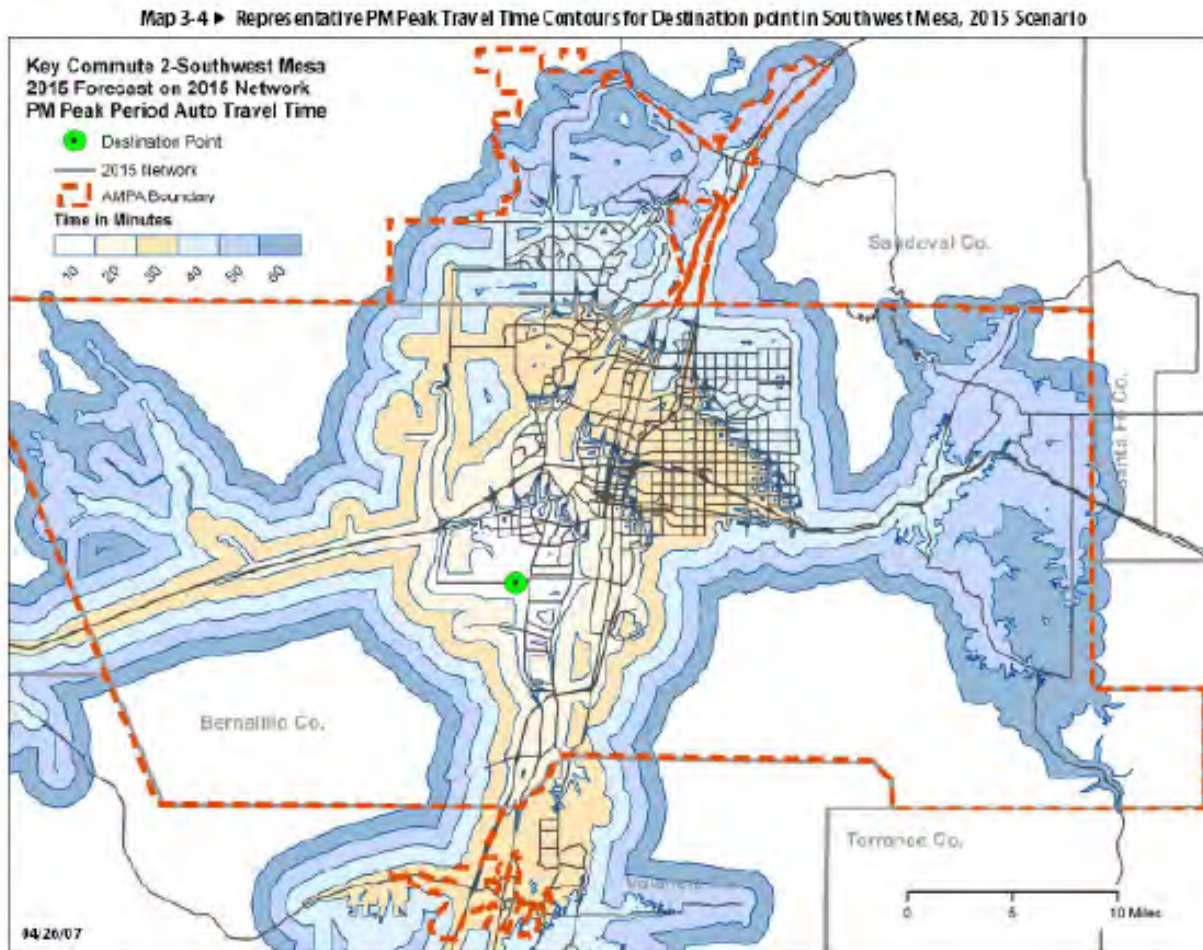


Figure 5-2: Free Flow Travel Time Contours (15 minutes) from Downtown-Midtown Activity Center (2005)



Source: "Congestion Management Process Update 2005: Technical Memorandum 5", Atlanta Regional Commission, 2005.

**Figure 11b:** Similar to the example from Atlanta above, Figure 11b is a travel time contour map from the Mid-Region Council of Governments in Albuquerque, New Mexico. In this example, the contour display is not constrained to the area within the MPO boundary, but is constrained to only show those areas within sixty minutes of the point of destination. This results in a map with a different visual appearance than the Atlanta example, but is based on similar forecasted peak period travel time estimates.

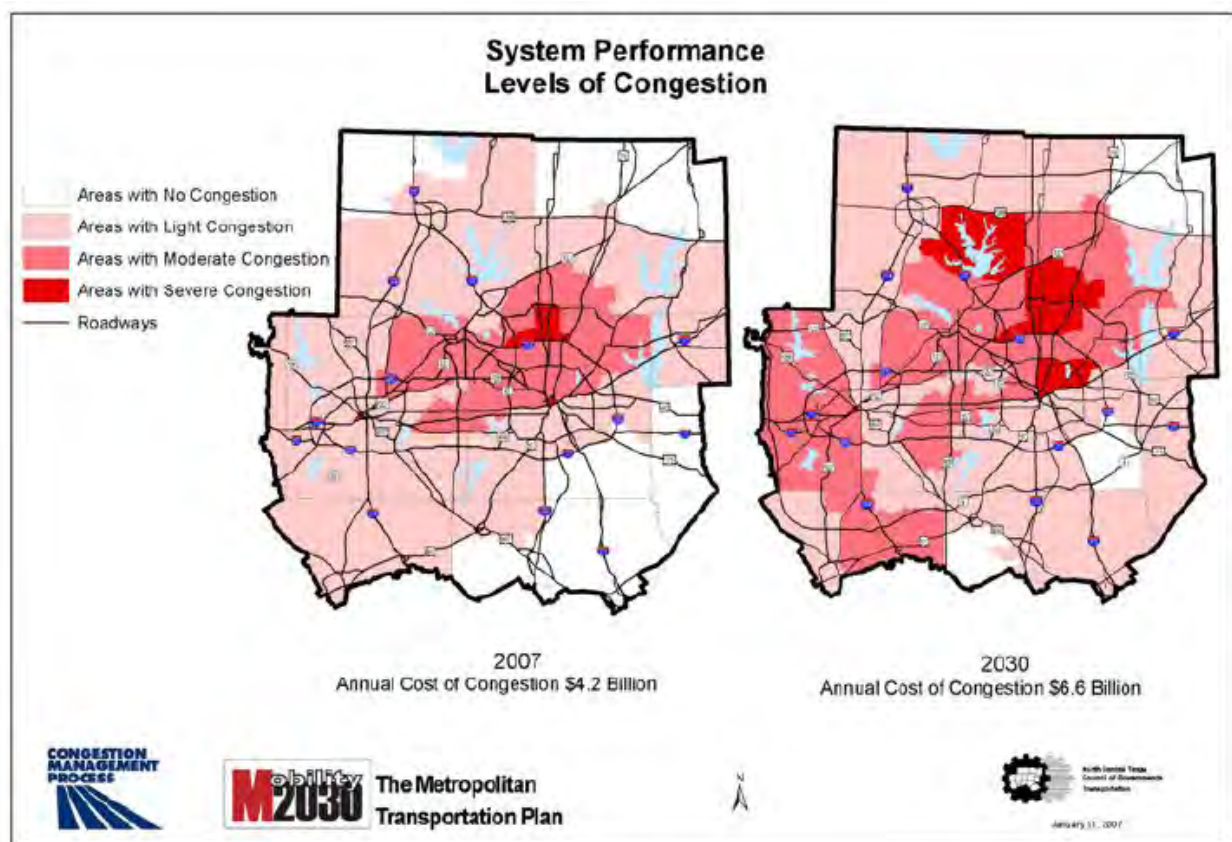


Source: “2030 Metropolitan Transportation Plan”, Mid-Region Council of Governments, 2007.



**Figure 12:** In the Dallas-Fort Worth area, the North Central Texas Council of Governments (NCTCOG) has developed maps showing areas of congestion, as opposed to congested corridors or facilities. These areas are defined based on various performance measures, applied to geographic areas (such as traffic analysis zones in the regional model). Figure 12 shows an example of this type of map.

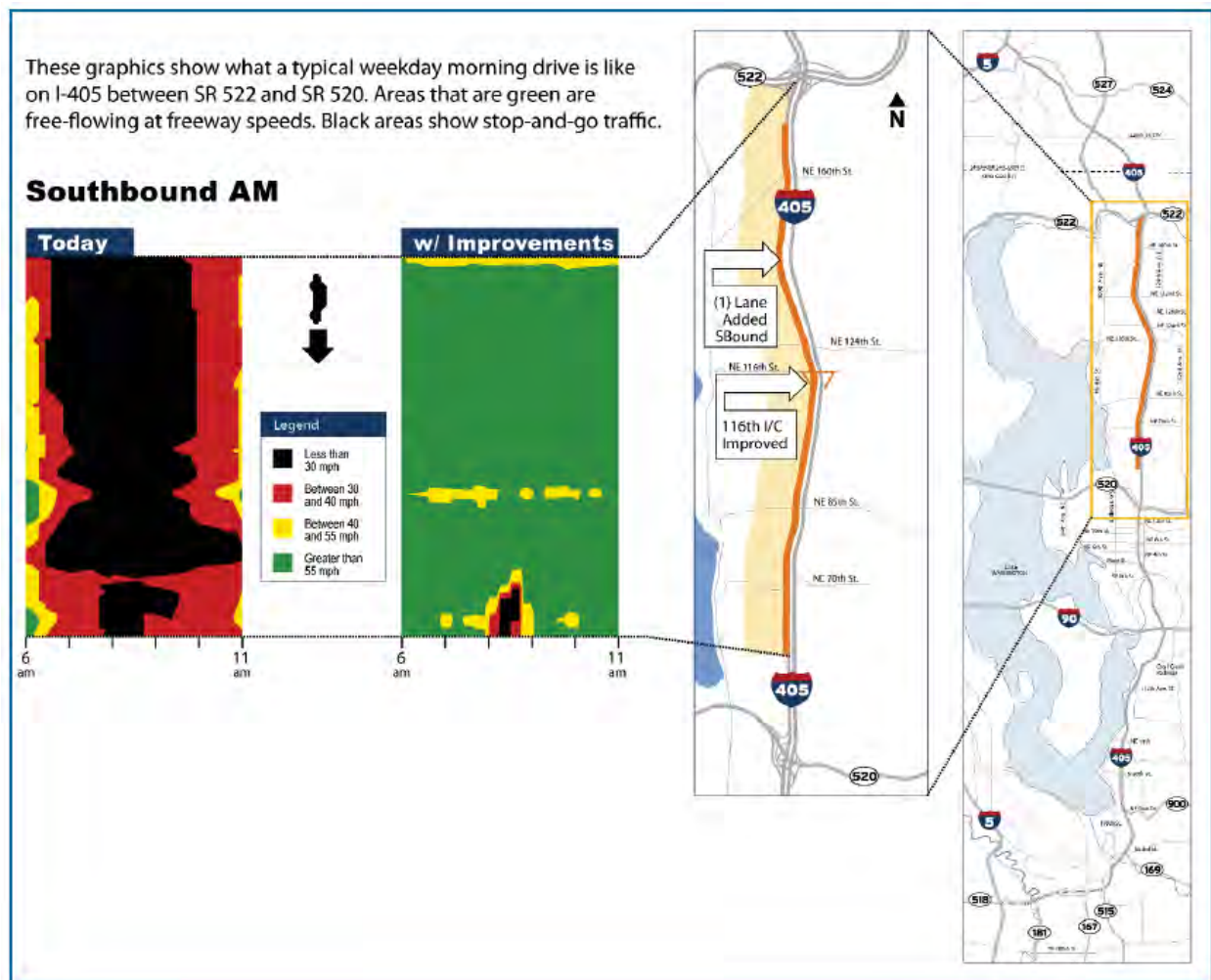
This map demonstrates what will result if the projects, programs, and policies in *Mobility 2030: The Metropolitan Transportation Plan* are implemented. It leads NCTCOG to conclude that if they are to meaningfully reduce congestion levels, they must pursue additional congestion mitigation strategies to reduce SOV travel and make the transportation system more efficient. The 36% increase in congestion in 2030 shows that while construction of new facilities will take place, effective and practical solutions to address the air quality and traffic congestion challenges will need to be identified and implemented.



Source: "Congestion Management Process Document", North Central Texas Council of Governments, <http://nctcog.org/trans/cmp/>

**Figure 13:** The Puget Sound Regional Council (PSRC) in the Seattle, Washington region has developed time-space diagrams, similar to those developed in Chicago using observed data (see Figure 6). However, at PSRC model results are used to develop a before-and-after picture of the congestion along a facility due to the presence of proposed improvements. This is a key link between the CMP and the project development process at PSRC.

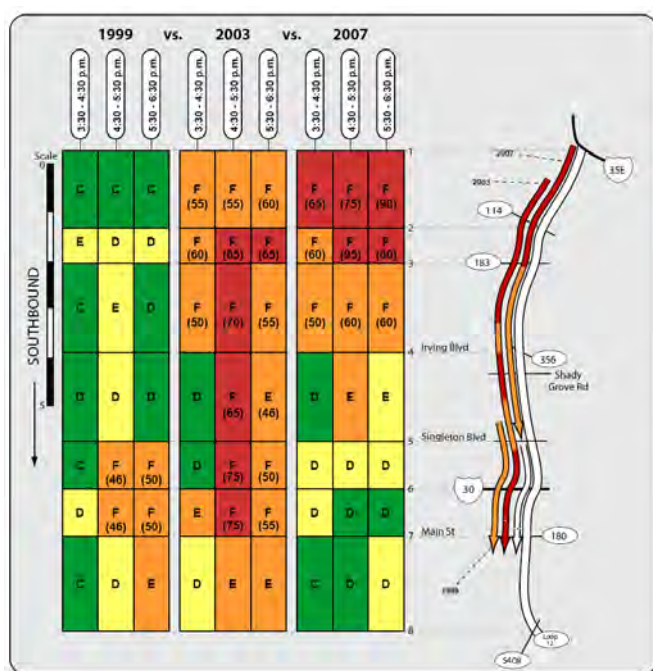
Compelling visions such as Figure 13 have helped PSRC communicate to elected officials, the media, and the public complex information about the transportation system and congestion. When data is presented in an appealing way, message disseminations can be increased as stakeholders use graphics in their communications to convey the importance of improvements.



Source: Puget Sound Regional Council. "The Relationship Between Congestion Management and the Planning Process." July 2006. Available at [http://www.plan4operations.dot.gov/docs/cs\\_relationship.pdf](http://www.plan4operations.dot.gov/docs/cs_relationship.pdf). October 8, 2009

## Displays of congestion trends and variability observed over time

**Figures 14a-b:** The ongoing data collection that occurs as a result of the CMP can also be a source of information on congestion trends over time. Several MPOs have developed methods of displaying this trend data on maps. There are two common approaches: to display results for several different years side by side on the map, as is done in the North Central Texas Council of Governments (NCTCOG) example in Figure 14a; and to display the relative change in results between two time periods, as is done in the Wilmington Area Planning Council example in Figure 14b. The NCTCOG method provides more detailed information than the Wilmington method, but may also be more difficult for laypeople to understand. Both methods are useful for tracking change over time, and can be useful tools in determining whether implemented CMP strategies are effective at addressing congestion concerns in certain corridors.

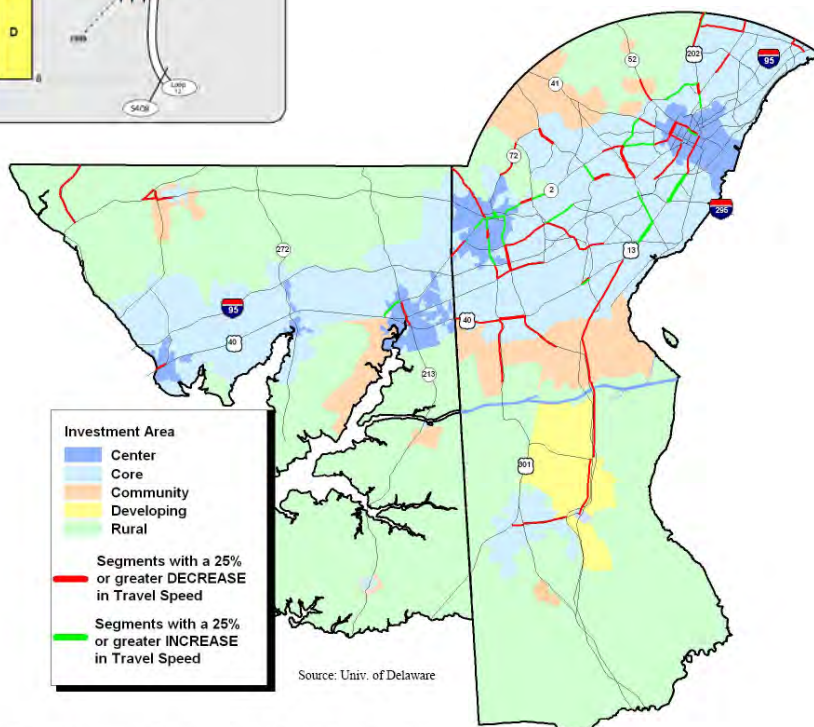


**Figure 14a**

Source: "2007 Traffic Conditions in the Dallas-Fort Worth Metropolitan Area", North Central Texas Council of Governments, 2007.

**Figure 14b**

Source: "2009 WILMAPCO Congestion Management System Summary", Wilmington Area Planning Council, 2009.



Source: Univ. of Delaware

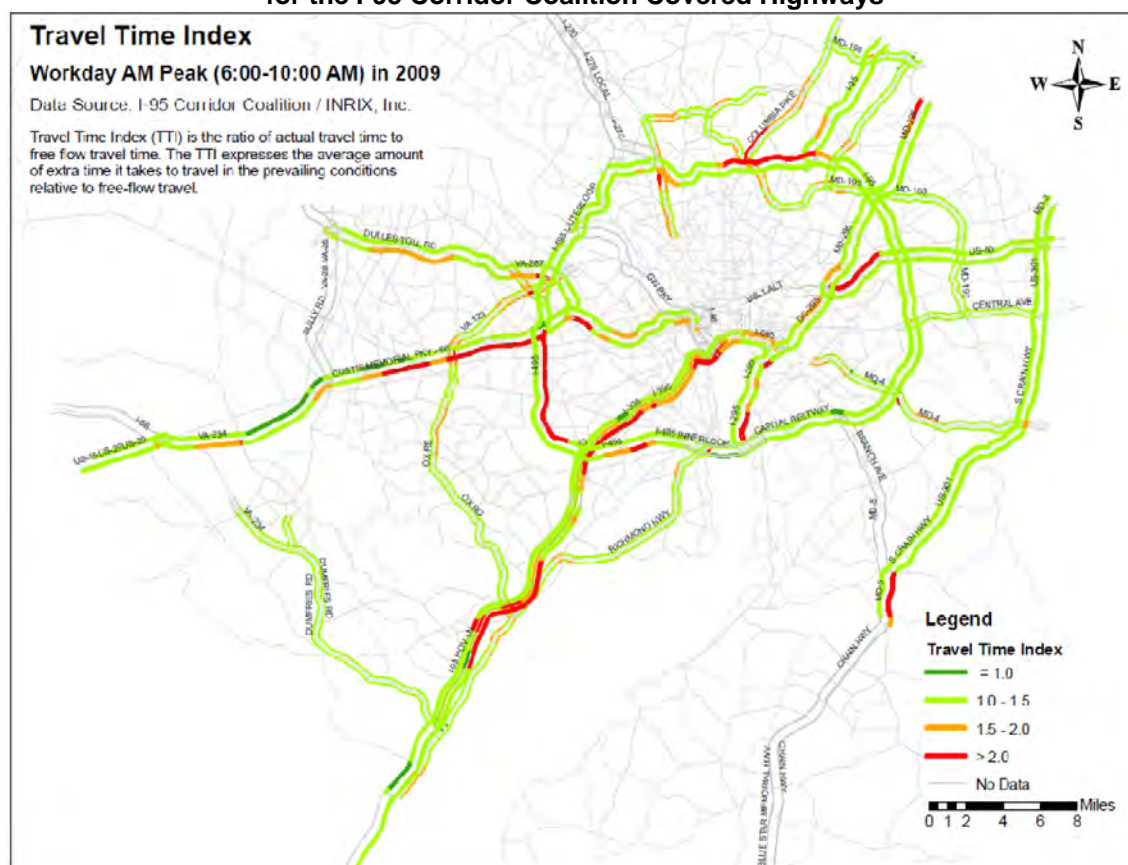
\*Data shown is a comparison of years 2001 & 2002 vs. the avg. of years 2007 & 2008



Figure 14a presented above shows the average temporal-variability within each year, the spatial variability along the roadway corridor, as well as the year-to-year trends of both. Most of the earlier visualizations of congestion have focused on the spatial variation in congestion levels from roadway to roadway. In addition to the year-to-year temporal variability, the temporal variability within the hours of a typical weekday, by day of the week, month of the year, or by season is also of interest to the general public, planning staff, and decision makers. The ability of the MPOs to gather such temporal variability of congestion is only recently becoming feasible through the use of archived data from various traffic management and/or traveler information systems.

**Figures 15a-c:** Figure 15a is one of a series of visuals from the draft 2010 CMP Technical Report being developed by staff of the Metropolitan Washington Council of Governments (MWCOC) in the Washington, DC area that is based upon the summarization of archived data from the I-95 Vehicle Probe Project purchased from INRIX, Inc. The visual shows the spatial variability of calculated travel time indexes per roadway segment and direction for the AM peak period for all workday-weekdays in 2009. It focuses on the spatial variability for the “covered highways”, which includes many of the area freeways and some arterials. The primary purpose of the operational, real-time data set is for interregional traveler information and as such not all of the roadways that could be sampled were actually sampled. Over time, more complete spatial coverage is being anticipated.

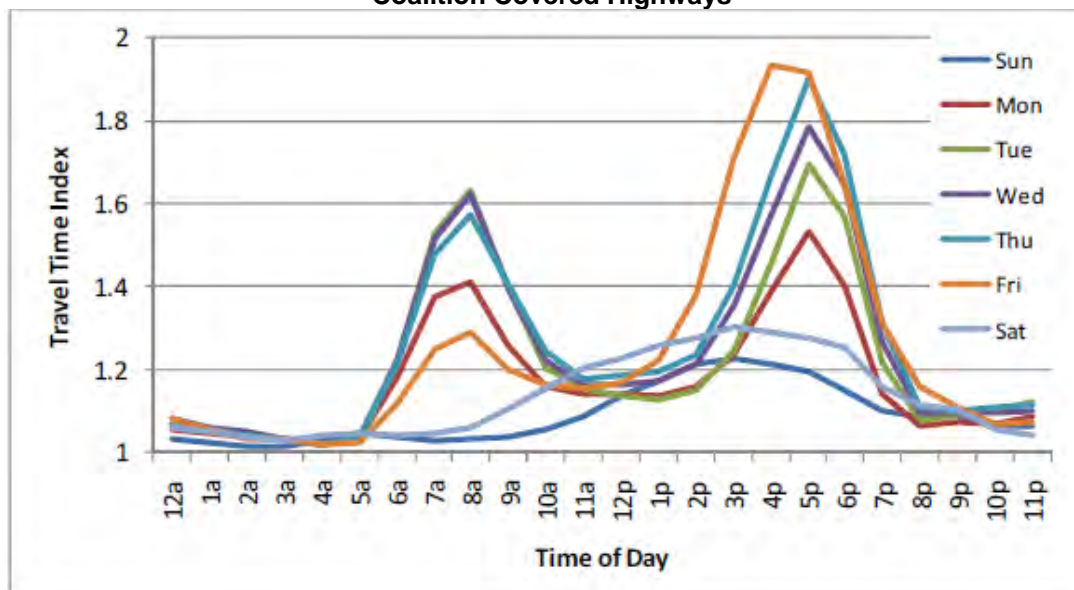
**Figure 15a: Sample Display of Travel Time Index for Weekday A.M. Peak for 6 to 10 A.M. for 2009 for the I-95 Corridor Coalition Covered Highways**



Source: “2010 CMP Technical Report (Draft) April 30, 2010”, Metropolitan Washington Council of Governments, 2010, Fig 19.

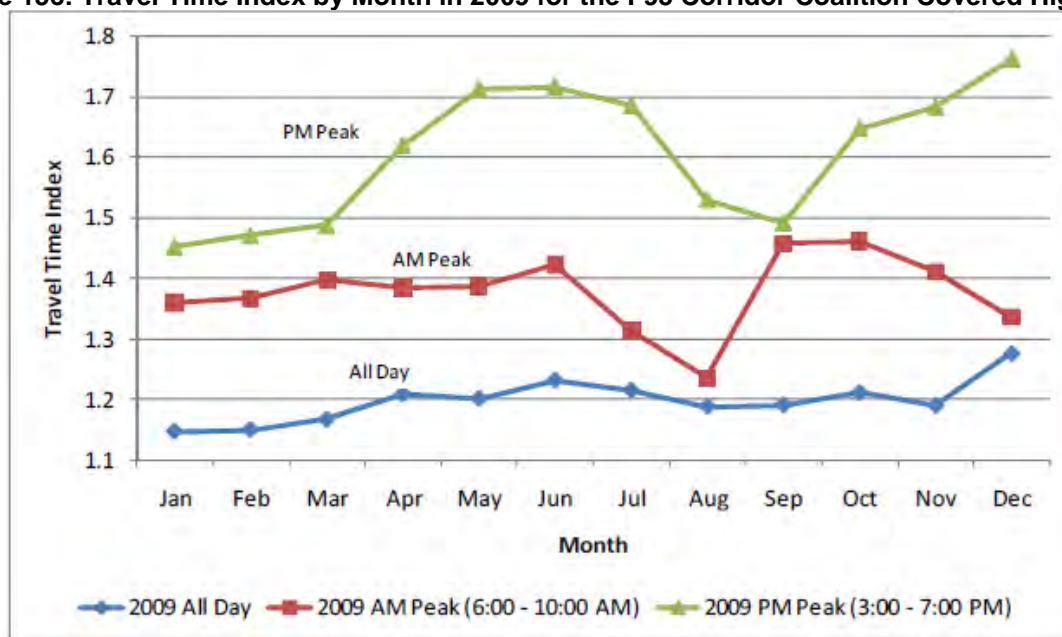
The same set of archived data was summarized to develop the Figure 15b that shows the temporal variability by time of day and day of the week, and Figure 15c that shows the month-to-month variability of the two peak periods compared to the daily totals. It is noted that this is the first attempt that we are aware of to use this new data source for CMP travel monitoring purposes. Doing so required a considerable effort to “mine” millions of data records and to appropriately organize and summarize them in such graphical and GIS-based map formats.

**Figure 15b: Travel Time Index by Time of Day and Day of Week in 2009 for the I-95 Corridor Coalition Covered Highways**



Source: “2010 CMP Technical Report (Draft) April 30, 2010”, Metropolitan Washington Council of Governments, 2010. Fig. 23

**Figure 15c: Travel Time Index by Month in 2009 for the I-95 Corridor Coalition Covered Highways**

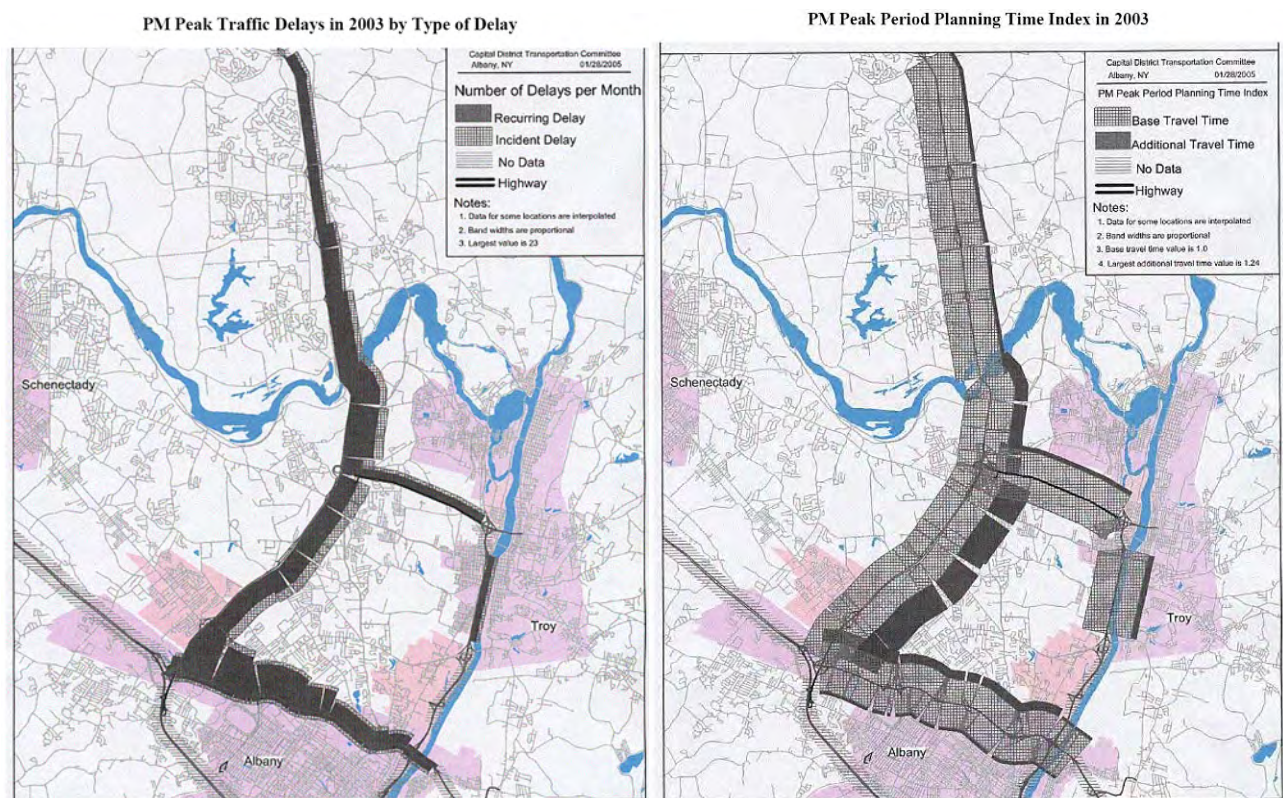


Source: “2010 CMP Technical Report (Draft) April 30, 2010”, Metropolitan Washington Council of Governments, 2010., Fig 21



## Displays of reliability data

**Figure 16:** Information on the reliability of transportation systems is often collected as part of the Congestion Management Process. Several MPOs have developed ways of displaying reliability data on maps. Some, such as those used by the Capital District Transportation Committee (CDTC) in Albany, New York, use derived metrics such as the planning time index. The CDTC maps use line widths to display base travel time and the additional travel time built into travel time planning to account for non-recurring congestion and delay. Many MPOs also develop simple maps displaying high-crash locations as a way to address the issue of non-recurring congestion. Figure 16 shows examples of these reliability visuals developed by CDTC.



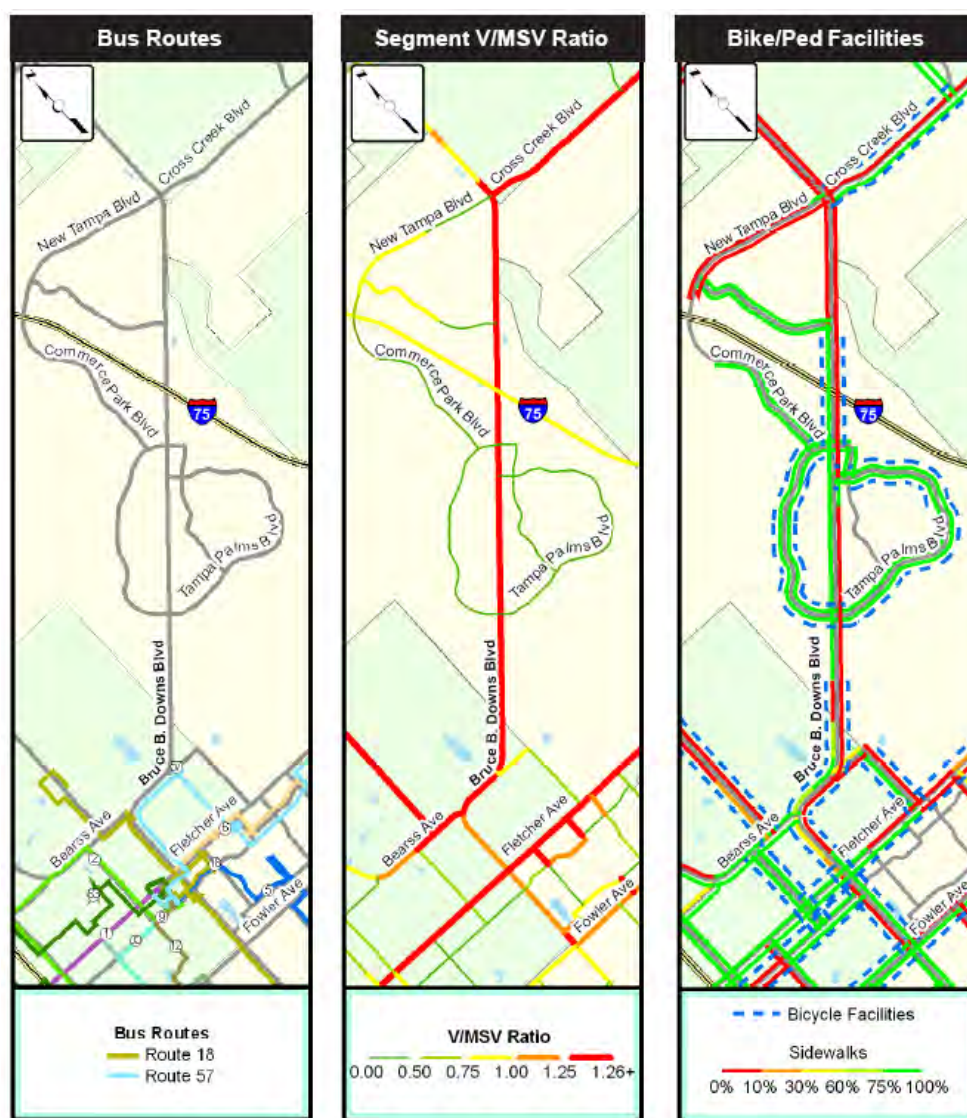
Source: "The Metropolitan Congestion Management Process", Capital District Transportation Committee, 2007.



### Displays of multimodal and transit data

Many MPOs include transit service and bicycle/pedestrian facilities in their analysis of congestion, both in terms of system performance and as a potential congestion management strategy. There are many ways in which this multimodal information can be visually displayed, ranging from simple maps of the locations of transit routes or bicycle/pedestrian facilities to detailed analyses of the congestion, level-of-service, and quality of these services and facilities.

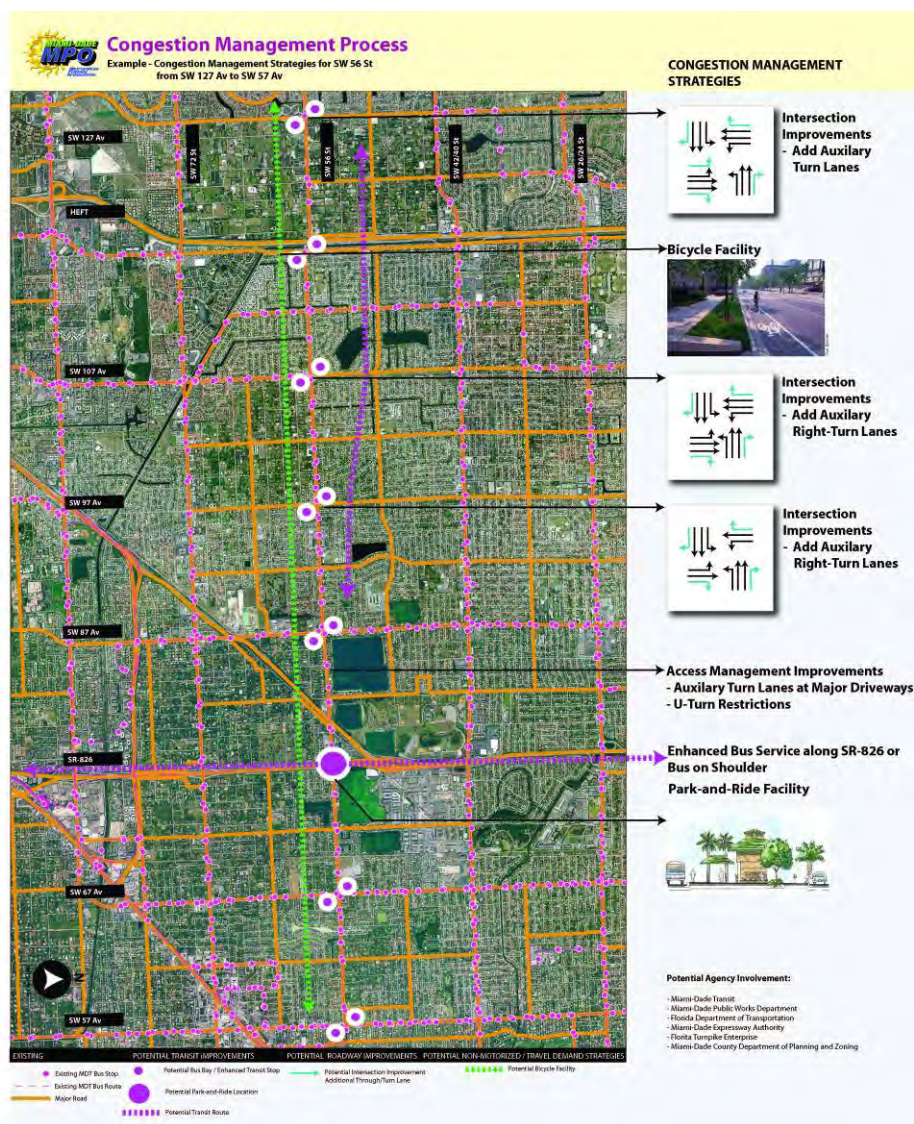
**Figure 17:** The Hillsborough County MPO in Tampa has an effective way of displaying information on the availability of multimodal facilities and services, in comparison with areas of highway congestion, through a series of strip maps shown side by side. These maps are well-suited for analysis of whether the multimodal system is aligned with the congestion-mitigation needs of the highway system. Therefore, these maps can be utilized to identify those areas where needs are not met, and plan for future construction of bus routes or increased bicycle/pedestrian facilities necessary for congestion mitigation.



Source: "Congestion Management System Performance Report", Hillsborough County MPO, 2005.

## Displays of recommended strategies for implementation

**Figure 18:** Many MPOs develop graphics to show the strategies that are recommended in the CMP. This provides an easy-to-read and understand one-stop source for location-based information on the strategies in the CMP. Maps can be developed to cover specific spot locations, corridors, or entire regions. The example shown below, from the Miami-Dade MPO in Miami, Florida, shows the strategies recommended as the result of a corridor analysis in their CMP.



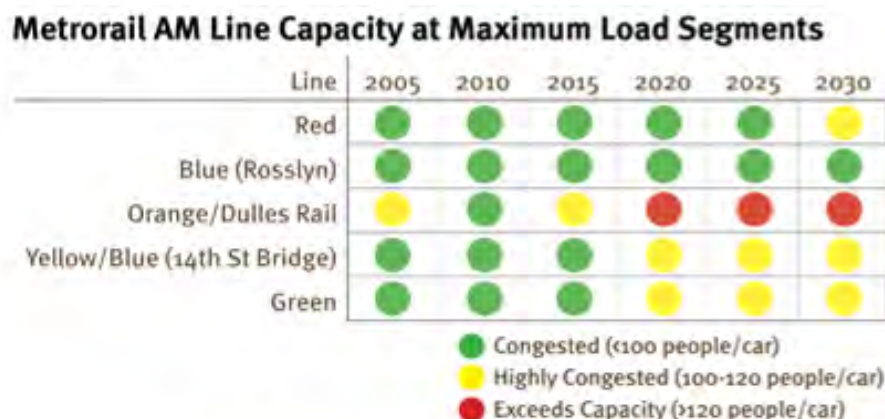
Source: Miami-Dade MPO LRTP Interactive Project Tool [www.miamidade2035transportationplan.com/ProjectGuide/](http://www.miamidade2035transportationplan.com/ProjectGuide/)



## Charts, graphs, and tables

Charts, graphs, and tables are a clear, easy to understand way of visualizing data and analysis results. Many MPOs use these as part of their CMP-related reporting. A few notable examples of these types of displays are shown in Figures 19-22 below.

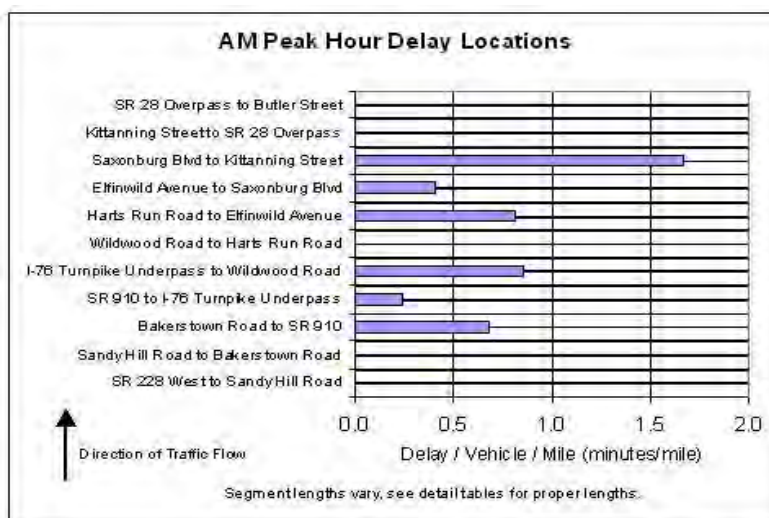
**Figure 19:** This table from the Washington Metropolitan Area Transit Authority, used in the Metropolitan Washington Council of Governments' CMP, clearly shows the relative levels of congestion on several transit lines in an easily-understood manner. It alerts the public to future capacity problems along certain lines, and can be used to help show policy makers the need for more funding or management and operations strategies for the Metrorail system to meet the needs of its ridership growth.



Source: WMATA Metrorail Station Access & Capacity Study, April 2008

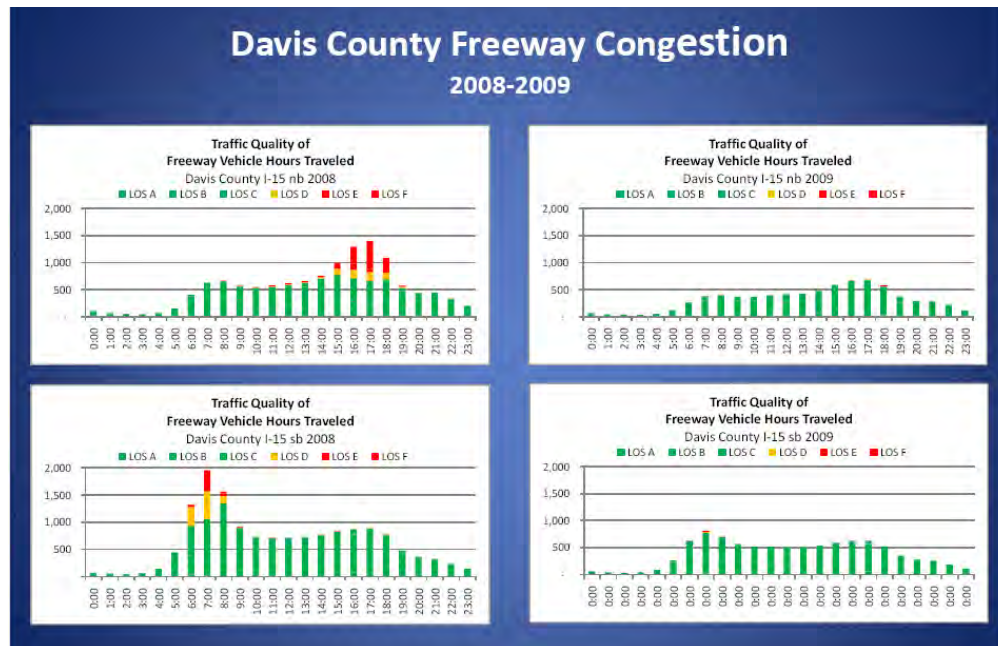
Source: MWCOG CLRP Website, <http://www.mwcog.org/clrp/performance/congestion.asp>

**Figure 20:** This bar graph from the Southwestern Pennsylvania Commission (SPC) in the Pittsburgh region shows detailed delay data for a specific corridor in the CMP analysis network, based on collected travel time and delay data. The fact that delay per vehicle per mile is significantly greater between Saxonburg Boulevard and Kittanning Street than in other segments allows SPC to conclude that targeted operational improvements may be an appropriate congestion mitigation strategy for this segment.



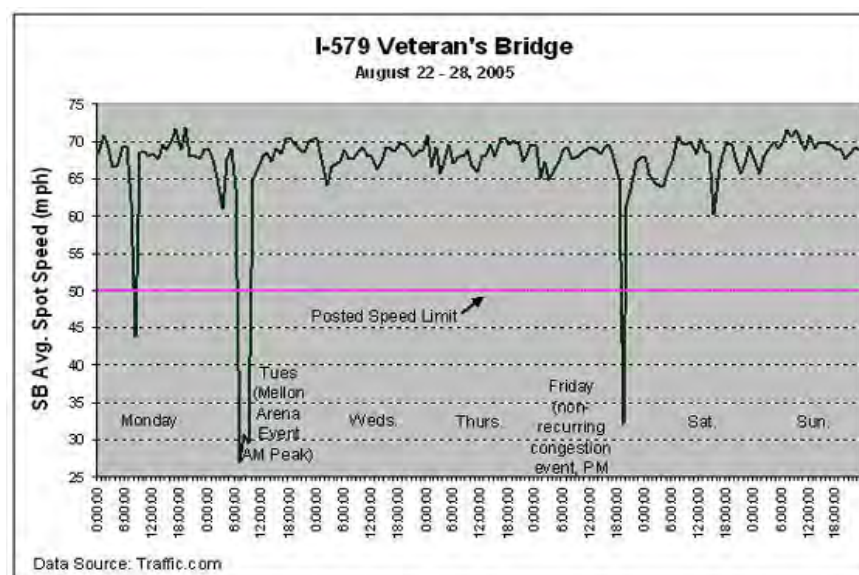
Source: SPC CMP Website, [http://www.spcregion.org/trans\\_cong.shtml](http://www.spcregion.org/trans_cong.shtml)

**Figure 21:** The bar graphs below from the Wasatch Front Regional Council (WFRC) in Salt Lake City use color to highlight time and extent of congestion. They are a visually impressive means of showing the change in congestion between 2008 conditions (left side) and 2009 conditions (right side). This allows WFRC to assess whether any congestion management strategies they implemented in 2008 have alleviated any congestion, and if so, exactly when during the day the strategies are most effective.



Source: "WFRC Traffic Congestion Report", Wasatch Front Regional Council, 2009.

**Figure 22:** This graph from the Southwestern Pennsylvania Commission (SPC) in Pittsburgh shows variability in speeds caused by incidents, as a measure of non-recurring congestion. While SPC's CMP does not currently measure non-recurring congestion, graphs like this help inform regional strategies for it, such as incident management, special event planning, and work zone management.



Source: SPC CMP Website, [http://www.spcregion.org/trans\\_cong.shtml](http://www.spcregion.org/trans_cong.shtml)

### ***Use of visuals to differentiate among CMP strategy options***

Beyond simply using visualizations to convey data, several MPOs use photo-simulation and other visual tools to conceptually convey the ideas presented as potential CMP strategies. The Capital District Transportation Committee, the MPO for the Albany area, uses photographs and photo-simulations to show the public what different CMP strategies would look like on the ground. This effort is tied in with the MPO's focus on issues of livability. An example of a before-and-after simulation showing potential multimodal facility improvements as a CMP strategy is shown in Figure 23.

**Figure 23:** These visuals show an existing corridor in the Albany area (top) and an example of what this corridor could look like with improvements to the bicycle and pedestrian infrastructure. The MPO uses these visuals to help the public understand differences between strategies outlined in the CMP.



Source: Capital District Transportation Committee

**Figure 24:** The Green Bay MPO has used Google SketchUp, a three-dimensional computer drawing program, to develop graphics showing the potential impacts of improvements along corridors to neighboring properties, as part of a CMP-related corridor study. The example below shows the potential improvements in relation to one of the affected properties – additional graphics were developed for each of the affected properties in the corridor.



Source: Green Bay MPO, <http://www.co.brown.wi.us>



### ***Use of video or animation in visuals***

**Figure 25:** This video from Evans City in the Southwestern Pennsylvania Commission (SPC) region demonstrates the result of SPC's regional traffic signal program, which is an outgrowth of its CMP. It utilizes an appealing visualization to make the results of the program more tangible and real, allowing drivers to see exactly how change will affect them. The display shows traffic conditions before and after the implementation of several CMP strategies at this location, and highlights the vast improvement in travel time through the corridor (as both videos are played simultaneously). SPC has found this video to be very useful in encouraging other municipalities to pursue similar types of operational improvements.



Source: SPC Transportation website: [http://www.spcregion.org/trans\\_ops\\_traff.shtml](http://www.spcregion.org/trans_ops_traff.shtml)

## 4—Visualizations Used in Related Transportation Activities

Visualization tools are being applied and used in other transportation-related activities such as project planning and design, performance measurement reporting systems, and Advanced Traveler Information System activities. Those other areas of application have their own needs and requirements and different audiences for whom the visualizations are being prepared. As such, the resulting visualizations tend to be organized, formatted, or structured differently from those presented in this state-of-the-practice review.

It is beyond the scope of this review to also explore and cull out useful methods and techniques from those other areas of application to see how they might also apply for use in the CMPs prepared by MPOs. Nevertheless some MPO staff indirectly appear to have been doing that and the evolving state-of-the-practice is beginning to reflect that of other areas and the overall state-of-the-art in the visualization of the use and performance of transportation systems. There are textbooks and nationally held workshops on the use of visualizations in the analysis of quantitative information. While the methods and techniques still have many aspects of an art, they are becoming more of a science that is based on the psychology and physiology of the perception of visualizations of data and information.

It is also important to note that in recent years a Committee on Visualization in Transportation was formed at the Transportation Research Board. That Committee has co-sponsored workshops and sessions with other Committees including those on: (1) Performance Measurement, (2) Regional Transportation Systems Management and Operations, and (3) Metropolitan Policy, Planning, and Processes. Further, a biennial conference is organized by the Committees within the Data and Information Systems Section, termed the North American Travel Monitoring Exposition and Conference (NATMEC), and supported by other organizations, including FHWA. At that conference in recent years, new state-of-the-art visualizations of data about congestion of the transportation system have often been presented and highlighted. Staff from MPOs who are involved in CMP activities attend and present improved methods, techniques, and data sources associated with the visualization of congestion.

## 5—Conclusion

Visualization is a useful tool in communicating CMP information, but there is no single visualization approach that is applicable in all MPOs – the best approach will vary for each MPO, based on the data and resources available, the goals and objectives of the CMP and the MPO in general, and the intended audience. For example, in areas with relatively low congestion, providing visuals that focus on non-recurring congestion may be more appropriate than those focused on recurring congestion. In an area where detailed and extensive data sets are available, it may be preferable to focus on generating detailed, data-driven visuals of observed conditions. Some MPOs use visualizations for internal analytical purposes, while others primarily develop visualizations for use by the public or elected officials. The final visualization approach followed by an MPO should be one that meets its own unique needs.

The effectiveness of CMPs and the use of visualizations is interdependent with the data sources available to MPOs. Newer and improved data sources can enable representations of congestion to be displayed as people experience it – over space and over time – helping to improve citizens' understanding and acceptance of recommended strategies for improvement.



## ***Lessons learned and future directions***

One important lesson learned with regard to visualization of the CMP is that visualizations intended for public consumption must be easy to understand and must clearly convey their intended message. Graphics should not be littered with superfluous information and should not attempt to show too much information all at once. At the same time, overly simplistic representations of the data may skip over or trivialize important interrelationships that need to be better understood to effectively select and gain support for implementing a particular congestion management strategy.

Several recent innovations appear to have useful application as CMP visualization tools. Several MPOs have begun using online mapping programs to present information in a way that is easier for the public to access and to interact with. Using a program such as this allows a person to view information at multiple scales, to delve into detailed information of interest to them, and to change the display properties to suit their interests (by doing things such as turning layers on and off). Additionally, animations and simulations are beginning to be used as a tool for visualizing congestion in some areas; there has been relatively little CMP-related activity using this tool so far, but it is an area that is ripe for future development.

Animations can be a useful adjunct tool because the nature of congestion is that it varies over time and space, and techniques such as animations that capture and “play-back” such concurrent observed variability in congestion patterns can greatly facilitate understanding of the nature of the problem that needs to be addressed. A drawback of this approach is that animations do not easily lend themselves being put into a static report. The electronic files needed to visualize the data in that manner can be large, which is a challenge to their dissemination and use by the appropriate audiences. However, the increasing competence of the public, officials, and their direct staff in the use of computers for communicating and sharing information and files may make this less of a concern in the future.

The increasing availability of new and improved sources of data on system performance is an important element in the implementation and improvement of CMPs over time. However, it is equally if not more important to ensure that available data is presented in a way that is useful and understandable, allowing informed decision making by MPO professional staff, decision makers, and the public.

Visualization can play a major role in organizing the spatial and temporal data collected as part of the CMP and in communicating the results of the CMP analysis to the public and elected officials. The primary goal of the CMP is for the congestion analysis to be a major factor in the development of long-range plans and short-range funding programs developed by MPOs, and to influence the selection of projects and management and operations strategies that are included in these plans and programs. For this to happen, it is vital for the congestion data collected and analyzed through the CMP to be distributed in a format that can exert that influence on the rest of the MPO planning process. Visualization is a very effective way of doing this.



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