Using Operations Data for Planning in the Delaware Valley: First Steps

August, 2011

The Delaware Valley Regional Planning Commission is dedicated to uniting the region's elected officials, planning professionals, and the public with a common vision of making a great region even greater. Shaping the way we live, work, and play, DVRPC builds consensus on improving transportation, promoting smart growth, protecting the environment, and enhancing the economy. We serve a diverse region of nine counties: Bucks, Chester, Delaware, Montgomery, and Philadelphia in Pennsylvania; and Burlington, Camden, Gloucester, and Mercer in New Jersey. DVRPC is the federally designated Metropolitan Planning Organization for the Greater Philadelphia Region — leading the way to a better future.

The symbol in our logo is adapted from the official DVRPC seal and is designed as a stylized image of the Delaware Valley. The outer ring symbolizes the region as a whole while the diagonal bar signifies the Delaware River. The two adjoining crescents represent the Commonwealth of Pennsylvania and the State of New Jersey.

DVRPC is funded by a variety of funding sources including federal grants from the U.S. Department of Transportation's Federal Highway Administration (FHWA) and Federal Transit Administration (FTA), the Pennsylvania and New Jersey departments of transportation, as well as by DVRPC's state and local member governments. The authors, however, are solely responsible for the findings and conclusions herein, which may not represent the official views or policies of the funding agencies.

Acknowledgement

Delaware Valley Regional Planning Commission (DVRPC) would like to gratefully acknowledge the cooperation of many partners in conducting the work that is covered in this report. While the following list is not everyone who participated, we would like to especially thank the following people for their ongoing help:

- John Allen, New Jersey Department of Transportation
- Manny Anastasiadis, Pennsylvania Department of Transportation-District 6
- Lou Belmonte, Pennsylvania Department of Transportation-District 6
- Gary Davies, AECOM
- Michael Pack, University of Maryland Center for Advanced Transportation Technology Laboratory
- Dave Wolfe, Pennsylvania Department of Transportation-District 6
- Stan Young, University of Maryland Center for Advanced Transportation Technology Laboratory

In addition, we thank Claire Beck, DVRPC Intern, for her significant help throughout the process.

Table of Contents

Figures and Tables

Appendices

Executive Summary

Throughout the Delaware Valley, transportation departments and other agencies monitor real-time roadway traffic conditions on major facilities and some additional roads. These agencies use traffic cameras, E-ZPass detectors, Global Positioning System (GPS) probes, and microwave sensors to collect information about traffic speed, travel time, and incidents. This kind of information is collectively called “traffic operations data.” When this data is archived, it can be used to evaluate the performance of the transportation system over time and to plan how to keep people and goods moving.

For planning purposes, this type of real traffic data can be more robust than data from modeling software or put together from a range of sources, and it may be easier for broad audiences to understand. For these reasons, the Delaware Valley Regional Planning Commission (DVRPC) and other planning agencies have begun investigating the use of archived traffic operations data.

This report includes a summary of current traffic operations data activities in the Delaware Valley, two case studies, and conclusions. The first case study focused on a section of I-76 using Dynac data from Pennsylvania Department of Transportation (PennDOT). The second case study used data from INRIX, a private-sector traffic data company, to analyze all freeways and some major arterials in the nine-county bi-state Delaware Valley.

DVRPC used INRIX data provided by the I-95 Corridor Coalition as part of their Vehicle Probe Project (VPP), that covers the East Coast. DVRPC worked closely with the I-95 Corridor Coalition, the University of Maryland Center for Advanced Transportation Technology (a partner in the VPP), and INRIX. In addition, DVRPC’s work is closely coordinated with New Jersey Department of Transportation (NJDOT), PennDOT, and others to provide the greatest value to transportation planning in the region.

The analysis using INRIX data in this report has been incorporated into DVRPC’s Congestion Management Process (CMP) and has been recognized in webinars presented by the I-95 Corridor Coalition and INRIX. A key to the success of this effort has been keeping the analysis tightly scoped and focusing on what we were trying to achieve. The raw data files are very large and there are many ways the data can be used. It is easy to become overwhelmed when using archived operations data.

The analysis made it clear that using archived traffic operations data is a valuable endeavor. It will be important for agencies in the Delaware Valley and beyond to work together. Some important areas of coordination include ensuring that traffic operations data continues to be archived, that analysis methodologies are coordinated among partners, and that the actual analysis steps continue to be mechanized so they may be run efficiently. Many partners are interested in performance measures, and where possible, measures should be coordinated and set up for ongoing tracking. A coordinated and clear message will be essential to communicate the results to a broad audience and have a positive effect on future real-time transportation.

CHAPTER 1

Using Operations Data in the Delaware Valley

Why Use Operations Data for Planning?

Many of the activities and studies performed by transportation planners rely on traffic volume, traffic speed, and travel times. In the past, much of this data had to be obtained from fragmented sources of data or travel simulations. Now, more and more sources of real traffic data are being collected and archived by agencies around the region. This data, representing real conditions on area roadways, can now be used in transportation planning and various congestion management processes. The use of quality real traffic data can provide an important improvement over modeled data. The recent advances in technology and practices for using this data are an exciting new development in the intersection of transportation operations and transportation planning.

What is operations data?

Operations data includes traffic, construction, weather, and incident-related information collected by various agencies, including departments of transportation, traffic management and operations centers, and individual counties and municipalities. This data is usually collected in real time and used to monitor and manage current traffic conditions on specific roadways. Most traffic operations data is collected by Intelligent Transportation System (ITS) equipment. ITS equipment can include in-pavement inductive loop detectors, radar detectors, Remote Traffic Microwave Sensors (RTMS), Bluetooth, and E-ZPass or other unique ID tag readers. Traffic operations data is increasingly being collected and disseminated by private-sector companies such as INRIX and Navteq. These companies generally collect data on traffic volume, traffic speed, and travel time using spot speed detectors, tag readers such as E-ZPass, and vehicle probes using Bluetooth or GPS technology. Note that frequently used technical terms and acronyms are defined in Appendix C.

What kinds of measurements can be obtained from operations data?

Traffic operations managers collect a variety of information types, including traffic congestion, incident location and duration, construction delays, weather events, and traffic signal operations. The basic building blocks for much traffic operations data, however, are traffic volume, traffic speed, and travel times. This data is collected by roadside, in-pavement, or in-vehicle sensor equipment on a continuous basis and aggregated at different time intervals ranging from 15 seconds to one hour. This kind of archived continuous data can be used to calculate many traffic mobility and reliability measures, including Delay per Traveler, Travel Time Index, Buffer Index, Congested Travel, and Planning Time Index (see Appendix A for definitions). Even more measures can be calculated when other data is available, such as vehicle miles traveled (VMT), vehicle occupancy, and detailed traffic incident information.

How can these measurements be used for planning purposes?

While traffic operations centers and departments of transportation use operations data for the day-to-day management of roadway conditions, archived operations data can be used for various planning purposes as well. Some of the strongest tools available when addressing congestion management are measures of reliability or variability that can be expressed as variations in travel time, delay, or average speeds over specific periods of time and segments of roadway. This data can be used to track performance measures, and, importantly, it may be possible to correlate changes in highway performance to specific congestion management or safety strategies.

Ultimately, a smooth and comprehensive integration of several types of operations data could result in better congestion management practices and traveler information services.

As may be expected, though, collecting and analyzing this quantity and variety of data is no small task. In fact, the task can be almost impossible if traffic operations data is not adequately archived and quality controlled. Because traffic operations data is collected continuously, it results in very large amounts of data; and because this data is intended for real-time use, it is not always archived for longer than a few days to a month before it is discarded. Additionally, continuously operating ITS equipment is prone to failure or errors from time to time, and thus missing and unreliable data must be identified and mediated. In short, while archived operations data can be a rich source of information for transportation planning, issues of data availability and reliability present a significant barrier.

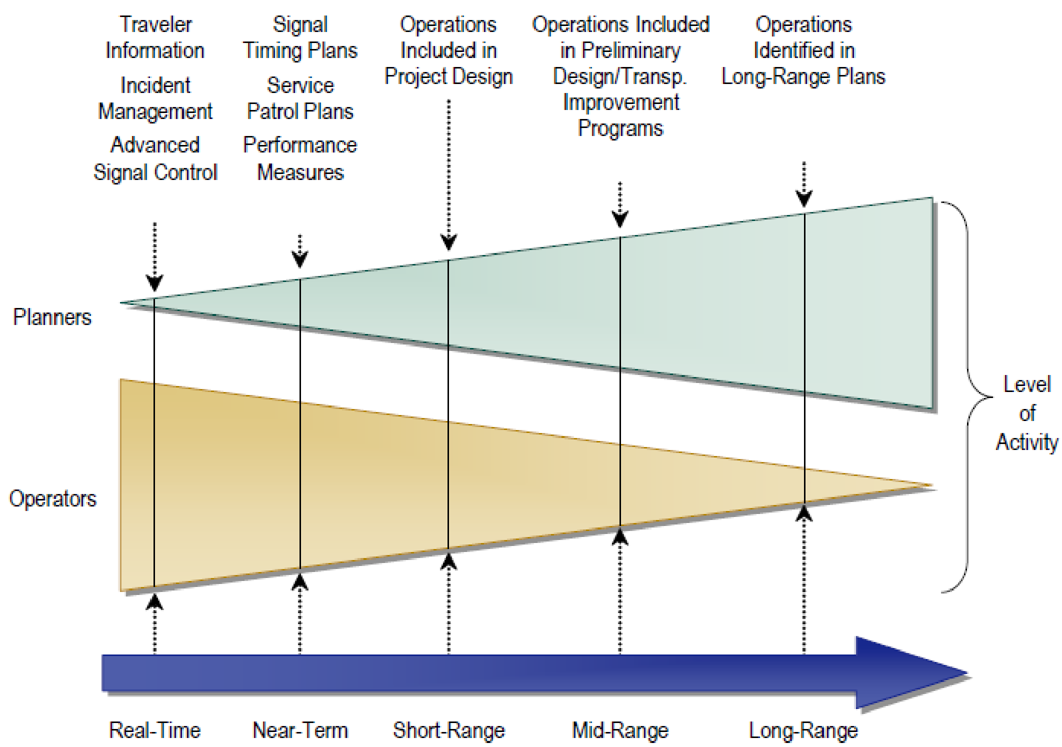
A Federal Highway Administration study on lessons learned from using operations data for planning addressed the topic of incomplete and/or imperfect data sources. This study advises planners not to wait for some “silver bullet” of perfectly complete and reliable data.[1] Instead planners should strive to perform useful analysis on available data while being aware of that data’s limitations and using caution with regard to some data that may be completely unreliable or unusable. By producing some kind of helpful analysis from available operations data, the utility of accurate and clean archived operations data can be communicated to traffic operators and other transportation planners, possibly resulting in better data management and archiving practices in the future.

[1] Federal Highway Administration, **Lessons Learned: Monitoring Highway Congestion and Reliability Using Archived Traffic Detector Data** (Washington, DC: Federal Highway Administration, October 2004), http://ops.fhwa.dot.gov/publications/lessons_learned/, 3.0.

Operations and Planning: Working Together

The key to being able to use archived operations data for planning is access to quality data. Not surprisingly, then, the first step in improving the likelihood of accessing this kind of data is to develop partnerships and data-sharing practices between agencies. Traffic operators and planners often seem to exist in two different worlds with divergent strategies, requirements, and concerns. However, traffic operators and planners are ultimately aiming toward the same things: reducing congestion, improving safety, and moving people and goods in an efficient manner. Figure 1 illustrates how the same data can be useful for both traffic operators and planners. This concept is important for encouraging operators and planners to work together and share information.

Figure 1: Roles and Activities for Planners and Operators



Source: Federal Highway Administration, **Traffic Congestion and Reliability: Trends and Advanced Strategies fro Congestion Mitigation** (Washington, DC: Federal Highway Administration, September 2005), http://ops.fhwa.dot.gov/congestion_report/chapter5.htm.

Once data-sharing partnerships have been formed, the issue of data quality assurance and archiving capabilities must be addressed. Effective partnerships between various traffic-operating and planning agencies must be built in order to ensure quality data that is collected and stored in a fashion useful for all parties involved. One example of such a partnership comes from the Detroit area of Michigan. The Michigan Intelligent Transportation Systems (MITS) Center collects traffic volume, speed, lane occupancy, and equipment failure rate information from about 2,600 inductive vehicle detectors throughout the Detroit region. The MITS Center archives this data into hourly totals for each detector location, which is then saved in a spreadsheet format and electronically transmitted to the Transportation Planning Bureau on a monthly basis.[2] The Planning Bureau is then able to use this data to calculate annual average daily traffic and analyze traffic trends for future planning purposes.

In most cases, planning agencies will be dealing with several municipalities, counties, and even states, which highlights the importance of coordination and cooperation. However, the producers and collectors of traffic operations data need to be convinced that this rich and detailed source of information should not go to waste by discarding data after short periods of time. As mentioned previously, transportation planners should perform at least preliminary analyses to demonstrate the utility of archived operations data for planning purposes. In other words, we want to get as much intelligence from intelligent transportation systems as possible. ITS data should be analyzed in order to turn data into useful information for planners and travelers alike. Once the potential uses of this data have been shown to various stakeholders, data collectors and managers will have greater impetus to obtain and share quality, comprehensive operations data.

The State of Operations Data for Planning in the Delaware Valley

Overview of Available Operations Data

Several agencies and offices throughout the Delaware Valley are beginning to archive real-time operations data from ITS equipment, develop methods of efficiently storing and sharing this data, and analyze these datasets for the purposes of performance measurement and various congestion management processes. Included below are summaries of several interviews conducted in the summer of 2010 with various people at agencies involved in creating and using real-time operations data in the Delaware Valley. The collection and use of operations data in the Delaware Valley is a quickly evolving field. Thus, some information gathered in these meetings was changed or updated during the time that it took to produce this report. Where updated information is available, it is noted in brackets. The information gathered from these meetings helps paint the big picture of operations data collection and use in our region. It also highlights that there is still much work to be done in developing useful and efficient methods of processing and analyzing the large amounts of real-time data available to us.

---

[2] Hu et al., **Cross-Cutting Studies and State-of-the-Practice Reviews: Archive and Use of ITS-Generated Data** (Oak Ridge, TN: Oak Ridge National Laboratory, Center for Transportation Analysis, April 2004), http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/13697/Chp5.htm, 5.2.4.

Summaries of Interviews

Use of Operations Data for Traffic Count and Speed Database (Scott Brady, Manager, Office of Travel Monitoring, DVRPC, June 17, 2010 meeting)

DVRPC performs over 3,000 traffic counts annually, many of which are classification counts. Count data is provided in 15- or 60-minute intervals, and many counts provide speed data as well. In addition to project counts, DVRPC contracts to do counts for PennDOT, NJDOT, and for the following counties: Mercer, Gloucester, and Camden. There were also 800 counts done for all cordon line stations for the travel demand model calibration in 2010, updating the ones done on a continuous 5 year basis.

All of DVRPC's traffic count and traffic speed records are contained in one Oracle database, which is now available online as a map application (http://www.dvrpc.org/Traffic/). There are over 50,000 counts in this database, and each data point is associated with a latitude-longitude coordinate.

DVRPC obtains traffic count data from NJDOT, Traffic.com, Burlington County, and others, in addition to collecting our own counts. They are listed with their sources in the public database. Mr. Brady is also working with several consultants on providing counts to DVRPC.

Traffic.com equipment exists in 174 expressway locations throughout PennDOT District 6 and collects continuous traffic counts and speeds. DVRPC receives mid-month, mid-week data from Traffic.com about a year after the data is collected. This data is included in DVRPC's database after Mr. Brady reviews it. This review is important due to issues with missing or inaccurate data from malfunctioning equipment. Mr. Brady has analyzed this data for several years in order to identify which counting stations are reliable and which are not. After making these determinations, he follows up with Traffic.com, which improves the data and helps them with quality control.

By selecting Traffic.com counting stations that are reliable, these archived counts could be used for some analyses.

Data from INRIX is available for most major roads in the Delaware Valley through the I-95 Corridor Coalition's Vehicle Probe Project (VPP) contract. INRIX collects traffic speed and travel time data from GPS-outfitted commercial vehicle fleets (vehicle probe data) as well as other sources.

Stan Platt, Manager of the Office of Transportation Operations Management, and Mr. Brady are working with PennDOT on a project to periodically collect real-time traffic data from a relay station that combines all of the ITS data collected by PennDOT. For security reasons, the data stream from this relay station would only be open for a short period of time, and DVRPC would collect this data as a "snapshot" of a representative day's data.

DVRPC is considering purchasing several Bluetooth-equipped measurement devices that will collect travel time and speeds for certain corridors. The equipment will be portable, which will allow it to be moved around to various facilities as needed. Bluetooth counting technology is most valid for measuring long distances on limited-access roads, but it is useful in that it provides origin-destination data for the movements monitored.

Coordinating with Other Operations Efforts (Chris King, Senior Transportation Planner, Office of Transportation Operations Management, DVRPC, June 23, 2010 meeting)

DVRPC's Office of Transportation Operations Management manages the Regional Integrated Multi-Modal Information Sharing (RIMIS) project. It is a web-based data interface project that will integrate real-time traffic and incident data from several sources throughout the Delaware Valley.

RIMIS will collect real-time traffic and incident data from New Jersey's State Wide Information for Traffic (SWIFT) and Regional Architecture systems as well as from PennDOT's Road Condition Reporting System (RCRS). The first phase of launching RIMIS will focus on incident data; traffic speed and travel time data will be integrated into the system at a later date. Once traffic data is being fed into the RIMIS system, the data likely will not be archived by RIMIS but will reside at the member agencies themselves.

Traffic speed and travel time data is gathered by NJDOT through the Transportation Operations Coordinating Committee (TRANSCOM) System for Managing Incidents and Traffic (TRANSMIT) system (E-ZPass tag readers), INRIX, and RTMS detectors. The TRANSMIT data is only available for northern New Jersey, outside of the DVRPC area.

Traffic speed and travel time data in Pennsylvania is also gathered via the E-ZPass readers and RTMS detectors. The Schuylkill Expressway is outfitted with E-ZPass readers, and PennDOT has also installed this system along I-95.

INRIX data in Pennsylvania is used to feed the 511 system, while data from E-ZPass and other roadway sensors is used by PennDOT's traffic operations centers for the variable message signs.

PennDOT Operations Data (Lou Belmonte, District Traffic Engineer, and Manny Anastasiadis, Assistant District Traffic Engineer for ITS and Traffic Operations, PennDOT District 6, June 29, 2010 meeting)

RCRS is a PennDOT database interface for incident data only. The data is entered manually by traffic operations centers and city or county officials.

Dynac is PennDOT's central software system, where all collected ITS data is fed (speed, volume, travel times, and video monitoring). The Dynac system has the capability to archive and produce reports on speed, volume, and travel time data; this archived data is only easily accessible going back three months.

Travel time data can be calculated from the E-ZPass system for point-to-point travel times, or by spot speed detectors such as RTMS and Traffic.com sensors.

PennDOT is in the process of installing travel time monitoring systems on many roadways in the region. Travel times on I-76 and US 1 (Roosevelt Blvd Extension) are gathered from E-ZPass tag readers, while travel times on US 202 are gathered from spot speed detectors. Travel Time systems for I-95, I-476, PA 63, and US 1 in Bucks County were complete in mid-2011. An additional section of US 202 (Section 320) is anticipated to have travel times from King of Prussia to US 30 in the fall timeframe. By the end of 2011, travel time is anticipated to be available for the PA 309 Expressway (Montgomery County).

The archived data reports produced by the Dynac system can be exported as Microsoft Excel files for speed, volume, and travel time data divided by date and location. PennDOT Operations staff, their service provider Transdyn, and DVRPC staff are currently working together to create a more manageable system for exporting data from the Dynac system for DVRPC use. The two agencies are working together to transfer three representative weekdays of data per month that will be summarized into DVRPC's traffic count/speed database that PennDOT can use.

Currently, data regarding the geographic location of ITS infrastructure in District 6 is incomplete. PennDOT is working with Jacobs Engineering to inventory and plot all of the ITS infrastructure, including fiber cables, in the region. This information will be available in Microsoft Access database and Geographic Information Systems (GIS) formats.

NJDOT Operations Data and Performance Measures (July 23, 2010 conference call with John Allen, Section Chief, Bureau of Systems Planning, NJDOT, and August 12, 2010 meeting led by John Allen and Jim Hadden, 511 and Special Projects, NJDOT)

The New Jersey Statewide Traffic Management Center (STMC) receives and archives real-time data from several sources, including TRANSMIT, INRIX, and ASTI (mobile traffic devices that have been installed for construction zones through contracts with ASTI Transportation Systems Incorporated).

Staff there have developed a Data Fusion Engine that, using an algorithm, prioritizes all of the real-time data sources and identifies the best data source for a particular area at that particular time. In many locations INRIX data will be the only data source available, but at times the data from TRANSMIT and ASTI may be preferred for accuracy where available. This Data Fusion Engine is open format so that if and when new data sources become available, they can be added to the algorithm. All data that comes into the STMC is archived, regardless of which data source was chosen by the Data Fusion Engine.

NJDOT's *Centerline* report, produced by the Asset Management Steering Committee (AMSC), has begun the process of using archived operations data for congestion management by using a sample of archived data to report on congestion performance measures. These are being tracked for two sample freeways in the state, I-78 and I-287, using TRANSMIT data. DVRPC provided NJDOT with an analysis for a tracking location in our region, NJ 42 between the Atlantic City Expressway and I-295. This analysis was done using VPP speed and travel time data from INRIX.

The *Centerline* performance measures used June 2008 data as a baseline measure, as this was before the economic downturn and before a steep rise in gasoline prices. The congestion goals are to avoid conditions that are worse than this June 2008 baseline.

Three main congestion measures were reported in *Centerline* for the corridors studied:

- Change in Peak-Hour Travel Times (using June 2008 as base measure);
- Duration of Congestion (with congestion defined as time when measured speeds drop below 70 percent of posted speed); and
- Percent Change in VMT.

NJDOT is planning to integrate the use of archived operations data into its Congestion Management System, but they are starting out with small, individual corridor studies in order to work out data issues. Moving forward, NJDOT would like to use VPP data for tracking congestion performance measures, because VPP provides greater coverage than TRANSMIT.

NJDOT staff believe that TRANSMIT and VPP archived data will eventually be used to develop full system performance assessments, in line with measures and targets established by the Department's AMSC. It will also be important to track how and why changes in the data occur, in order to rationalize changes in performance measures (for example, to determine whether changes in travel time are due to changes in gas prices, a congestion mitigation project, etc.)

AECOM Transportation, under contract to NJDOT, has been participating in this effort. AECOM is currently developing a method to efficiently process and analyze INRIX data, provided for the entire New Jersey freeway system 365 days a year. AECOM is also exploring which performance measures will be most appropriate for use with INRIX data. For example, AECOM has experimented with using INRIX data to calculate the "30th Hour Speed." This measure provides the speed during the hour when the average speed was 30th from the slowest in the time period analyzed. The concept is that the hours with the very slowest speeds are rare outliers, but the 30th slowest speed hour becomes a realistic measure to track. It is comparable to considerations used in developing road capacity projects.

CHAPTER 2

Case Study Using Pennsylvania Dynac Data

Several offices within DVRPC, as well as organizations from around the region, are interested in the possibility of collecting and analyzing archived traffic operations data for the purposes of transportation planning, congestion management, and performance measurement tracking. DVRPC is beginning to examine the use of data from PennDOT's Dynac system and the VPP for such purposes. Staff from DVRPC's Office of Transportation Safety and Congestion Management have met with several representatives from PennDOT, NJDOT, and other offices within DVRPC in order to gain access to and knowledge about the existing data resources in the region. As a first step, a relatively small amount of data was obtained from PennDOT's Dynac system for a portion of I-76. The following pages contain a summary of this data analysis and sample graphical representations of the available data.

Data Processing Technique for Sample PennDOT Data

PennDOT staff provided a first set of data for analysis. It included speed, volume, and travel time data for four consecutive Thursdays in the year 2010 (June 24, July 1, July 8, and July 15). It was for the section of I-76 from I-476 to I-95, selected to coordinate with another study. The data is reported in 15-minute intervals. Speed and volume data is reported from 40 eastbound locations and 39 westbound locations. Travel time data is reported for six eastbound segments and seven westbound segments on the same portion of I-76.

It was not immediately clear how to export from Dynac to Microsoft Access, so the data arrived in Microsoft Excel spreadsheets. Steps were taken to organize and clean the data. The most important step was to assign a number to each detector location or segment to make it possible to sort the data. PennDOT, their service provider, and DVRPC are coordinating on more efficient ways to transfer data in the future.

After the data was organized, each worksheet could be sorted by time and location in order to isolate peak-period data only. A separate filtered peak-period worksheet was created for each dataset, so as to keep the original data intact. In agreement with DVRPC's travel model methodology, the peak periods were defined as 7 to 9 AM and 3 to 6 PM.

In order to calculate average speeds and travel times for the peak periods, the following reported times were used for each peak period:

- AM Peak: 7:00, 7:15, 7:30, 7:45, 8:00, 8:15, 8:30, 8:45, 9:00; and

- PM Peak: 15:00, 15:15, 15:30, 15:45, 16:00, 16:15, 16:30, 16:45, 17:00, 17:15, 17:30, 17:45, 18:00.

Travel Time Analysis

For travel time computations, in some cases peak travel times were missing data (“zero” values). In these situations, the reported “typical travel time” for the corresponding 15-minute interval was used in place of the actual travel time. For each average AM and PM peak travel time computation, a “confidence” level is reported on the Excel file, as being real data, imputed (typical) data, or a mixture of these two types.

A first type of analysis tested was the Travel Time Index (TTI). In some places this is known as the Speed Difference measure to be more widely understandable. In order to calculate the TTI, a “Free-Flow Travel Time” value was needed. Rather than calculating this value using the posted speed limit and the segment length, the free-flow travel time was calculated as the average of the typical travel time for the midnight to 1 AM period for each segment. This value is likely a more accurate representation of travelers’ free-flow speeds than a metric based on the speed limit. The fact that posted speed limits vary within Dynac travel time segments would pose a problem for a speed limit-based methodology as well.

The initial resulting figures are on the pages that follow (Figures 2 and 3). A few highlights to consider are the following:

- The TTI is represented by different colors for lower and higher TTI values on each segment. A higher TTI value means that the actual travel time for that segment was much longer than the free-flow travel time. This map shows the average of all PM Peak TTI calculations for the four Thursdays analyzed. Additional data can be added to this calculation as it is collected.

- The segment data provided by PennDOT is provided in overlapping rather than contiguous segments. Thus, on the map, some areas of I-76 are represented with more than one color because of this segment overlap. For example, the I-76 Eastbound map includes a large segment represented in yellow that is overlapped by three other shorter segments represented in green and red.

- The graphs on the maps represent actual AM and PM peak travel times for specific road segments. These graphs illustrate the changes in travel times over the weeks.

- The average TTI values are useful for identifying specific recurring bottlenecks along a roadway, while the day-to-day comparison of travel time values is useful for visualizing travel time reliability and variability, and for determining changes over time.

Figure 2: Travel Time Variability and Change on I-76 Eastbound, June and July 2010

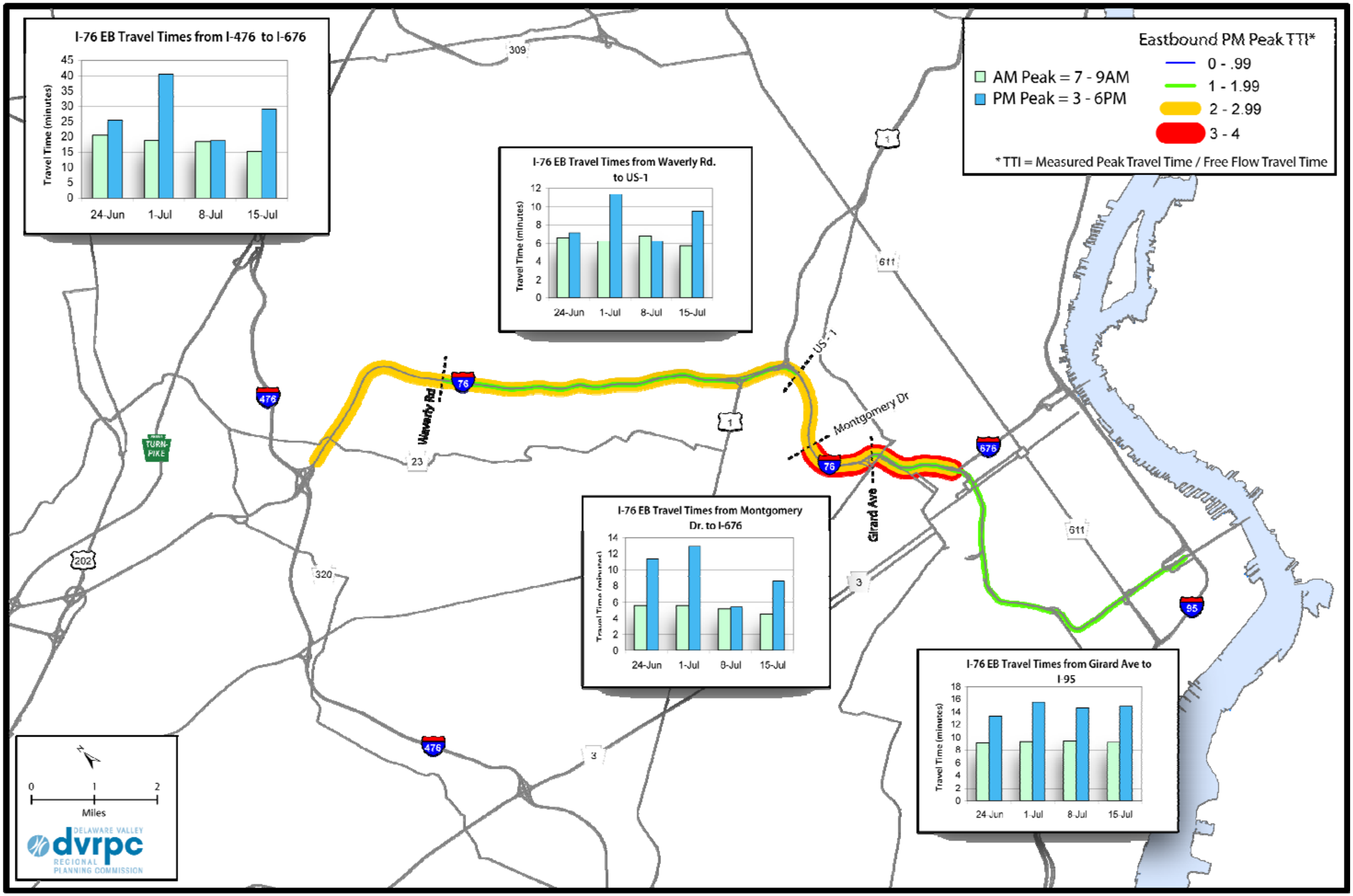
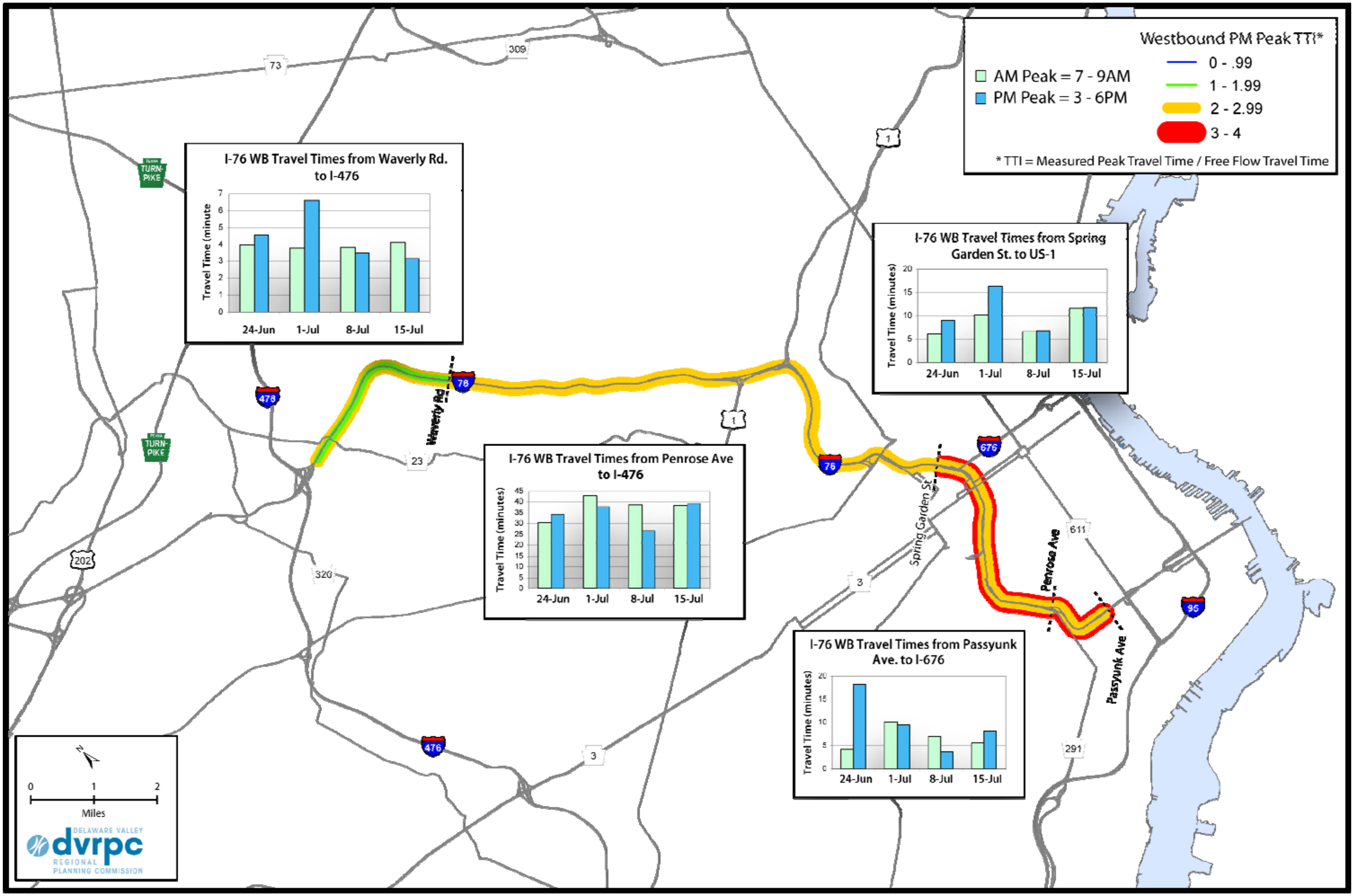


Figure 3: Travel Time Variability and Change on I-76 Westbound, June and July 2010



Traffic Speed

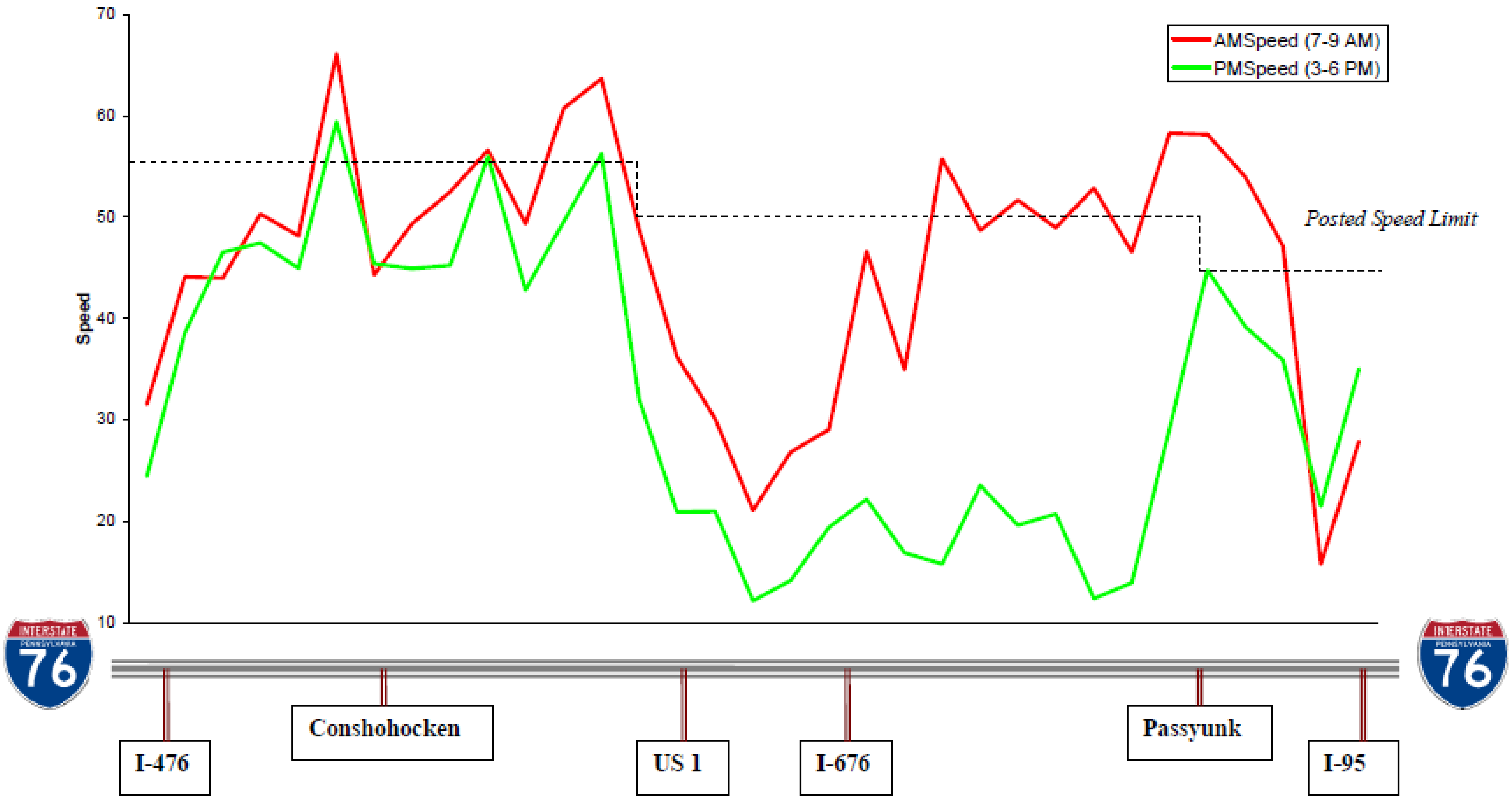
In some cases peak-period speed data was missing ("zero" values). For traffic speed computations, the missing data from peak periods was actually removed from the dataset, and average peak-period speeds are only reported for dates and locations with complete data. When a peak period was only missing data for one 15-minute interval, the average was calculated from the remaining non-zero values.

The following measurements were not calculated for this initial dataset due to the complications of large amounts of missing data or discontinuous segments in the sample dataset: Duration of Congestion and Delay per Traveler. The sample dataset retrieved from Dynac included a large number of "zero" values for speed, which makes it difficult to accurately calculate performance measures such as Duration of Congestion. According to PennDOT, this missing data results from periodic equipment malfunctions.

The initial resulting figures are inserted on the pages that follow (Figures 4 and 5). A few highlights to consider are the following:

- These graphics are intended to represent the geographical distribution of traffic speeds during the AM and PM peak periods of one representative day (June 24, 2010). The specific locations and intensities of traffic bottlenecks can be identified from these graphics.
- An interpretive straight-line representation of I-76 is provided, rather than an accurate map, due to the fact that the precise locations of speed detectors along I-76 are not available at this time.
- As noted on the graphic, the extremely low average speeds for some of the PM peak period may be due to an incident on I-76 on this date. While construction and incident data was not analyzed alongside the Dynac data for this initial exercise, detailed information regarding incidents would be important in the future for any analysis of short-term datasets.

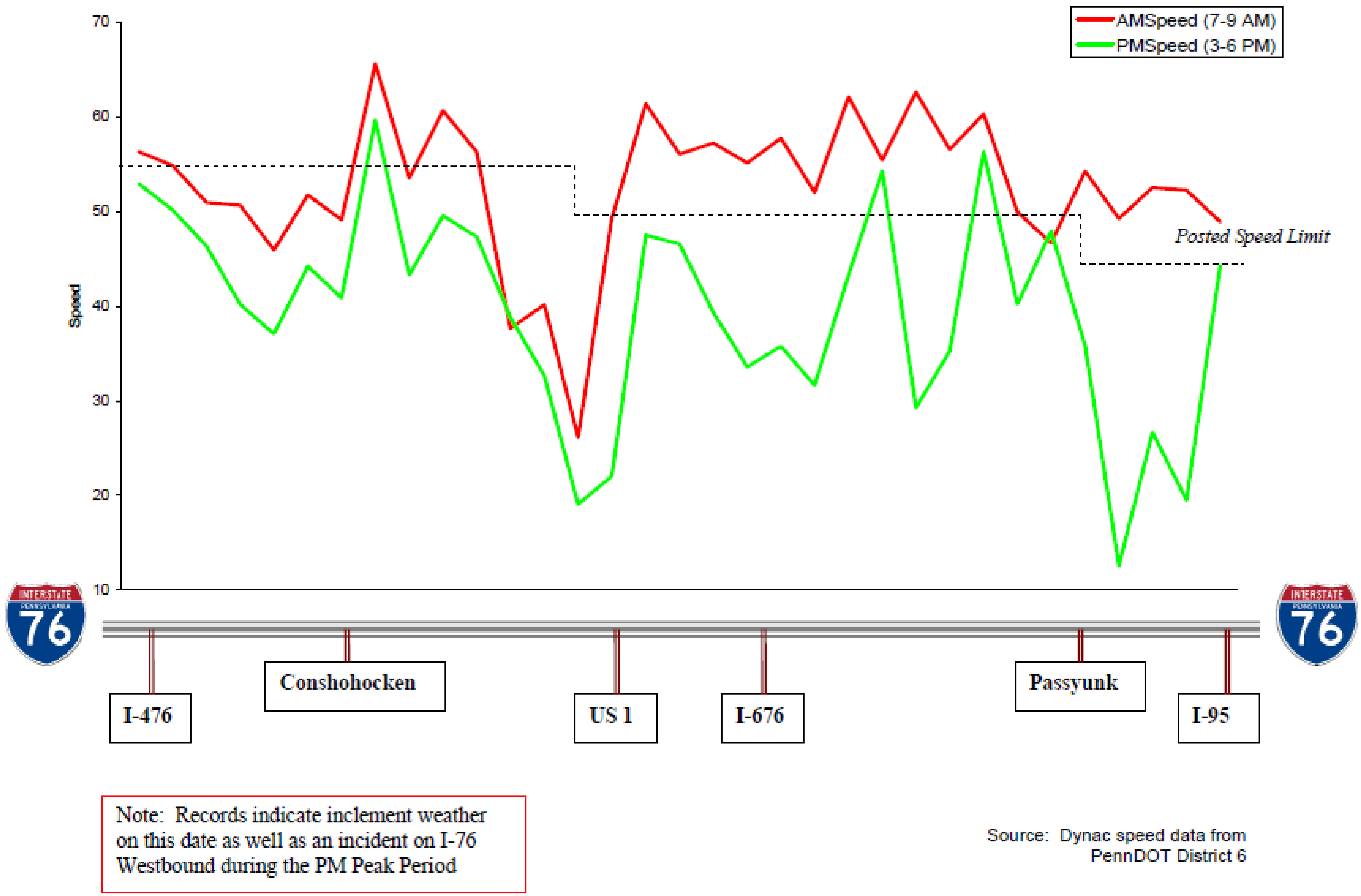
Figure 4: I-76 Eastbound Peak-Period Speeds, June 24, 2010



Note: Records indicate inclement weather on this date as well as an incident on I-76 Westbound during the PM Peak Period

Source: Dynac speed data from PennDOT District 6

Figure 5: I-76 Westbound Peak-Period Speeds, June 24, 2010



Case Study Using the I-95 Corridor Coalition's VPP (INRIX) Data

To further explore the use of archived operations data for planning, and specifically to pursue region-wide data analysis useful to the CMP, staff at DVRPC analyzed traffic speed data from INRIX, Inc. provided through the I-95 Corridor Coalition's VPP. The traffic speed data available from VPP covers almost all freeways and a number of major arterials across the DVRPC region, making it equally applicable to both Pennsylvania and New Jersey. The INRIX data is also accurate and reliable based on documented data validation research by the VPP as well as informal comments from staff at regional agencies. With consideration of the types and amount of available VPP data, it was important to limit a first effort to use the data to a scale that could be completed. One performance measure was pursued and only for the evening peak hour of 5 PM to 6 PM. This performance measure, Duration of Congestion, can be conceptualized as the average number of minutes during the evening peak hour that drivers on a roadway experience congested conditions. This is a measure NJDOT had selected for peak-period analyses. One reason DVRPC used this measure was to coordinate with and support NJDOT.

NJDOT developed and implemented the Duration of Congestion performance measure in their asset management report, *Centerline*[3]. NJDOT's Duration of Congestion measure, calculated using archived travel time and traffic speed data from TRANSCOM's TRANSMIT system, defines congestion as measured speeds that fall below 70 percent of the posted speed limit. NJDOT calculated duration of congestion for each sample road segment by counting the number of speed records during the combined morning and evening peak periods (6 to 9 AM and 4 to 7 PM) that had speeds below 70 percent of the posted speed limit. The ratio of "congested" speed records to total speed records is then calculated, and this can be converted to the total number of minutes out of the six hours of peak periods that were congested. Thus, NJDOT's Duration of Congestion measure can be conceptualized as the average number of minutes during the morning and evening peak periods that a roadway experiences congested conditions.

The Duration of Congestion measure developed and used at DVRPC is very similar to NJDOT's measure, with the main difference being that DVRPC only collected and analyzed speed data for the evening generalized peak hour of 5 to 6 PM. This decision was made due to data processing and staff time limitations. As will be discussed later, the resulting database from using one year of VPP weekday speed data from only 5 to 6 PM contained over 1.5 million records. Based on these numbers, it could be expected that analyzing the morning and evening peak periods for the same roadways would result in at least seven million speed records. While analyzing only the 5 to 6 PM peak hour does not capture all of the possible congested conditions on the region's roadways, within the constraints of data processing limitations and DVRPC's CMP timeline, the evening peak hour alone provides an acceptable representation of roadway congestion conditions on a region-wide basis.

---

[3] New Jersey Department of Transportation, **Centerline: A Semi-Annual Report on the Performance of Our Transportation System** (Trenton, NJ: New Jersey Department of Transportation, August 2010), http://www.state.nj.us/transportation/about/asset/pdf/centerline0810.pdf.

The following sections of this chapter address in more detail the nature of VPP data, the process of analyzing and mapping this data, the calculation of the Duration of Congestion measure, and the results of this analysis.

INRIX and I-95 Corridor Coalition VPP

INRIX is a private traffic information company that provides real-time traffic data and traveler information services for over 450,000 miles of roadway in twenty countries.[4] INRIX gathers traffic data through a combination of GPS-enabled vehicles and mobile devices, road sensors, and other sources such as local transportation agencies. Their primary function is to provide real-time and predictive traffic information to the traveling public through online services and mobile device applications. However, historical traffic information from archived real-time data is also available from INRIX. In the DVRPC region, the I-95 Corridor Coalition has contracted with INRIX and is assisted by the University of Maryland Center for Advanced Transportation Technology Laboratory, for the VPP. Through this collaboration, the VPP provides traffic data for over 4,700 centerline miles throughout the I-95 corridor region, including many in New Jersey and southeastern Pennsylvania.[5]

It should be noted that starting in 2010, the Texas Transportation Institute's annual *Urban Mobility Report* switched to using INRIX traffic data to calculate congestion measures in 439 urban areas across the United States.[6] The Texas Transportation Institute report uses INRIX speed data and transportation agency traffic counts to provide a variety of broad congestion measures on a metropolitan-area scale. The report ranks metropolitan areas on measures such as "Yearly Delay per Auto Commuter" and "Travel Time Index."[7] DVRPC's analysis, using mostly the same INRIX data, is able to provide a more detailed look at the Delaware Valley than the Texas Transportation Institute report. The fact that DVRPC and the Texas Transportation Institute *Urban Mobility Report* can now use the same data source is significant considering that the general public has some familiarity with the Texas Transportation Institute's reports, and this puts DVRPC's INRIX analysis into an understandable context.

As a member agency of the I-95 Corridor Coalition, DVRPC is able to access archived and real-time INRIX traffic data for select roads in the I-95 corridor region. The archived VPP data was acquired through a data request from the I-95 Corridor Coalition monitoring website hosted by INRIX. Archived data can be requested through this website by date range, state, and type of road coverage (freeway, arterial, or both). Because the data request format on this website did not allow certain time periods or counties to be filtered out in the request, the data request website was not particularly useful for DVRPC's data download needs. For DVRPC's Duration of Congestion measure, the specific data need was speed data for all available roads in the DVRPC nine-county region for the 5 to 6 PM period for all weekdays in the year 2009, aggregated to 15-minute time intervals. Stanley Young, Michael Pack, and staff from the University of Maryland Center for Advanced Transportation Technology Laboratory, who have since developed a data download tool to aid with these types of tasks, helped DVRPC to obtain this desired data. Since the original download of data for this VPP analysis task, the University of Maryland has worked through the Regional Integrated Transportation Information System (RITIS) to release a helpful web interface for downloading targeted and large amounts of archived VPP data. This interface will make future data retrieval much easier.

---

[4] INRIX, Inc., http://www.inrix.com/trafficinformation.asp.
[5] I-95 Corridor Coalition, http://www.i95coalition.org/i95/Default.aspx.
[6] "Economic Recovery Bringing Renewed Congestion Growth," Press Release, Texas Transportation Institute, January 20, 2011, http://mobility.tamu.edu/ums/media_information/press_release.stm.
[7] Texas Transportation Institute, **Urban Mobility Report**, 2010 (College Station, TX: Texas Transportation Institute Texas A&M University System, December 2010), http://tti.tamu.edu/documents/mobility_report_2010.pdf.

INRIX data is gathered in one-minute intervals. INRIX archives this data as five-minute intervals, but the University of Maryland maintains one-minute intervals in their archive. Because one- or five- minute intervals would have resulted in an overwhelming number of records, DVRPC requested data in 15-minute intervals. INRIX provided them by calculating the average of three five-minute interval data points. Because the University of Maryland archives the one-minute interval data, it would be possible moving forward to gather 15-minute data that is computed as the average of fifteen one-minute interval data points. As of June, 2011 the University of Maryland has completed a shift to provide fifteen-minute data as the average of fifteen one-minute intervals.

Data Processing and Mapping

The VPP data obtained from the University of Maryland consisted of a .csv file with eight fields and over 1.5 million records. This data was imported into a Microsoft Access database for processing. The fields in this database particularly relevant to DVRPC's analysis were the Traffic Message Channel (TMC) code and speed (though other fields such as travel time and reference speed are provided). The Traffic Message Channel (TMC) code is the location referencing system used by INRIX. Each TMC code represents a directional road segment, ranging in length from less than 0.1 mile to about 10 miles. In order to give these TMC codes a more understandable locational meaning, a "location lookup table" was provided by the University of Maryland that associates each TMC segment code with a route number, street name, direction, and beginning and ending latitude–longitude coordinates. This location information cannot readily be mapped on DVRPC's centerline files, however. The TMC codes provided by INRIX were mapped using the TMC tables from the Tele Atlas Dynamap package. The TMC codes from the INRIX database were joined with the TMC codes in the Tele Atlas TMC path table, and this allowed the INRIX data to be mapped in GIS. This method does not result in a perfect match-up between the INRIX roads file and the DOT centerline files.

When the TMC codes were joined with the Dynamap package, the resulting attribute table contained a very large number of records. This is because each TMC code segment is made up of several Dynamap ID segments. Because the INRIX speed data is provided by TMC code, the individual Dynamap ID segments were not needed for analysis. Therefore the GIS dissolve tool was used to dissolve the attribute table by TMC code, resulting in only one record per TMC segment and a much more manageable number of records in the attribute table.

The 1.5 million original speed records from the VPP database break down into about 12,000 TMC segments, most of which have slightly over 1,000 speed records per segment representing peak-hour speed measurements for the 260 weekdays in the year 2009. The Duration of Congestion measure was calculated for each TMC segment within Microsoft Access. The calculation of this measure involves a number of steps. First, a field for posted speed limit must be added to the Access table. This information is not included in the VPP data but is available from the Tele Atlas tables. Unfortunately, this posted speed data turned out to be inaccurate. Thus, DVRPC staff obtained posted speed data from PennDOT and NJDOT and manually populated the VPP TMC code table with this information. In cases where posted speed data was missing or inaccurate, Google "Street View" was used to verify speed limits.

Before further calculations were performed, speed records with a value of zero were removed from the database. The second step in calculating Duration of Congestion is to insert another field that calculates 70 percent of the posted speed limit for each TMC segment. The third step is to calculate, for each TMC segment, the number of measured speed records that are less than the 70 percent of the posted speed value. Using these resulting values and the number of total (non-zero) speed records for each TMC segment, a new value can be calculated representing the percentage of measured speed records for each TMC segment that falls below 70 percent of the posted speed limit. Finally, this percentage value is multiplied by 60 to obtain the number of minutes during the peak hour that each TMC segment experienced congested conditions. This final value is essentially the annual average minutes that the road segment is congested at the peak hour, with numbers falling between 0 and 60 minutes. The equation for Duration of Congestion follows as Figure 6. A step-by-step guide to performing this analysis in included as Appendix B.

Figure 6: Duration of Congestion Equation

$$\text{Duration of Congestion} = \left(\frac{\text{\# speed records below 70\% posted speed}}{\text{\# of total non-zero speed records}} \right) *60$$

(in minutes per segment)

Results

For data processing reasons, Duration of Congestion was only calculated for TMC segments that had one or more speed records below 70 percent of the posted speed limit. Once a Duration of Congestion value was assigned to each TMC segment, this data was joined to the Tele Atlas TMC table for mapping. The Duration of Congestion values for the DVRPC region ranged from 0 to 60 minutes, and for map visualization purposes these values were divided into three categories: greater than 0 to 20, greater than 20 to 40, and greater than 40 to 60. These categories can be thought of as low, medium, and high levels of peak-hour congestion. The three categories are represented on the map by a thin green line for low congestion, a medium orange line for medium congestion, and a thick red line for high congestion. Because VPP data is provided in directional TMC segments of various lengths, many roadways show several colors simultaneously. Similar to the maps of PennDOT Dynac data, however, the thickest line, or highest level of congestion, is more visible above overlapping segments of lower congestion. A future enhancement will be off-setting each direction for easier viewing.

The Duration of Congestion calculations for freeways and arterials were mapped separately. Because of the differences in traffic flow characteristics between arterials (signalized) and freeways (unsignalized), it is currently unclear how to compare speed data between these two categories of roadways. INRIX representatives have also noted that the arterial speed data has been through less validation testing than freeway speed data, and the reliability and meaning of the arterial data is less well understood. Figure 7 shows the Duration of Congestion on freeways, and Figure 8 the Duration of Congestion on arterials. A few things to note are the following:

- This Duration of Congestion measure is intended to provide a broad measure of general congestion on a regional basis. Because the measure is an annual average, incident- or weather-related conditions will generally be absorbed in the “bigger picture” of average congestion unless they are outstanding characteristics of the segment. The TTI measure produced with Dynac data provides a better representation of roadway reliability, while Duration of Congestion provides a sense of prevailing conditions.

- While many lane-miles of VPP data coverage are available from the I-95 Corridor Coalition, not all major roads in the region are represented. Notably, the Northeast Extension of I-476 from the PA Turnpike through Montgomery County and NJ 73 south of NJ 70 are missing. INRIX data is available for many more roads throughout the Delaware Valley, but this data is only available for additional fees outside of the I-95 Corridor Coalition membership.

- In general, the arterial roadways (such as US 202 and NJ 73) covered by VPP data show more severely congested conditions than the freeways (such as I-76 and I-95). As noted above, this may be because the VPP speed data from arterial roadways incorporates the slower speeds associated with slowing and stopping traffic on signalized roads, whereas a more stable speed is more likely to occur on non-signalized freeways. In other words, the amount of time that drivers on a signalized arterial could possibly spend at or above the posted speed limit is logically less than that of drivers on non-signalized freeways. Though the meaning of this data difference is unclear at this point, it is important that congestion on signalized arterials is being measured and represented. Major arterials have high rates of congestion and crashes. They are also of interest because increasingly coordinated and adaptive traffic signal systems are a very promising congestion-mitigating ITS strategy. At this point, however, VPP data should only be used to compare measures between arterials, not between arterials and freeways.

Figure 7: Duration of Congestion on Freeways Map

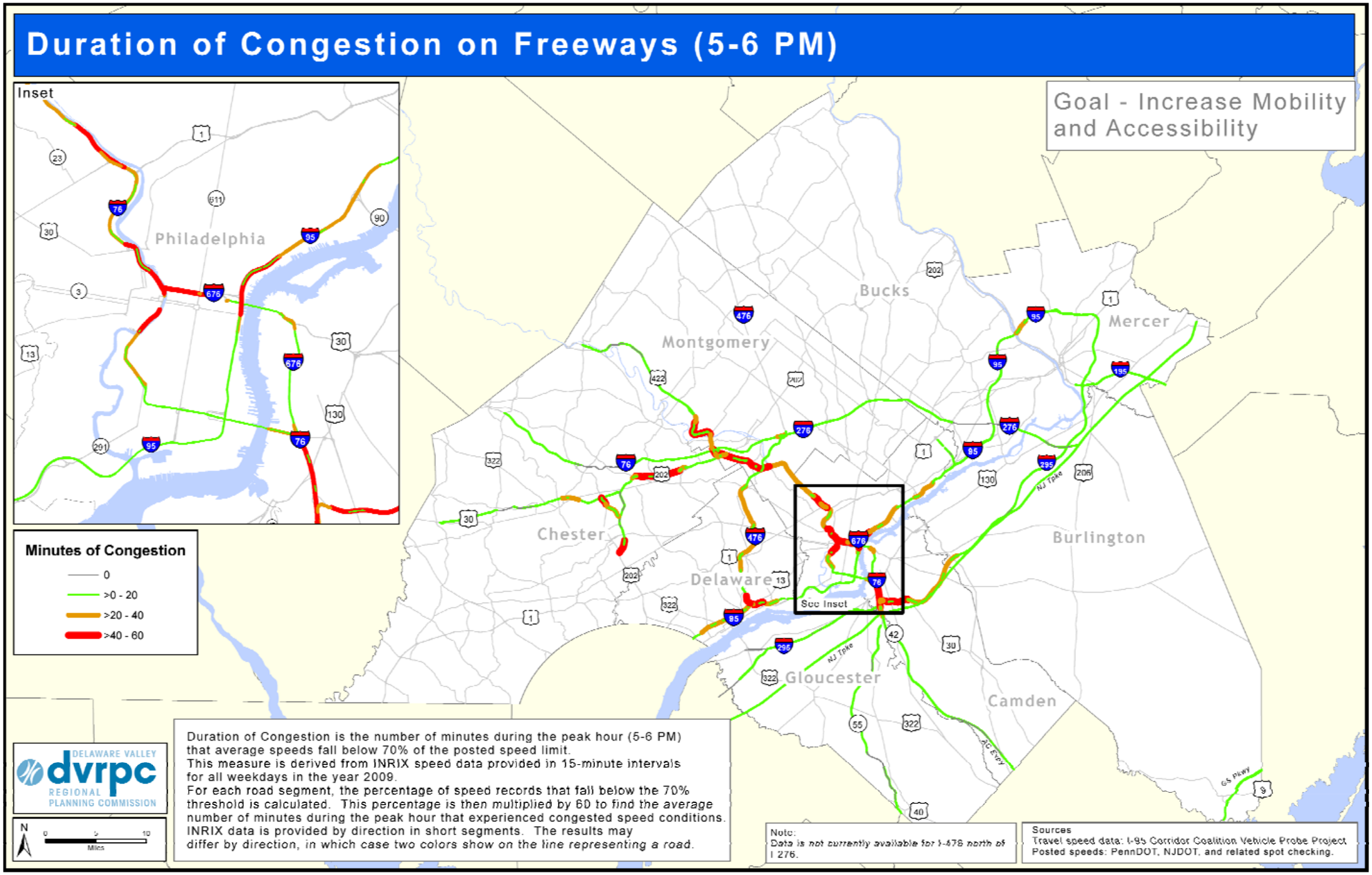
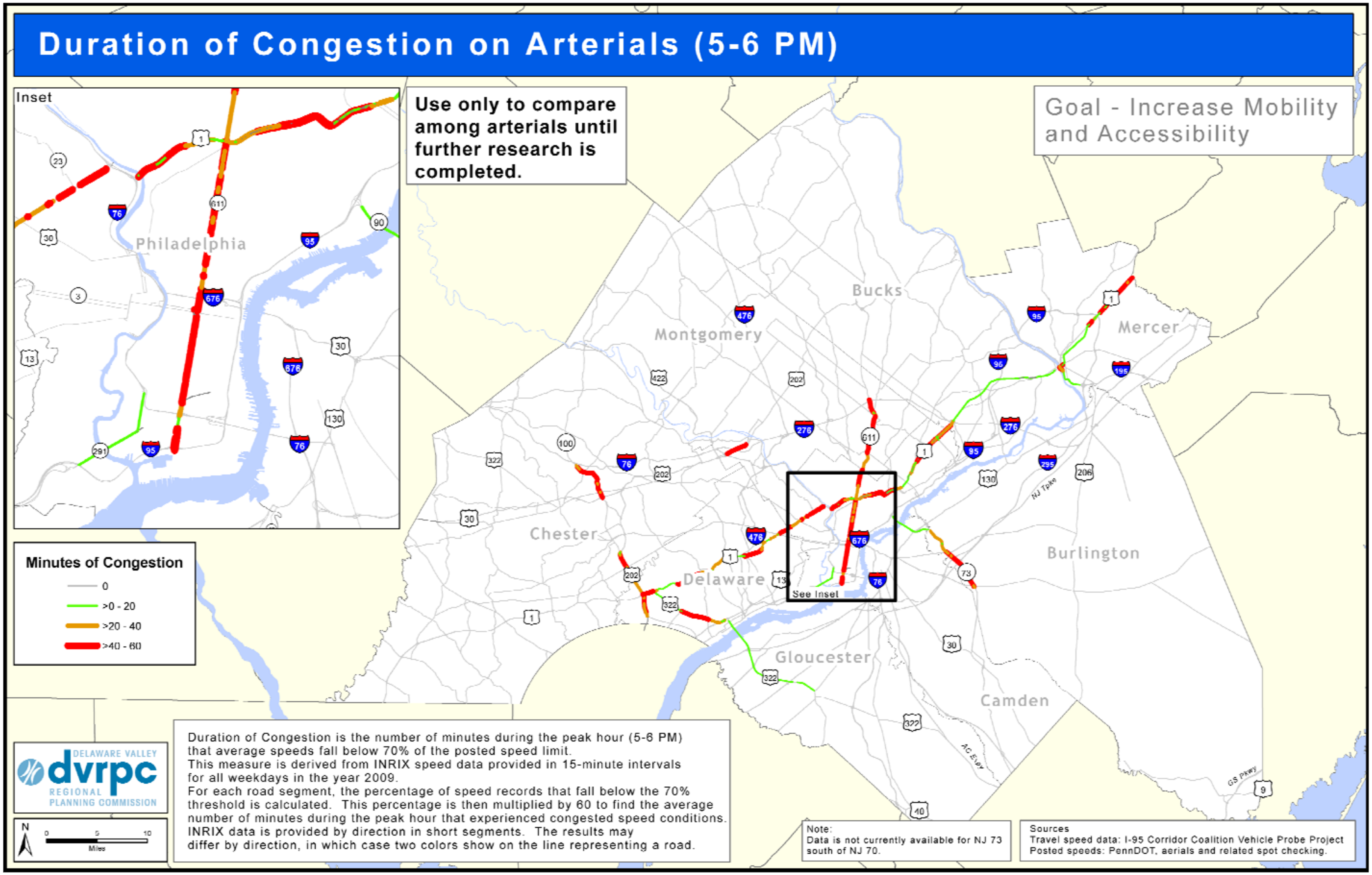


Figure 8: Duration of Congestion on Arterials Map



Analysis

At this time, DVRPC is more focused on analysis of freeways because of the uncertainties surrounding arterial data. It is thought that the arterial data can be used to compare between arterials included in the data-set, although differences in the density of traffic signals may be an issue.

A simple form of analysis using the Duration of Congestion measure is to rank order road segments by minutes of congestion. Tables 1 and 2 below show the top six road segments in the freeway and arterial categories that result from sorting TMC segments by minutes of peak-hour congestion. Each of these segments experienced more than 55 minutes of congestion during the average PM peak-hour in 2009. The peak-hour directional traffic volume is listed for each road segment to give an idea of the magnitude of people in vehicles affected by the congestion. This concept will also be explored later in this section.

It should be noted that in many cases, projects are planned or even completed that will reduce this measured congestion. For example, a major improvement project to the intersection of NJ 73 and NJ 70 (see Table 2) opened for use in Summer 2011 that will reduce congestion in this area. This location is expected to come off the top congestion list in the future. For more information on planned improvements, see the Transportation Improvement Program at www.dvrpc.org/TIP or contact DVRPC, PennDOT, or NJDOT.

Table 1: Top Six Freeway Segments with Longest Duration of Congestion

Route	***Description***	***Direction of Most Congestion***	***State***	***Peak-Hour Volume***	***Minutes of Peak Hour Congestion***
I-676	Between Broad Street/PA 611 and I-76	Eastbound	PA	4,796	55
US 202	Between PA 29 and N. Valley Road	Southbound	PA	3,249	54
I-76	At I-676	Eastbound	PA	5,168	53
I-295	Between US 30 and I-76	Southbound	NJ	5,785	52
I-76	At I-295	Eastbound	NJ	6,892	52
I-95	Between I-676 and Aramingo Avenue	Northbound	PA	5,811	51

Note: Volume values represent only the direction of most congestion.

Table 2: Top Six Arterial Segments with Longest Duration of Congestion

Route	Description	Direction of Most Congestion	State	Peak-Hour Volume	Minutes of Peak Hour Congestion
PA 611	At I-95	Southbound	PA	566	59
NJ 73	Between I-295 and NJ Turnpike	Southbound	NJ	2,937	59
NJ 73	At NJ 70	Southbound	NJ	1,298	59
US 1	At I-76	Southbound	PA	1,668	58
PA 611	Between I-676 and South Street	Southbound	PA	1,126	58
PA 611	Between Wyoming and Olney Avenue	Northbound	PA	1,356	58

Note: Volume values represent only the direction of most congestion.

Another way to analyze this VPP data is to look at the severity of congestion in terms of how many people it affects. Using the peak hour vehicle volume along with the number of congested minutes for each TMC segment, a “vehicle-hours of congestion” measure can be calculated. This measure was calculated for freeways in the Delaware Valley to pull out the roadways where peak-hour congestion affects the greatest number of people. After filtering the data for only road segments with 35 minutes or more of peak hour congestion, the following formula was used to calculate “vehicle-hours of congestion” for each TMC segment (Figure 9):

Figure 9: Vehicle-Hours of Congestion Formula

$$\text{Vehicle-Hours of Congestion (by TMC Code)} = \left(\frac{\text{Peak Hour Volume} * \text{Minutes of Congestion}}{60} \right)$$

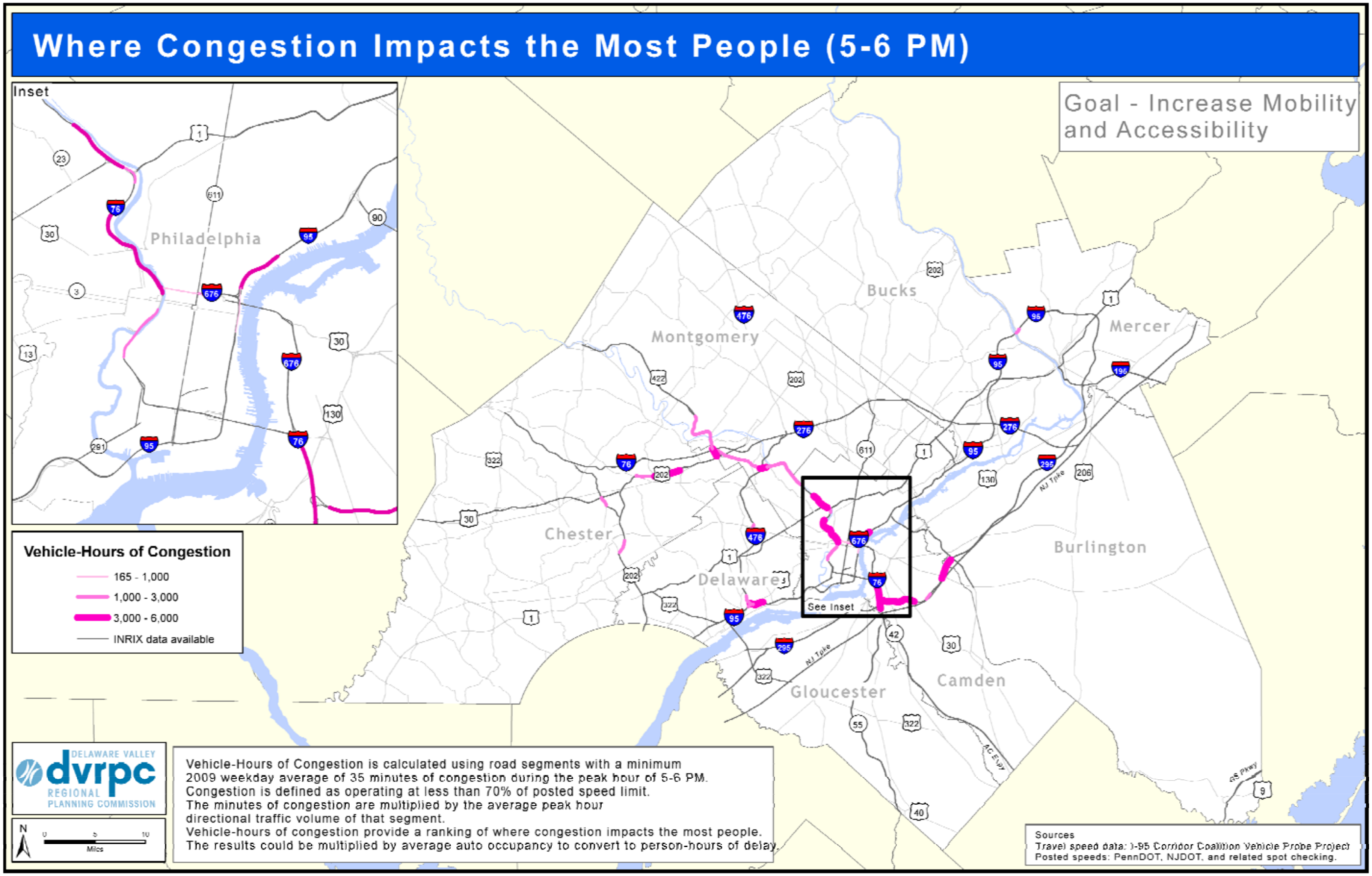
After sorting the resulting list by the “vehicle-hours of congestion” field, the top freeway segments whose congestion has the greatest impact on people in the Delaware Valley are highlighted. Table 3 lists the freeway segments with the highest vehicle-hours of congestion. Note that the road segments and vehicle-hour values are directional. Figure 10 is a map representing the vehicle-hours of congestion on Delaware Valley freeways. The thickest lines represent the highest vehicle-hours of congestion and correspond to the segments in Table 3.

Table 3: Top Segments with High Vehicle-Hours of Congestion

Route	Description	Minutes of Peak-Hour Congestion	Vehicle-Hours of Congestion	Direction of Most Congestion	State
I-76	Between Walt Whitman Bridge and I-295	52	5,984	East	NJ
I-295	Between US 30 and I-76	52	5,023	South	NJ
I-95	Between I-676 and Aramingo Avenue	51	4,973	North	PA
I-76	Between I-676 and Montgomery Drive	53	4,582	East	PA
I-676	Between Broad Street/PA 611 and I-76	55	4,537	West	PA
I-76	Between Belmont Avenue and US 1	48	4,034	West	PA
I-95	At I-476 Interchange	40	3,792	South	PA
US 202	Between PA 29 and North Valley Rd.	53	3,510	South	PA
US 422	Between 202 and just north of PA Turnpike	42	3,379	West	PA
I-295	Between NJ 73 and NJ 70	37	3,078	South	NJ
I-76	At I-476 Interchange	47	3,068	East	PA
I-76	At Conshohocken Curve	37	2,368	West (though both directions are highly congested)	PA

Note: All segments and calculation values represent one direction only.

Figure 10: Vehicle-Hours of Congestion Map



Analysis of congestion measures, along with traffic volume data, helps us understand the magnitude of congestion's affects across the Delaware Valley. As a limited example, on just the top congested road sections included in Table 3 drivers experience at least 40,000 vehicle-hours of congestion on one average weekday peak hour. This can by multiplied by the Delaware Valley regional average vehicle-occupancy rate of 1.37 to convert to 54,000 person-hours of congestion. Person-hours of congestion is a useful measure both in making the numbers understandable and in setting the stage for multimodal analysis. The transportation system in the Delaware Valley is strongly multimodal, so it makes sense to move forward using measures that can be calculated for more than just drivers.

With additional sources of data and calculations, this VPP data could help provide information about the amount of lost worker productivity time in a year or the amount of increased vehicle emissions resulting from congested conditions. The combination of real traffic counts and traffic speed data provides a powerful tool for performance measurement and asset tracking looking toward the future.

CHAPTER 4

Next Steps

Short-Term Steps

One or two more measures are being developed by DVRPC to track on a regular basis. Considerations include which performance measures NJDOT and PennDOT are using or interested in, whether we are able to replicate their analysis, and whether similar analysis can be done in both states. DVRPC may do additional work for the CMP or other projects. DVRPC wants to coordinate with the DOTs in order to produce useful analysis for all three agencies and to help communicate with a broader regional audience in a manner that causes as little confusion as possible. DVRPC is also coordinating with other metropolitan planning organizations (MPOs) and DOTs in the I-95 corridor on potential shared measures. National Cooperative Highway Research Program Report 618 provides useful information regarding appropriate performance measures for specific needs.

After Duration of Congestion, the first additional measure will focus in more depth on reliability of roads throughout the region. While Duration of Congestion provides baseline analysis across the region, we need to be able to measure which roads fluctuate the most in their reliability. The possibility of calculating TTI or Buffer Index with VPP or other similar data is being explored, primarily with PennDOT (refer to Appendix A for performance measure definitions). Travel Time Tax is another term that is being considered as it is very similar to both TTI and Buffer Index. Additionally, both PennDOT and NJDOT are interested in using performance measures of archived operations data in order to benchmark certain roads or corridors to an average day. Furthermore, by carefully using archived data in conjunction with before and after studies, performance measures can be used to evaluate the cost-effectiveness of projects and strategies.

As previously noted, PennDOT and DVRPC staff are working on a more efficient way to transfer data from the Dynac system. Even once the data from PennDOT is received in a more analysis-ready format on a regular basis, the issue of missing and incorrect data must be addressed. There should be a way to automate the process of identifying days and locations with acceptable data quality, addressing both missing and repetitive data. As this equipment produces quite a bit of data errors, a protocol needs to be developed for either discarding or correcting the missing or outlying data points.

There are some other technical elements of the Dynac data to figure out. Two such elements are:

- The specific location of tag readers and other vehicle detectors that are providing the data is not yet available. Efforts to gather this location data and relate it to the Dynac traffic data are currently underway.

- The definition of the "typical" travel time and traffic speed values is still unknown. These values could possibly be useful where real-time data is missing or inaccurate. More information is needed about how they were calculated from Transdyn.

There are also some specific issues with using VPP data. These include:

- The links (segments) vary widely in length and are often very short. If travel time analysis is to be performed with the VPP data, a meaningful way of interpreting these segments will need to be devised.

- The use of VPP data is already proving to be a useful tool for planning and congestion management, and thus all regional agencies should work together to ensure that access to this data is continued into the future throughout the Delaware Valley. As of April 2011, it is more definite than in previous discussions that Pennsylvania will continue to pay for the current or expanded level of VPP coverage after June 2011.

- As discussed on page 21, the time-interval and data aggregation format of future VPP data analysis may be revisited. Though we do not anticipate any significant changes in results, if future analysis is performed with a different data aggregation technique, DVRPC will do a comparison to the original analysis of 2009 data.

An area of technical work relating to both the Dynac and VPP data is analysis of how they relate to each other. Initial efforts are underway but will need the more complete mapping of Dynac detectors. A first step will be to analyze how similar the two data-sets are for I-76. Investigating where differences are greatest may result in opportunities to improve both data sources.

One of the most important short-term steps to advance the use of operations data for planning in the Delaware Valley is to continue to build and strengthen partnerships throughout the region. As a first step, an email list has been created that includes a number of people from agencies throughout the Delaware Valley involved in the use of archived operations data. The members of this email list will be updated by request.

A further step would be to form a committee of regional partners to focus on the use of traffic operations data for planning. This would help facilitate more face-to-face meetings and collaboration on performance measures and projects.

Longer-Term Steps

The DVRPC effort to use operations data for planning has as its central tenet to not get overwhelmed and end up doing nothing. As a result, there will always be longer-term steps that are needed or desirable. The list so far includes:

- Continue to collect and analyze data in order to monitor where congestion gets better or worse over time, and to understand why. This includes analyzing archived traffic data alongside incident data and perhaps significant weather events. Performance measures regarding incident clearance time and secondary accident avoidance may be useful to the DVRPC safety program and the Office of Transportation Operations Management.
- Analyze data for more roads, for more hours, and for more days. In particular, we are interested in learning how to more fully use the data on major arterials.
- Address compatibility issues and bring together VPP and Dynac data, as well as other real-time data sources.
- Continue to understand reliability and quality issues for different data sets.
- Further automate the importing, analysis, and mapping functions of the data.
- Continue to develop how to communicate the results of these analyses to various audiences and how to use the results to reduce congestion.

APPENDIX A

Selected Mobility and Reliability Measures

The following definitions and equations are taken from *Cost Effective Performance Measures for Travel Time Delay, Variation, and Reliability* (National Cooperative Highway Research Program - Report 618).

Delay per Traveler: The delay per person or delay per peak-period traveler (in daily minutes or annual hours) can be used to reduce the travel delay value to a figure more useful in communicating to nontechnical audiences. The equation for Delay per Traveler is shown below.

Delay per Traveler Calculation

$$\text{Delay per Traveler (annual hours)} = \frac{\begin{pmatrix}\text{Actual Travel Time (minutes)} - \text{FFS or PSL Travel Time (minutes)}\end{pmatrix} \times \text{Vehicle Volume (vehicles)} \times \text{Vehicle Occupancy (persons/vehicle)} \times \frac{\text{250 week days}}{\text{year}} \times \frac{\text{hour}}{\text{60 minutes}}}{\text{Vehicle Volume (vehicles)} \times \text{Vehicle Occupancy (persons/vehicle)}}$$

Source: National Cooperative Highway Research Program, **Cost Effective Performance Measures for Travel Time Delay, Variation, and Reliability,** Report 618, (Washington, DC: Transportation Research Board, 2008), 15.

Note: FFS = Free-Flow Speed and PSL = Posted Speed Limit

Travel Time Index: The Travel Time Index (TTI) is a dimensionless quantity that compares travel conditions in the peak period to travel conditions during free-flow or posted speed-limit conditions. For example, a TTI of 1.20 indicates that a trip that takes 20 minutes in the off-peak period will take 24 minutes in the peak period or 20 percent longer. The general equation for the TTI is shown below

Travel Time Index Calculation

$$\text{Travel Time Index} = \frac{\text{Actual Travel Rate (minutes per mile)}}{\text{FFS or PSL Travel Rate (minutes per mile)}}$$

Source: National Cooperative Highway Research Program, **Cost Effective Performance Measures for Travel Time Delay, Variation, and Reliability,** Report 618, (Washington, DC: Transportation Research Board, 2008), 14.

Buffer Index: Buffer Index (BI) is a measure of trip reliability that expresses the amount of extra buffer time needed to be on time for 95 percent of the trips (e.g., late for work on one day out of the typical 20-workday month.) The equation for BI is shown below.

Buffer Index Calculation

$$\text{Buffer Index (\%)} = \left[\frac{\text{95th Percentile Travel Time (minutes)} - \text{Average Travel Time (minutes)}}{\text{Average Travel Time (minutes)}} \right] \times 100\%$$

Source: National Cooperative Highway Research Program, **Cost Effective Performance Measures for Time Travel Delay, Variation, and Reliability,** Report 618. (Washington, DC: Transportation Research Board, 2008), 16.

Planning Time Index: Planning Time Index represents the total travel time that should be planned when an adequate buffer time is included. Planning Time Index differs from the BI in that it includes typical delay as well as unexpected delay. Thus, the Planning Time Index compares near worst case travel time to light or free-flow traffic travel time. The equation for computing Planning Time Index is shown below.

Planning Time Index Calculation

$$\text{Planning Time Index (no units)} = \frac{\text{95th Percentile Travel Time (minutes)}}{\text{Travel Time Based on Free-Flow or Posted Speed (minutes)}}$$

Source: National Cooperative Highway Research Program, **Cost Effective Performance Measures for Time Travel Delay, Variation, and Reliability,** Report 618. (Washington, DC: Transportation Research Board, 2008), 16.

Congested Travel: Congested travel is a measure that captures the extent of congestion. It estimates the extent of the system affected by the congestion. The definition of congestion must be defined for this measure. The equation for computed Congested Travel follows.

Congested Travel Calculation

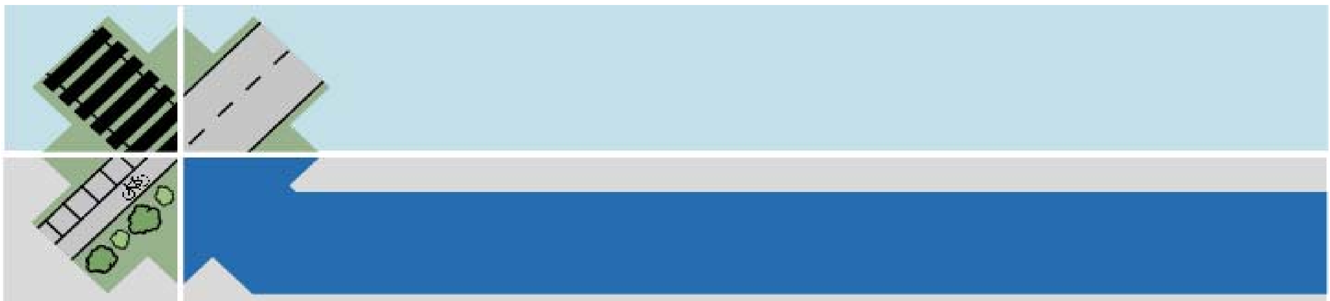
$$\begin{matrix}\text{Congested Travel} \\ (\text{vehicle - miles})\end{matrix} = \sum \left(\begin{matrix}\text{Congested} \\ \text{Segment Length} \\ (\text{miles})\end{matrix} \times \begin{matrix}\text{Vehicle Volume} \\ (\text{vehicles})\end{matrix} \right)$$

Source: National Cooperative Highway Research Program, **Cost Effective Performance Measures for Time Travel Delay, Variation, and Reliability,** Report 618. (Washington, DC: Transportation Research Board, 2008), 14.

Note: The mobility and reliability measures in this report are presented as examples only, and do not represent the exact measures that will be used by the Delaware Valley Regional Planning Commission (DVRPC) in future analyses. DVRPC will coordinate with New Jersey Department of Transportation, the Pennsylvania Department of Transportation, and other agencies in order to use the same measures and methodologies wherever reasonable.

APPENDIX B

Duration of Congestion Methodology Summary



Overview of Methodology to Calculate Duration of Congestion

As of March 2011

This methodology was applied to one peak hour, 5 to 6 PM, for weekdays in 2009 for all available freeways and other roads for which VPP provides data in the Delaware Regional Planning Commission (DVRPC) nine-county region.

1. Select all speed records that have a non-zero value and calculate the total number of non-zero speed records for each TMC code.

2. Assign a “posted speed limit” value for each Traffic Message Channel (TMC) code. In DVRPC’s case, much of this work was done manually using data from the Pennsylvania Department of Transportation (PennDOT) and the New Jersey Department of Transportation (NJDOT).

3. For each TMC code, calculate the number of speed records that fall below 70 percent of the posted speed limit (this threshold is our definition of “congested” conditions).

4. Calculate the ratio of records that indicate congestion (above) to total valid records.

   For example, 457 records out of a total 1,040 records below 70 percent of the posted speed limit for a single TMC code = 44 percent

5. Multiply the above ratio by 60 minutes to get the number of congested minutes in an average peak hour for each segment. This will give you an annual average duration of congestion value for each TMC code.

In the example above, 44 percent of 60 minutes = 26.4 minutes of congestion during the peak hour for that TMC code segment.

6. To map the VPP data in a Geographic Information System, first join the TMC codes to the Tele Atlas road network using the Tele Atlas TMC Path Table included in the Dynamap package. This process will result in a much larger database than the original, as there are multiple “Dynamap ID” attributes per TMC code. If desired, the resulting attribute table can be dissolved by TMC code to simplify the database.

7. Finally, map the results by symbolizing each TMC code by minutes of congestion. For TMC segments with 0 minutes of congestion, use a darker, wider line to show where VPP data is provided but there is no congestion. Then use colors to symbolize the TMC segments with various levels of congestion. The breaks identified in the DVRPC analysis are >0 to 20 minutes, >20 to 40 minutes, or >40 to 60 minutes of peak-hour delay on average for weekdays in 2009.

This methodology was developed to coordinate with NJDOT work. DVRPC expresses appreciation to John Allen (NJDOT) and Gary Davies (AECOM) for their assistance. Data and much help along the way were provided by the I-95 Corridor Coalition, the University of Maryland Center for Advanced Transportation Technology Laboratory, and INRIX. DVRPC appreciates the gracious help of all these organizations in preparing the analysis.

APPENDIX C

Acronyms and Terms

Acronyms and terms relevant to traffic operations data and planning in the Delaware Valley are defined in this appendix. This appendix is oriented toward specific terms and acronyms used in this report and is not intended to cover all the acronyms that traffic operations planners use.

Acronym or Term	Definition
511 Traveler Information	Real-time information on transportation and traffic conditions available by phone or web in many states, including Pennsylvania and New Jersey
ASTI	A company that provides mobile and permanent traffic measurement and control devices, usually for use in road construction projects
Bluetooth	Bluetooth is an open wireless technology standard for exchanging data over short distances. Vehicles containing Bluetooth-equipped devices can be sensed by roadside Bluetooth readers and tracked over time and space using each device's unique ID. This traffic sensing technology operates similarly to E-ZPass systems.
CMP	Congestion Management Process—A systematic process to manage congestion required in all metropolitan areas
DVRPC	Delaware Valley Regional Planning Commission – Metropolitan planning organization for the nine-county bi-state Philadelphia metropolitan region
Dynac	PennDOT's software system for collecting and managing real-time traffic operations data
E-ZPass	An electronic toll collection system that utilizes a system of electronic transponders located in vehicles and stationary tag readers installed at toll plazas and along freeways
FFS	Free-Flow Speed
FHWA	Federal Highway Administration—A division of the U.S. Department of Transportation focused on roadways
GIS	Geographic Information System
GPS	Global Positioning System
I-95 Corridor Coalition	An alliance of transportation agencies and organizations that provides a forum to address transportation management and operations issues in the corridor from Florida to Maine and into Canada. The I-95 Corridor Coalition manages the VPP and other technical efforts.
Incident Management	Range of strategies to reduce congestion of the transportation network due to non-recurring events such as crashes or inclement weather
INRIX	A company that provides real-time traffic information to the public as well as transportation agencies. INRIX traffic data is collected using vehicle probe methodologies.

Acronym or Term	Definition
NCHRP	National Cooperative Highway Research Program of the Transportation Research Board, a coordinated project of American Association of State Highway and Transportation Officials and FHWA
NJDOT	New Jersey Department of Transportation
PennDOT	Pennsylvania Department of Transportation
PSL	Posted Speed Limit
RCRS	Road Condition Reporting System—PennDOT's data integration and sharing software for roadway maintenance and incident information
RIMIS	Regional Integrated Multi-Modal Information Sharing— Web-based transportation operations information exchange network for the Delaware Valley staffed by DVRPC
RITIS	Regional Integrated Transportation Information System—A project of the University of Maryland Center for Advanced Transportation Technology Laboratory; an automated data-sharing system among transportation agencies in Maryland, Virginia, and Washington D.C.
RTMS	Remote Traffic Microwave Sensors—Stationary traffic sensors that use microwave-band radar to collect data on traffic counts, speeds, and lane occupancy
SWIFT	State Wide Information for Traffic—NJDOT's data integration and sharing software for roadway maintenance and incident information
TOC	Traffic Operations Center
Traffic.com	A company that provides real-time traffic information to the public as well as transportation agencies. Traffic.com data is collected using roadside RTMS equipment.
Traffic Operations	This broad field generally uses data to help keep people and goods moving, often through relatively low-cost strategies such as timing of traffic signals, or more ITS-related approaches such as providing information to travelers that helps them make efficient decisions.
Transdyn	The traffic technology company that develops and provides support for PennDOT's Dynac software system
TRANSMIT	The U.S. Transportation Command System for Managing Incidents and Traffic—System that collects traffic speed and travel time information using the E-ZPass Toll Tag reader system
TTI	Travel Time Index
VMS	Variable Message Signs— Electronic traffic signs installed along roadways intended to give travelers information about special events, incidents, and traffic conditions
VMT	Vehicle Miles Traveled— A measure of overall vehicle travel
VPP	Vehicle Probe Project— An initiative of the I-95 Corridor Coalition to provide and analyze INRIX data for the broad I-95 corridor through a collaboration with INRIX and the University of Maryland Center for Advanced Transportation Technology Laboratory

Publication Title: Using Operations Data for Planning in the Delaware Valley: First Steps

Publication Number: 11049

Date Published: August, 2011

Geographic Area Covered: The nine-county Greater Philadelphia area, which covers the counties of Bucks, Chester, Delaware, Montgomery, and Philadelphia in Pennsylvania; and Burlington, Camden, Gloucester, and Mercer in New Jersey

Key Words: archived operations data, real-time, congestion management process (CMP), performance measures, Dynac, INRIX, congestion, Travel Time Index, I-76, freeways, major arterials

Abstract: Real-time traffic operations data has been gathered for several years on an increasing number of roads throughout the Delaware Valley. The archives of this data are a tremendous potential resource for transportation planning. Use of the data, however, has posed significant technical challenges. This report summarizes how the data can be used, the state of operations data for planning in the Delaware Valley, and the results of two case studies.

The first case study used data from the Pennsylvania Department of Transportation's Dynac system about speed and travel time on a section of I-76. The second case study used data provided by the I-95 Corridor Coalition Vehicle Probe Project (VPP) from INRIX, a private-sector traffic data company. The second case study analyzed duration of congestion on weekdays in 2009 for freeways in the Delaware Valley. This analysis was used in the region’s 2011 Congestion Management Process.

Staff Contact:

Zoe Neaderland, AICP
Manager, Office of Transportation Safety and Congestion Management
☏ (215) 238-2839
ZNeaderland@dvrpc.org

Delaware Valley Regional Planning Commission
190 N. Independence Mall West, 8th Floor
Philadelphia PA 19106
Phone: (215) 592-1800
Fax: (215) 592-9125
Internet: www.dvrpc.org

DELAWARE VALLEY
dvrpc
REGIONAL
PLANNING COMMISSION