DELAWARE VALLEY REGIONAL PLANNING COMMISSION

CMP Strategy Evaluation: Testing Short-Listed Programs

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Executive Summary

Since 2006, DVRPC's Congestion Management Process (CMP) staff has researched tools and techniques to evaluate the anticipated performance and expected benefits of appropriate congestion management strategies. Particularly challenging to evaluate are the anticipated effects of sets of multiple congestion management strategies implemented together. The ability to evaluate the anticipated effects of CMP strategies is envisioned as a resource that DVRPC staff would offer to its partner organizations to help develop and refine transportation projects.

DVRPC's previous research on this topic was documented in the report *Selecting Software to Evaluate the Anticipated Effectiveness of CMP Strategies* (Publication #10023). In it, DVRPC reviewed 34 transportation software programs and determined that no one sketch-level program was able to analyze all of the strategy categories or strategies used in the CMP. The current report followed up on specific programs noted in the *Selecting Software* report and evaluated one new program. Although none of the programs meet all of the needs of CMP strategy analysis, the four programs short-listed for testing and evaluation have the potential to analyze a majority of the most used strategies in the CMP. The four short-listed programs are:

- Cal-B/C – A spreadsheet-based sketch modeling tool that can analyze highway, transit, and operations strategies.
- TOPS-B/C – A spreadsheet-based tool that can perform sketch modeling analysis of select highway and transit operations strategies.
- Commuter Model 2.0 – A spreadsheet-based sketch modeling tool that can quantify changes resulting from travel demand management strategies.
- Center for Clean Air Policy (CCAP) Transportation Emissions Guidebook (TEG) – A spreadsheet tool that uses rule-of-thumb estimates to determine changes from implementing smart growth and other policies.

The US 30 Corridor west of the intersection with US 202 in Chester County, Pennsylvania, was selected for testing, in part because the *US 30 Intelligent Transportation Systems (ITS) Master Plan* was recently developed by the DVRPC Office of Transportation Operations Management. The study included potential ITS deployment scenarios and project cost estimates, which were used to test the short-listed programs. Two potential projects to deploy Dynamic Message Signs (DMS) along the US 30 corridor were tested in Cal-B/C and TOPS-B/C. Since the DMS strategy is designed to mitigate congestion when incidents occur, specific days were identified with incidents that resulted in large delays, and data from those days was incorporated into the test scenarios. Archived operations data from the I-95 Corridor Coalition Vehicle Probe Project (VPP) Suite provided travel times, speeds, and other performance measures that allowed robust testing of a variety of scenarios in Cal-B/C and TOPS-B/C. The results of these tests are documented in Chapter 3. All of the test scenarios produced positive Benefit-Cost (B/C) ratios. **Examining the results of the B/C analysis in conjunction with the VPP Suite data suggests that the most effective investments for the US 30 corridor would target the eastbound AM peak movement in locations where vehicle volumes are highest.**

Commuter Model has the advantage of being able to analyze multiple strategies together, something none of the other programs selected for testing are capable of doing. Scenarios were created to test two CMP strategies together in Commuter Model. While the results showed promise, the data gaps to properly use Commuter Model are too large to overcome at this time.

In an attempt to perform multistrategy analysis, the CCAP TEG was used to combine the expected results of implementing Smart Growth strategies with the outputs from Commuter Model. While the results were interesting, this method was not able to perform adequately sophisticated analysis of multiple CMP strategies deployed together.

Between the four short-listed programs, there is the potential to analyze a majority of the CMP's most used strategies and the Strategies Appropriate Everywhere. DVRPC's CMP software evaluation efforts have progressed to the point that staff is now familiar enough with the four short-listed programs to begin exploring further applications of these tools. Although the tools are not capable of meeting all of the goals of CMP strategy evaluation, they have proven to have the ability to at least provide insight into the expected benefits of CMP strategies. Staff will continue to develop and enhance the capacity to use these tools.

Next steps will include:

- Attempting to resolve data issues in order to enhance the ability to use the tools for all locations in the region;
- Selecting a location, gathering appropriate data, and coordinating with planning partners to conduct detailed analysis of multiple transportation improvement alternatives in Cal-B/C; and
- Testing Cal-B/C, TOPS-B/C, and Commuter Model in New Jersey.

To date, CMP staff has based testing of the software tools largely on locations where data was available. Strategies were at times selected because they could be tested with the available tools, and not necessarily because they were the best strategies to address the problem. **The long-term goal of CMP staff is to identify CMP subcorridors where improvements are needed to relieve congestion and to have the ability to test proposed strategies and combinations of strategies using the software tools explored in this report.**

CHAPTER 1

The Challenge: Evaluating Anticipated Effects of CMP Strategies

Background

Since developing its Congestion Management Process (CMP), DVRPC has actively tried to identify a software program or programs to help provide insight into the probable effects of specific congestion management strategies and sets of strategies. The Safe, Accountable, Flexible Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) stated in its guidelines that a metropolitan planning organization's (MPO) CMP shall include:

> "Identification and evaluation of the anticipated performance and expected benefits of appropriate congestion management strategies that will contribute to the more effective use and improved safety of existing and future transportation systems…"[1]

This task has proven difficult, due to the number of strategies included in the CMP, the size of the region, and the lack of suitable tools. However, CMP staff continues to research new tools and techniques in hopes of finding a means to evaluate the anticipated performance and expected benefits of appropriate congestion management strategies.

Particularly challenging to evaluate are the anticipated effects of sets of multiple congestion management strategies. For example, certain strategies, when implemented together, may have a greater impact than any of the strategies involved would have had individually. In other words, some strategies may have a complementary, or synergistic, relationship. Other combinations of strategies may have duplicative effects, such that when implemented together, their overall impact would not be as great as the impact each strategy would have had if it were implemented on its own.

As an example, two different CMP strategies may each individually be expected to reduce Volume-to-Capacity (V/C) ratios on a road segment by five percent. When paired together, they may have a synergistic effect that results in reducing V/C by a total of 12 percent. Two other strategies, each expected to individually reduce V/C by five percent, may have duplicative effects such that, when implemented together, they reduce V/C by a total of only six percent. These synergistic or duplicative effects grow more complex as the number of strategies increases.

[1] 23 CFR 450.320(c).

The *2012 DVRPC Congestion Management Process (CMP) Report* (Publication #11042) lists and defines over 100 strategies, grouped into the following five strategy categories:

- Operational Improvements, Transportation System Management (TSM), and Intelligent Transportation Systems (ITS);
- Transportation Demand Management (TDM), Policy Approaches, and Smart Transportation;
- Public Transit Improvements and New Investments;
- Road Improvements and New Roads; and
- Goods Movement.

To date, no single model has been found that is able to consider all five strategy categories, much less that is able to consider every strategy listed in the CMP. Therefore, DVRPC's efforts have focused on attempting to find a software package or packages that can analyze as many strategy types as possible, with emphasis on covering the most commonly used strategies.

The ability to evaluate the anticipated effects of strategies is envisioned as a helpful resource that DVRPC staff would offer to partner organizations. For example, software analysis could be used by department of transportation (DOT) staff, members of the CMP Advisory Committee, such as county planning staff, and other stakeholders to develop and refine transportation projects.

Past Efforts by DVRPC Staff

DVRPC began considering different software options for the CMP in 2006. A first step was to seek guidance from the Federal Highway Administration (FHWA), which has developed a significant amount of documentation relating to transportation software. The *Traffic Analysis Toolbox Volume II: Decision Support Methodology for Selecting Traffic Analysis Tools* document reviewed the different types of models used in transportation planning, design, and operations, and developed a decision-making process to determine which kind of model is most appropriate for an agency's need. DVRPC staff used this decision support tool to determine that sketch planning tools and travel demand models were most suited to the needs of the CMP.

An integrated travel demand model and land use model might be the best solution to analyze CMP strategies and their possible impacts, but unfortunately, these models are difficult to set up and use. These complex models must be run by the DVRPC Office of Modeling and Analysis, which can help with the CMP effort to some extent, but does not have the resources to perform all, or even most, CMP modeling needs. Sketch planning tools offer a more viable alternative. For this report, a short set of sketch planning tools was explored for its potential to evaluate the anticipated effects of CMP strategies.

For more information about sketch planning and other tools, please refer to the previous report documenting DVRPC's research on this topic, *Selecting Software to Evaluate the Anticipated Effectiveness of CMP Strategies* (Publication #10023). In it, DVRPC reviewed 34 transportation software programs that were potentially capable of the type of analysis needed for the CMP. The capabilities and limitations of each program were identified. **After reviewing these 34 software packages, it was determined that no one sketch-level program was able to analyze all of the strategy categories or strategies used in the CMP.** Policy Approaches, Smart

Transportation, and Goods Movement proved to be particularly challenging to model; only a few of the software packages were capable of evaluating strategies in these categories. Another challenge identified by this research was that the ability to analyze multiple strategies together is found in very few software packages.

Previous Software Selections

Based on the preliminary findings of DVRPC's software evaluation effort, a list of programs to investigate further was developed. DVRPC CMP staff met with staff from the Office of Modeling and Analysis in 2006 to coordinate how to move forward and several of the initially short-listed programs were eliminated from consideration based on these discussions. This left the following short set of programs:

- Commuter Model 2.0; and
- ITS Deployment and Analysis System (IDAS).

Commuter Model 2.0 was developed by the US EPA and is a spreadsheet-based program. It quantifies changes as a result of travel demand management programs, calculating the impact of the mode share changes from these programs and translating the mode share changes into changes in VMT. Commuter Model 2.0 uses a pivot point (logit choice) approach to allow for analysis of multiple strategies at once.

IDAS is a hybrid sketch and travel demand modeling program, developed by Cambridge Systematics (CS) for FHWA. It can analyze alternative ITS operations deployment scenarios and test tradeoffs of traditional highway and transit infrastructure options, using the outputs of a four-step model. CMP staff has been interested in IDAS from the beginning of this effort because it is one of only a few programs with multiple-strategy analysis capabilities. FHWA provided funding to DVRPC and the Mid-America Regional Council to test IDAS through their standing contract with CS. However, CS was unable to get IDAS to work with the travel demand model that DVRPC had at the time. Therefore, it was dropped from the short set of programs to test.

In preparing the *Selecting Software* report, DVRPC staff researched new tools. This resulted in the addition of a new program, Cal-B/C, to the short-list of programs to investigate. Cal-B/C is a free, downloadable, spreadsheet-based sketch modeling tool that can prepare analyses of highway, transit, operations, and transportation systems management strategies. The model calculates Benefit/Cost (B/C) ratios and can measure four categories of benefits that result from highway or transit projects. These include travel time savings, vehicle operating cost savings, accident cost savings, and emission reductions.

One other resource identified in the *Selecting Software* report was the Center for Clean Air Policy (CCAP) Transportation Emissions Guidebook (TEG). The CCAP TEG is a spreadsheet-based sketch model planning program that uses rule-of-thumb estimates to determine changes to VMT based on a number of strategies, including many that are not included in either Cal-B/C or Commuter Model 2.0.

To summarize, the following three programs were short-listed for investigation and testing:

- CCAP TEG;
- Commuter Model 2.0; and
- Cal-B/C.

Cal-B/C has the ability to evaluate many of the strategy categories that Commuter Model 2.0 cannot. In addition, it can perform B/C analysis using relatively few inputs. DVRPC staff has completed testing of Cal-B/C in a corridor where modeling work was also completed to see how the results compared. DVRPC has also conducted initial tests of the CCAP TEG's ability to fill in the gaps of Cal-B/C and Commuter Model 2.0. These test results were detailed in Chapter 3 of the *Selecting Software* report.

Common Measures

When analyzing the impacts of strategies, individually or as a group, a set of common measures is needed that can be used across various modes. A critical step in developing the CMP is the analysis of the performance of the regional transportation system. The criteria used to develop the 2012 CMP were a refinement of those used in the 2009 CMP and flowed from the goals of the Long-Range Plan. Briefly, the current CMP criteria used in selecting corridors and as a consideration in developing strategies are:

- Roads with current peak-hour congestion measured by high V/C ratios;
- Locations where comparison of the current and future travel model simulations suggest high growth in peak-period V/C ratios;
- Roads with high duration of congestion based on available archived operations data;
- Existing transit service (bus, trolley, or train);
- Areas where transit might succeed in 2035 based on demographic forecasts regardless of whether they have transit service now;
- Major roads and freight facilities;
- Roads where high crash rates lead to unexpected congestion;
- Critical population and employment centers, bridges, and other facilities of special concern for security preparedness;
- Current or future development areas and Land Use Centers identified in the Long-Range Plan; and
- Areas of high and low environmental impact, with low impacts being preferred for transportation investments.

Many of these measures, such as facilities of concern for security preparedness, Land Use Centers, and areas of low environmental impact, are difficult to quantify using most sketch modeling programs. However, they are critical for making decisions about how to prioritize regional transportation investments. Other measures, such as crash rates and transit ridership information, are important inputs for nearly all of the software programs evaluated.

For this effort, it was important to choose simple measures that most of the programs would be capable of producing. V/C ratios are most suited to analysis of road projects, and may present challenges when evaluating transit or pedestrian enhancements. However, they are a useful and readily available measure of congestion. In the current economic climate, with limited funds available for transportation improvements, B/C analysis could be a useful tool to help ensure that the region receives the best value for its investments. Therefore, although B/C ratios are not a criterion in the CMP, they were selected as a useful measure for CMP software analysis.

Increasingly, archived operations data is becoming available for planning purposes. For example, the I-95 Corridor Coalition's Vehicle Probe Project (VPP) Suite provides member agencies with speed and travel time data for freeways and select arterial roads. DVRPC CMP staff now has access to this rich data source. In addition, DVRPC has convened a group of users of archived operations data along the East Coast. Among other things, this group has worked to develop a set of shared measures of transportation congestion and reliability in order to present information to elected officials and the public in a consistent and easily understandable manner. Of the measures under discussion, Travel Time, which is a simple measure of how long a trip takes, seems to be the most straight-forward and appropriate measure to evaluate the anticipated effects of CMP strategies. This measure includes travel times during free flow, usual, and worst-day-of-the-month conditions to provide a better understanding of how travel times fluctuate.

Based on these considerations, as well as the capabilities and limitations of the available software options, the measurements in Table 1 will be used to analyze the impacts of CMP strategies, at least for the purposes of this report:

Table 1: Common Measures for Congestion Management Process Software Analysis

Measurement	Outcome
V/C ratios	In general, a decrease in V/C ratio would be considered a positive outcome, although corridor implications must also be considered. (For example, a higher V/C ratio may be a healthy sign in a central business district, and a decrease in V/C at one point in a corridor may just move congestion to another point.) Decreasing values to the vicinity of 0.85, a generalized Level of Service (LOS) E across functional classes is the focus.
B/C ratios	In general, a higher B/C ratio would be considered a positive outcome. In addition, B/C ratios greater than one are preferred.
Travel Time, including: ▪ Free Flow; ▪ Usual Congestion; and ▪ Worst-Day-of-the-Month.	In general, a decrease in travel time would be considered a positive outcome. However, there is a point beyond which travel times should not be further decreased; this is defined by the posted speed limit for the specific road and the length of the corridor.

Source: Delaware Valley Regional Planning Commission (Philadelphia: DVRPC, 2013).
Note: B/C = Benefit-Cost. V/C = Volume-to-Capacity.

In addition, the VPP Suite allows a number of other performance measures to be calculated. Travel Time Index (TTI) is a measure that compares average travel conditions in the peak period to travel during free-flow conditions. For example, a TTI of 1.2 indicates that a trip that takes 20 minutes in the off-peak period will, on average, take 24 minutes in the peak period, or 20 percent longer. Similarly, Planning Time Index (PTI) compares the 95th percentile slowest travel time to the free-flow travel time to estimate how much time a person should budget in order to ensure on-time arrival nearly every day. Just like TTI, a PTI of 1.5, for example, indicates that for a trip that takes 20 minutes during free-flow conditions, a traveler should budget at least 30 minutes to ensure on-time arrival, or 50 percent longer. PTI is used to measure the reliability of travel along a roadway. These performance measures will be used in this report as additional ways to analyze the impacts of CMP strategies, when possible.

It is important to keep in mind that no model can account for all of the factors that impact travel behavior. Using software models can help with making decisions, but these models present an incomplete picture of the transportation system and must be combined with review and discussion.

C H A P T E R 2

Review of Software Packages

Updates and Reevaluations

Software packages are periodically updated or improved upon. In preparing this report, staff investigated whether or not updates had been made to IDAS that would allow it to work for the purpose of CMP strategy evaluation. In addition, one program that had been investigated in the past was examined more closely, based on a recommendation in the *Selecting Software* report.

ITS Deployment and Analysis System (IDAS)

As a longer-term piece of the CMP software evaluation effort, DVRPC has committed to investigating whether improvements have been made to IDAS and whether it would work with the new VISUM travel demand model.

As of this report, IDAS has not been improved or updated since it was last evaluated for its ability to analyze the anticipated effects of CMP strategies. IDAS could be compatible with the VISUM model in place, but only if sections small enough to work with IDAS were carved out.

DVRPC will continue to check periodically to find out if IDAS has been updated or improved upon, but it seems unlikely that this will happen because FHWA's priorities have shifted toward supporting other software packages.

Sketch Planning Analysis Spreadsheet Model (SPASM)

The *Selecting Software* report recommended reevaluating SPASM because of its ability to model induced demand and to compare alternatives of various modes.

SPASM is a free, spreadsheet-based sketch modeling program for corridor-level planning created by FHWA. It is capable of calculating B/C estimates and can compare different transportation investments, including transit system improvements, highway capacity expansion projects, High-Occupancy Vehicle (HOV) improvements, auto-use disincentives, such as tolling, and traveler information systems. The user must develop estimates for transportation modeshare changes as a result of the improvement(s). SPASM is not able to consider the impact of multiple strategies, nor does it consider bicycle and pedestrian trips. It is primarily designed for corridor analysis in small- to medium-sized urban areas.

SPASM generates estimates of annualized public capital and operating costs, employer costs, system user costs and benefits, air-quality and energy impacts, and cost-effectiveness measures.

One appealing aspect of SPASM is its ability to estimate induced VMT in a corridor due to changes in travel time resulting from transportation improvements or policy changes. These estimates are based on travel time elasticity, which is defined as the percentage change in traffic demand due to a one percent increase in travel time. In other words, the software is able to account for new vehicle trips that may be induced by improved travel times on the facility, and to estimate how much travel times would have to increase for new traffic to no longer be induced. This analysis capability allows for a more realistic assessment of the congestion relief benefits that could be expected from a given project or policy.

The spreadsheet performs the following steps:

- It develops an initial estimate of travel time savings (in percentage terms) due to the actions under consideration based on "before" and "after" volumes and capacities provided by the model user.
- It develops an initial estimate of induced traffic using time savings and the elasticity of demand.
- Next, SPASM recalculates travel time savings, accounting for the additional delay caused by induced traffic.
- Then, it recalculates induced traffic using the revised estimate of travel time savings.
- Finally, SPASM repeats the two preceding steps until travel time savings and induced traffic do not change significantly from iteration to iteration.

More information on SPASM can be found at: www.fhwa.dot.gov/steam/spasm.htm.

While SPASM's ability to calculate induced demand is a useful feature, the program also has several disadvantages as a tool to evaluate the anticipated effects of CMP strategies. One issue is that the strategies it can test are already testable with the other short-listed programs. Also, SPASM was not developed in a way that facilitates easily moving from testing one strategy to another. In fact, it seems likely that a significant amount of time would have to be invested to set up strategies and scenarios to test. The software seems best suited to sketch-level analysis of a set of proposed alternatives for a corridor. For the purposes of the CMP, the number of strategies that the tool can test is too limited.

In conclusion, it does not seem that SPASM adds significantly to the short-listed programs.

Research of New Tools

An important part of this continuing research is to investigate any new tools that have been developed. DVRPC has worked with FHWA to provide input about new tools, including the new spreadsheet-based tool described below.

Tool for Operations Benefit/Cost (TOPS-B/C)

As part of an ongoing study, DVRPC staff has provided input regarding a new tool being developed by CS for FHWA. The Tool for Operations Benefit/Cost (TOPS-B/C) is a spreadsheet-based tool designed to assist practitioners in conducting benefit/cost analysis by providing four key capabilities, including the following:

- The ability for users to investigate the expected range of impacts associated with previous deployments and analyses of many Transportation Systems Management and Operations (TSM&O) strategies;
- A screening mechanism to help users identify appropriate tools and methodologies for conducting a B/C analysis based on their analysis needs;
- A framework and default cost data to estimate the life-cycle costs (including capital, replacement, and continuing operations and maintenance (O&M) costs) of various TSM&O strategies; and
- A framework and suggested impact values for conducting simple B/C analysis for selected TSM&O strategies.

In addition to these capabilities, TOPS-B/C is also intended to serve as a repository of relevant parameters and values appropriate for use in B/C analyses. The sketch planning capabilities within TOPS-B/C are generally applicable for screening and estimating order of magnitude of benefits. The program is relatively simple to set up and use, since many parameters and features are already entered into the spreadsheet.

Chapter 3 of this report includes a test scenario using TOPS-B/C.

Short-Listed Programs for Testing

To summarize, the following are the short-listed programs for testing in this report and going forward. Brief descriptions of the capabilities and salient characteristics of each are listed below.

Cal-B/C

Cal-B/C is a free, downloadable, spreadsheet-based sketch modeling tool that can prepare analyses of highway, transit, operations, and transportation systems management strategies. The model calculates B/C ratios and can measure four categories of benefits that result from highway or transit projects. These include travel time savings, vehicle operating cost savings, accident cost savings, and emission reductions.

Commuter Model 2.0

Commuter Model 2.0 was developed by the US EPA and is a spreadsheet-based program. It quantifies changes as a result of travel demand management programs, calculating the impact of the mode share changes from these programs and translating the mode share changes into changes in VMT. It uses a pivot point (logit choice) approach to allow for analysis of multiple strategies at once.

Center for Clean Air Policy (CCAP) Transportation Emissions Guidebook (TEG)

The CCAP TEG is a spreadsheet-based sketch model planning program that uses rule-of-thumb estimates to determine changes to VMT based on a number of strategies, including many that are not included in either Cal-B/C or Commuter Model 2.0.

Tool for Operations Benefit/Cost (TOPS-B/C)

This spreadsheet-based tool is designed to provide the ability for users to investigate the expected range of impacts and benefits associated with selected TSM&O strategies.

Programs and Strategies

Table 2 lists the most used strategies in the 2011 CMP and notes which ones can be tested with the short-listed software packages. Strategies that can either definitely or probably be tested by at least one of the four programs listed in the table are **highlighted in black**. Between the four programs, it is likely that all but eight strategies can be tested. The strategies from the most used list that cannot be tested by any of the current software options are:

- Improve Circulation;
- Turning Movement Enhancements;
- Engineering for Smart Growth;
- Park-and-Ride Lots;
- Transit First Policy;
- Environmentally Friendly Transportation Policies;
- Local Delivery Service; and
- Multilingual Communication.

Several of the strategies that cannot be tested, including Improve Circulation, Turning Movement Enhancements, and Engineering for Smart Growth, represent groups of strategies that include engineering-based solutions, such as Roundabouts (Improve Circulation), Center-Turn Lanes (Turning Movement Enhancements), or Traffic Calming (Engineering for Smart Growth). It may be more appropriate to analyze these location-specific strategies using a microsimulation program such as Synchro. These strategies are challenging to model at the corridor or regional level because specific conditions may vary greatly within a corridor.

Strategies focused on transportation policies also remain challenging to test. These include strategies such as Transit First Policy and Environmentally Friendly Transportation Policies. Although it is difficult to quantify the impacts of these strategies, they represent goals and values that are important to maintaining and improving the quality of life in the Delaware Valley region.

Table 2: Ability of Short-Listed Programs to Analyze Most Used Congestion Management Process Strategies

Most Used CMP Strategies (by Rank)	Strategy Category	Cal-B/C	TOPS-B/C	Commuter Model 2.0	CCAP-TEG
Modifications to Existing Transit Routes or Services	Transit Improvements	**Yes**	No	**Yes**	**Yes**
Signal Improvements	Operations	**Yes**	**Yes**	**Yes**	No
Transit Infrastructure Improvements	Transit Improvements	No	No	**Yes**	No

Table 2: Ability of Short-Listed Programs to Analyze Most Used Congestion Management Process Strategies (continued)

Most Used CMP Strategies (by Rank)	Strategy Category	Cal-B/C	TOPS-B/C	Commuter Model 2.0	CCAP-TEG
Improve Circulation	Operations	No	No	No	No
Turning Movement Enhancements	Operations	No	No	No	No
Engineering for Smart Growth	TDM/Policy/Smart Transportation	No	No	No	No
New Passenger Rail Improvements	Transit Improvements	**Yes**	No	**Yes**	No
Park-and-Ride Lots	TDM/Policy/Smart Transportation	No	No	No	No
TOD	TDM/Policy/Smart Transportation	No	No	No	**Yes**
New Bus Services	Transit Improvements	**Yes**	No	**Yes**	No
Transportation Services for Specific Populations	Transit Improvements	No	No	**Yes**	No
Walking and Bicycling Improvements	TDM/Policy/Smart Transportation	No	No	**Yes**	**Yes**
BRT or Exclusive Right-of-Way Bus Lanes	Transit Improvements	**Yes**	No	**Yes**	No
Transit First Policy	TDM/Policy/Smart Transportation	No	No	No	No
Maintenance Management	Operations	**Yes**	**Yes**	No	No
Environmentally Friendly Transportation Policies	TDM/Policy/Smart Transportation	No	No	No	No
Minor Road Expansions	Road Improvements	**Yes**	No	No	No
ITS Improvements for Transit	Transit Improvements	**Yes**	**Yes**	No	No
Land Use Transportation Policies	TDM/Policy/Smart Transportation	No	No	No	**Yes**
Local Delivery Service	TDM/Policy/Smart Transportation	No	No	No	No
Adding Capacity to Existing Roads	Road Improvements	**Yes**	No	No	No
Comprehensive Policy Approaches	TDM/Policy/Smart Transportation	No	No	No	**Yes**
Multilingual Communication	TDM/Policy/Smart Transportation	No	No	No	No
Incident Management	Operations	**Yes**	**Yes**	No	No
Planning and Design for Nonmotorized Transportation	TDM/Policy/Smart Transportation	No	No	**Yes**	**Yes**
Shuttle Service to Stations	Transit Improvements	No	No	**Yes**	No

Source: Delaware Valley Regional Planning Commission (Philadelphia: DVRPC, 2012 CMP).
Note: BRT = Bus Rapid Transit. CMP = Congestion Management Process. ITS = Intelligent Transportation Systems. TDM = Transportation Demand Management. TOD = Transit-Oriented Development.

In addition to the most used strategies, it is also desirable to be able to model the 13 strategies listed as “Appropriate Everywhere” in the CMP. Table 3 illustrates the ability of the short-listed programs to analyze these strategies. The programs should be able to model nine out of the 13 Strategies Appropriate Everywhere, although some of these may stretch the limits of what the software was intended to do, as indicated by the “Maybe” categorization.

Table 3: Ability of Selected Programs to Analyze Congestion Management Process Strategies Appropriate Everywhere

CMP Strategies Appropriate Everywhere	Strategy Category	Cal-B/C	TOPS-B/C	Commuter Model 2.0	CCAP-TEG
Safety Improvements and Programs	Operations	**Maybe**	**Maybe**	No	No
Signage	Operations	No	No	No	No
Improvements for Walking and Bicycling as Appropriate	Smart Transportation	No	No	**Yes**	**Yes**
Basic Upgrading of Traffic Signals	Operations	**Yes**	**Maybe**	No	No
Signal Preemption for Emergency Vehicles	Operations	No	**Maybe**	No	No
Intersection Improvements of a Limited Scale	Operations	**Yes**	No	No	No
Bottleneck Improvements of a Limited Scale, Vehicle or Rail	Operations/ New Transit	**Yes**	No	**Yes (rail only)**	**Yes**
Environmental Justice Outreach for Decision-Making	Policy	No	No	No	No
Access Management (both engineering and policy strategies)	Operations/Policy	No	No	No	No
Marketing/Outreach for Transit and TDM Services where Applicable*	TDM	No	**Yes**	**Yes**	No
Revisions to Existing Land Use/Transportation Regulations	Policy	No	No	No	**Yes**
Growth Management and Smart Growth	Policy	No	No	No	**Yes**
Context-Sensitive Design	Smart Transportation	No	No	No	No

Source: Delaware Valley Regional Planning Commission (Philadelphia: DVRPC, 2012 CMP).
Notes: CMP = Congestion Management Process. TDM = Transportation Demand Management.
*Includes carpool, vanpool, and ride-matching programs; alternative work hours; telecommuting; emergency ride home; promotion of a regional commuter benefit; and car-sharing programs.

Summary

Although none of the reviewed programs meet all of the needs of CMP strategy analysis, between the four short-listed programs there is at least the potential to analyze a majority of the most used strategies and the Strategies Appropriate Everywhere. The remainder of this report will explore the capabilities of these programs by testing specific examples.

To summarize, the four short-listed programs for testing are:

- Cal-B/C – This spreadsheet-based sketch modeling tool can analyze highway, transit, and operations strategies. Its primary output is B/C ratios.
- TOPS-B/C – In addition to serving as a repository of information pertaining to TSM&O strategies, this spreadsheet-based tool can perform sketch modeling analysis of select highway and transit operations strategies. Its primary output is B/C ratios.
- Commuter Model 2.0 – This spreadsheet-based sketch modeling tool can quantify changes resulting from travel demand management strategies. Its primary outputs are changes in mode share and VMT.
- CCAP TEG – This spreadsheet-based sketch model planning program uses rule-of-thumb estimates to determine changes from implementing smart growth policies. Its primary outputs are changes in VMT.

C H A P T E R 3

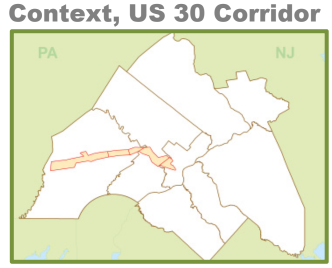
Software Testing

Testing Operations Improvements in the US 30 Corridor

DVRPC's efforts to evaluate the anticipated effects of CMP strategies and sets of strategies have focused on what can reasonably be done with readily available data and software. Although the review of existing software determined that there is no one sketch-level program that is able to analyze all of the strategy categories or strategies used in the CMP, the decision was made to move forward. This chapter documents efforts to test the programs that seem to hold promise for at least evaluating some of the most commonly used strategies, as detailed in the previous chapter. The *Selecting Software* report documented initial tests of Cal-B/C and the CCAP TEG. This chapter expands upon that work.

The US 30 Corridor west of the intersection with US 202 in Chester County, Pennsylvania, was selected for testing, in part because the corridor-wide *US 30 ITS Master Plan* was recently developed by the DVRPC Office of Transportation Operations Management. The study includes potential ITS deployment scenarios and project cost estimates. This information was used to develop scenarios with which to test the short-listed programs for CMP strategy evaluation.

Figure 1: Regional Context, US 30 Corridor



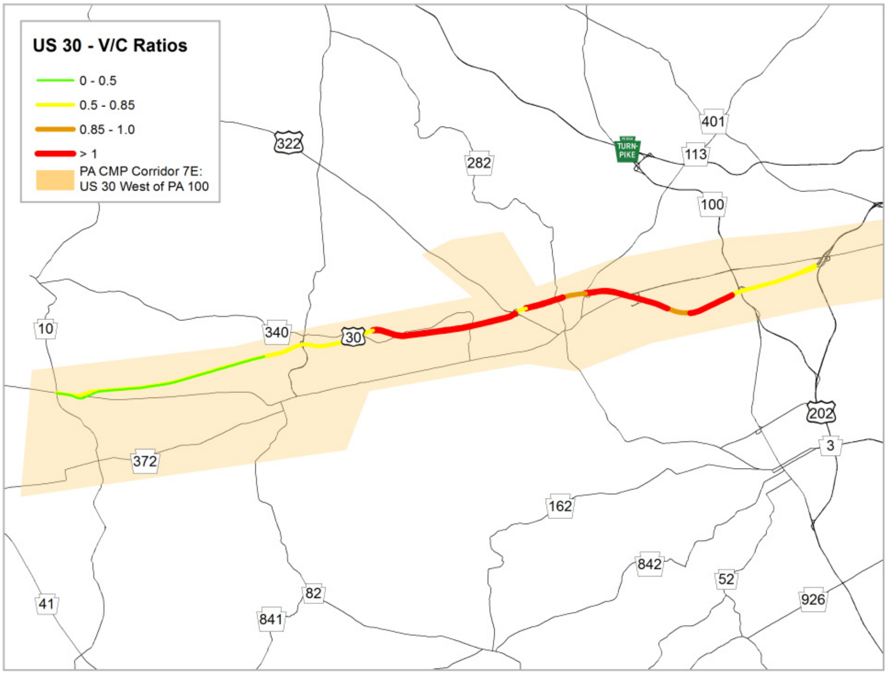
Source: DVRPC, 2013.

Context: US 30 Corridor

Congestion has four components: duration, extent, intensity, and variation. The intensity of the congestion on US 30 can be described at least in part by V/C ratio. As detailed in Chapter 1, current peak-hour congestion, measured by high V/C ratios, was one of the criteria used in the 2012 CMP. The CMP set a threshold of 0.85 or higher to indicate severe peak-hour congestion in the regional analysis of the transportation network. It should be noted that the V/C ratios included in the CMP were obtained through sketch-level analysis at a regional scale, and are therefore not as precise as those that might be obtained from an area-specific study.

As seen in Figure 2, the section of US 30 between PA 100 and US 322 experiences severe congestion during peak hours. However, the western portion of the corridor from PA 82 to PA 10 experiences significantly less peak-hour congestion.

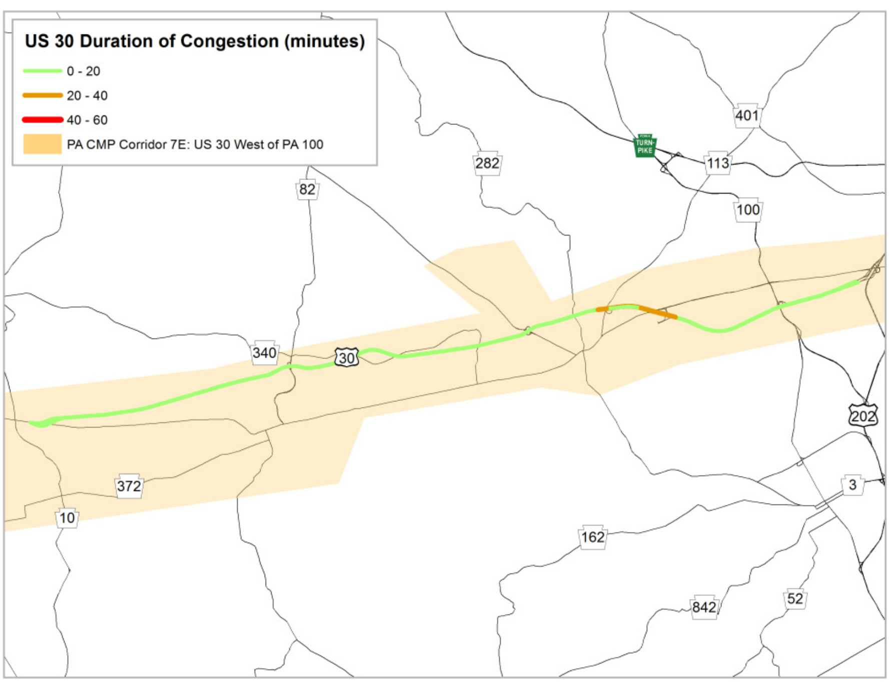
Figure 2: Volume-to-Capacity (V/C) Ratios



Source: DVRPC, *2012 Congestion Management Process Report*. Volume-to-capacity ratio analysis updated 2009.

The 2012 CMP also measured Duration of Congestion, defined as the number of minutes during the peak hour (5:00 to 6:00 PM) that average speeds fell below 70 percent of the posted speed limit. The regional results were grouped into three "bins" of congested conditions, including 0 to 20 minutes, 20 to 40 minutes, and 40 to 60 minutes of congestion during the peak hour.

Figure 3: Duration of Congestion

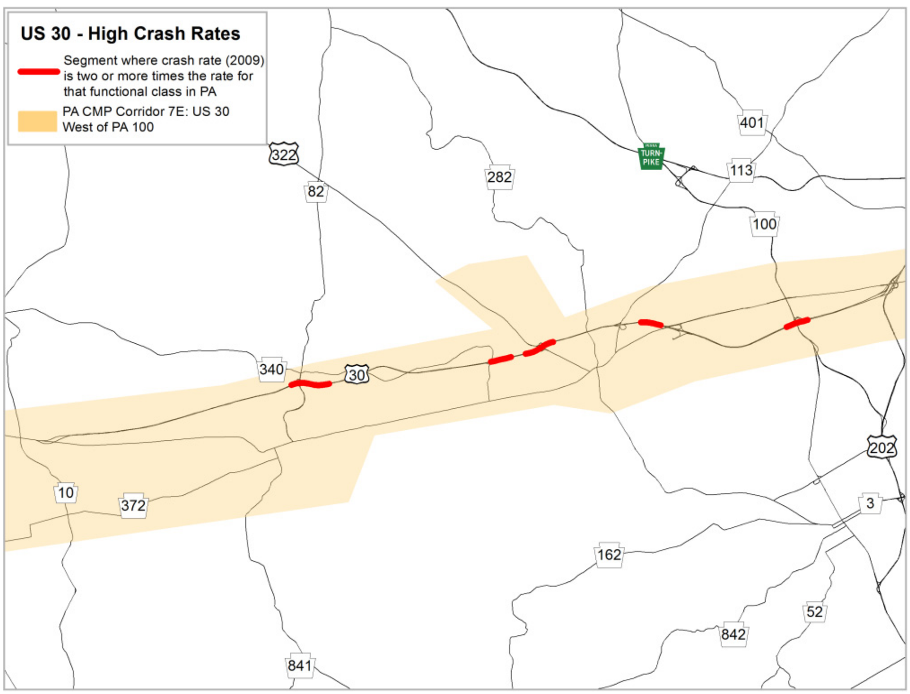


Source: DVRPC, *2012 Congestion Management Process Report*.

As shown in Figure 3, most segments of US 30 experienced congested conditions for 20 minutes or less during the peak hour. There is a stretch of US 30 between PA 113 and US 30 Business that falls within the 20 to 40 minutes of congestion bin; the segment with the highest value in this stretch was congested for 26 out of 60 minutes during the peak hour. Compared to some places in the Delaware Valley, such as certain parts of I-76 and I-476 that regularly experience 40 to 60 minutes of peak-hour congestion, the duration of congestion in the western portion of US 30 is not particularly severe. In other words, travel speeds on US 30 during peak hours are not reduced as much or for as long as they are on other congested roads in the region. As mentioned in Chapter 1, TTI is a measure that compares average travel conditions in the peak period to travel during free-flow conditions. For this section of US 30, the TTI during the peak hour is about 1.1. In other words, on average, it takes about 10 percent longer to travel the corridor during peak periods. **Evaluating V/C ratios, Duration of Congestion, and TTI together, it seems that although US 30 experiences peak-hour volumes at or near its capacity, average travel speeds only decrease moderately during peak hours.**

High Crash Rates were another criterion used in the 2012 CMP. The analysis compared the number of crashes for a road segment to the rate for that functional class of road in the counties of that state in the region. Figure 4 shows the locations in the study area that met this criterion.

Figure 4: Crash Rates

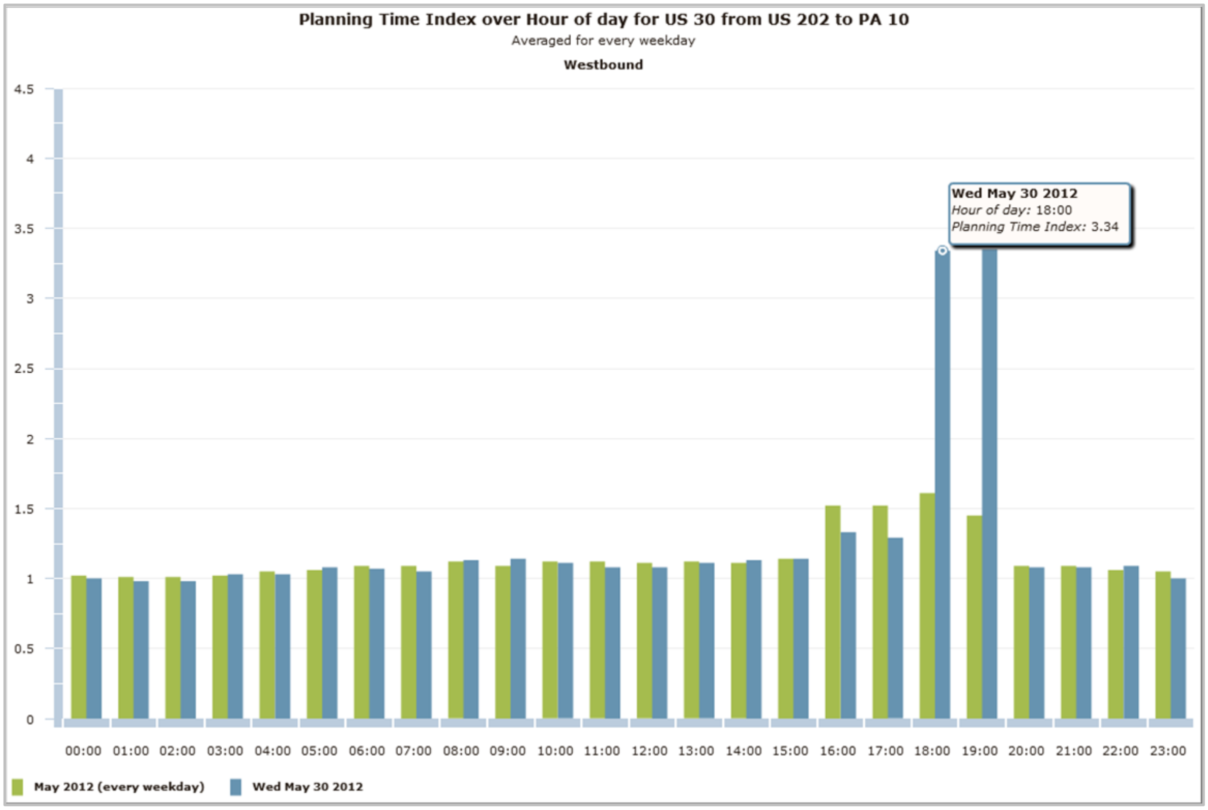


Source: DVRPC, *2012 Congestion Management Process Report*.

The nature of crashes, bad weather, and other incidents is that they are difficult to predict. Partially as a result of the fact that peak volumes are already at or near capacity along this section of US 30, incidents, bad weather, and other unexpected events can sometimes result in large delays for commuters. This can make it challenging for commuters in the US 30 corridor to predict the travel conditions that they will encounter on any given day.

Travel time reliability is determined by the variation in how long it takes to make the same trip from one day to another. As mentioned in Chapter 1, PTI compares the 95th percentile slowest travel time to the free-flow travel time to estimate how much time a person should budget in order to ensure on-time arrival nearly every day. For both the eastbound AM and westbound PM periods of this section of US 30, the PTI averages over 1.5. However, on a day with a major incident, the PTI can rise dramatically, as illustrated by Figure 5. This concept will be explored further in the test scenarios detailed later in this chapter.

Figure 5: Planning Time Index Comparison



Source: VPP Suite, 2013.

Strategies for US 30

The US 30 Corridor provides an interesting test case because it has also been studied for major roadway capacity additions. In the Fiscal Year 2013 PA Transportation Improvement Program (TIP) for the DVRPC region, the proposed US 30 widening project was placed on the "Illustrative Unfunded" list, with an estimated cost of nearly half a billion dollars. This means that there are not funds at this time to advance the project. In the current climate of fiscal constraint, it is unlikely that this level of funding will become available in the near future. Projects such as the US 30 ITS Master Plan have been initiated to investigate operational and transportation demand management strategies, which tend to be much less capital intensive, but can still help reduce congestion in the western portion of the US 30 corridor. These projects also have the advantage of being much faster to design and implement than capacity-adding projects.

The portion of US 30 being evaluated in this chapter is contained within CMP corridor PA 7E (US 30 communities west of PA 100). CMP Strategies for 7E are listed in Table 4. The strategies in bold could be tested using one or more of the short-listed programs.

Table 4: Congestion Management Process Strategies for US 30

CMP Corridor	Very Appropriate Strategies	Secondary Strategies
PA 7E US 30 communities west of PA 100	■ **Signal Improvements** ■ Improve Circulation ■ Park-and-Ride Lots ■ **Transit-Oriented Development (TOD)** ■ **Transportation Services for Specific Populations**	■ **Incident Management** ■ Environmental Justice Outreach for Decision-Making ■ Multilingual Communication ■ **Planning and Design for Nonmotorized Transportation** ■ **Transit Infrastructure Improvements** ■ Turning Movement Enhancements ■ **Encourage Use of Fewer Cars** ■ Local Delivery Service ■ **Comprehensive Policy Approaches** ■ **Land Use-Transportation Policies** ■ Engineering for Smart Growth ■ Economic Development Oriented Transportation Policies ■ Transit First Policy ■ **Modifications to Existing Transit Routes or Services** ■ **Minor Road Expansions** ■ **Adding Capacity to Existing Roads** ■ **New Bus Services** ■ **Fixed-Rail Service (new, extensions, or added stations)** ■ Arterial or Collector Road ■ **Also see strategies appropriate everywhere**

Source: DVRPC, 2013.

A majority of the Very Appropriate and Secondary strategies could be analyzed using the available tools, although several strategies remain untestable. It should be noted that these strategies are from the 2012 update of the CMP. The next update of the CMP will take place in Fiscal Year 2014 and will likely result in slight revisions to the list of Very Appropriate and Secondary strategies. For example, the recommendations of the *US 30 Intelligent Transportation Systems (ITS) Master Plan* would be taken into consideration at this time.

US 30 Intelligent Transportation Systems (ITS) Master Plan

The *US 30 ITS Master Plan* focused on the US 30 Bypass Corridor in Chester County. The objective was to present a long-term vision for which ITS assets were required to manage traffic in the corridor. The plan presented an unconstrained vision for investment in ITS applications, including Closed Circuit Television (CCTV) cameras, Dynamic Message Signs (DMS), incident and travel time detectors, traffic signal systems, and other operational elements. In today's constrained transportation funding environment, the likelihood of securing funding for a full-scale US 30 Corridor ITS project is doubtful. The significance of the *US 30 ITS Master Plan* is that the entire vision for the corridor was broken down into pieces that could be programed on an incremental basis. The plan gives the Chester County Planning Commission (CCPC) and PennDOT the opportunity to select implementation packages if and when funding becomes available.

Two potential projects were developed for the *US 30 ITS Master Plan*. “Option 1” would extend ITS coverage on US 30 all the way to PA 10, covering approximately 19 miles. Among other elements, it would include six DMS and about 10.5 miles of fiber optic cable. The total cost of this project was estimated to be about $3.2 million. “Option 2” would extend ITS coverage only as far as PA 82, covering approximately 13 miles. It would include four DMS on US 30, and an additional two DMS on key arterial roadways. It would require about 5.4 miles of new fiber optic cable. The total cost of this project was estimated to be about $3.1 million.

For the purposes of testing the CMP strategies with the short-listed software, some elements included in the original versions of the two scenarios were removed. For example, the “Option 1” project cost estimate developed for the *US 30 ITS Master Plan* included nine E-Z Pass Tag Readers. Since the benefits of this equipment could not be captured by the TOP-B/C tool, these costs were dropped from the analysis. This illustrates the difficulty of using existing tools to evaluate multiple strategies meant to be deployed together. Although the DMS strategy can be evaluated by itself using TOPS-B/C or Cal-B/C, in a real-world situation, this strategy would be complemented by other strategies, such as E-Z Pass Tag Readers.

Data Gathering

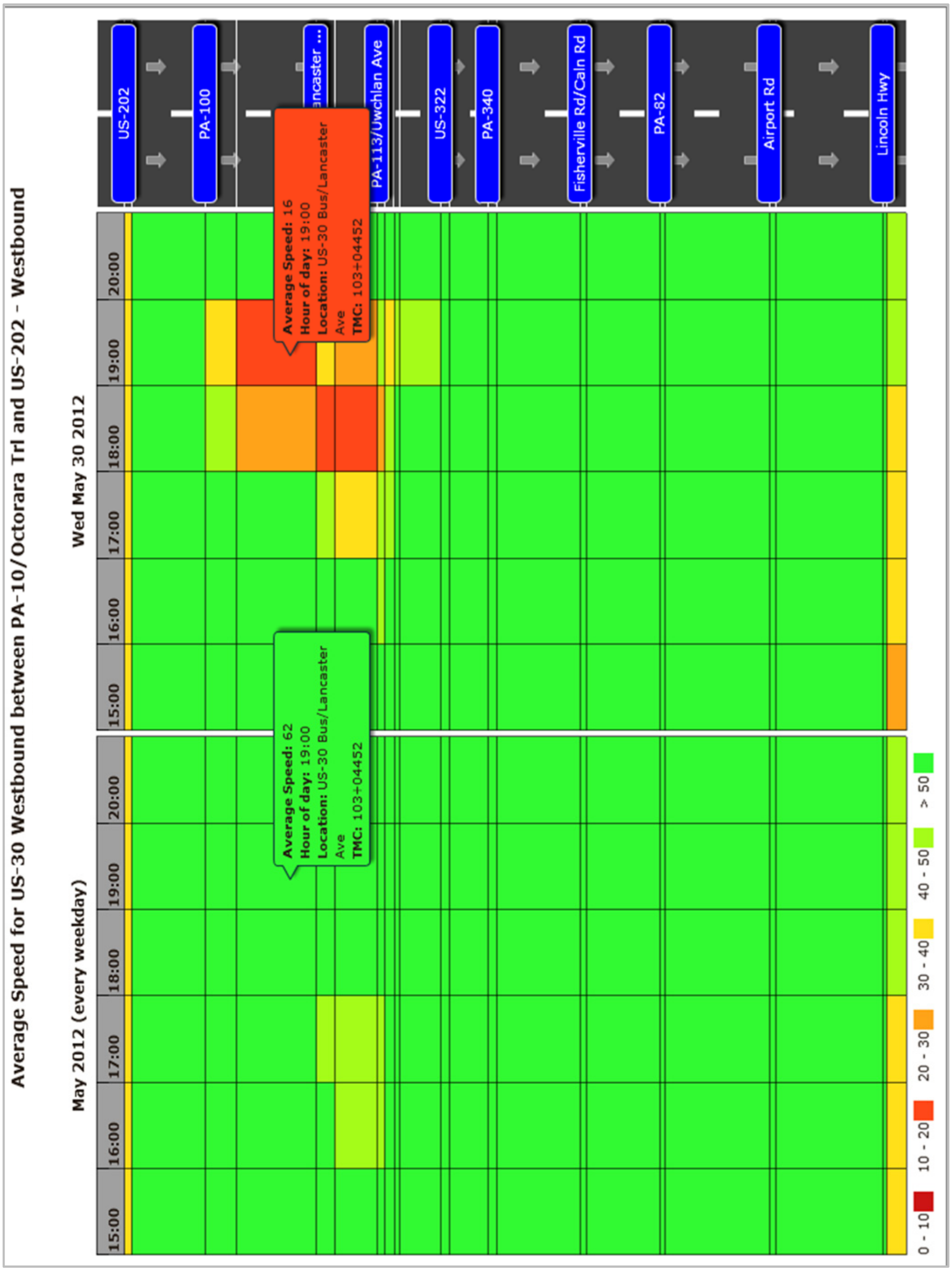
Data was gathered from a variety of readily available sources, including the CMP, the DVRPC traffic count database, DVRPC GIS files, and the I-95 Corridor Coalition VPP Suite.

Travel Time and Speed

The VPP Suite allows access to archived traffic operations data obtained anonymously in real time from Global Positioning System (GPS) probes of fleet and passenger vehicles. Speed and travel time data from the VPP Suite is generally averaged over a period of time, whether five-minute increments, a single day, or longer periods, such as weeks or months. However, averaging this data can sometimes obscure the impacts of incidents and other events that cause more congestion than usual to occur along a section of roadway. **Since the DMS strategy is aimed at mitigating congestion when incidents occur, it was important to analyze speeds and travel times that reflected these conditions**. Historical data was researched in coordination with the Office of Transportation Operations Management, using the Regional Integrated Multimodal Information Sharing (RIMIS) tool to obtain information about incidents. Specific days were identified when incidents that resulted in large delays occurred.

Figure 4 shows the results of a VPP Suite scan of congested conditions on May 30, 2012, a day when a major incident occurred on westbound US 30 during the PM peak period. This multivehicle accident happened between PA 282 and US 322 and closed part of US 30 westbound for over two hours. The left side of the figure depicts average PM peak speeds for the month of May 2012. The right side of the figure depicts the average travel speeds on US 30 westbound during the PM peak period for May 30, 2012, when speeds dropped as low as 16 miles per hour (MPH) in some sections. For comparison, the monthly average for the same time of day was 62 MPH.

Figure 6: "Worst Case" Conditions on US 30



Source: VPP Suite, 2013.

Congestion data from a day when a major crash was known to have occurred was used to obtain the "Worst Day" numbers in Tables 5 and 6. Within the worst day scenarios, the 95th percentile worst travel time of the worst hour was identified in addition to the average travel time for the hour.[2] Tables 5 and 6 also provide average travel times derived from analysis of the same month as the day with the major incident. These peak-hour and daily average travel times were essentially the same when all data for 2012 was analyzed.

Tables 5 and 6 correspond to the two improvement scenarios developed for the *US 30 Operations Master Plan* described in the preceding section. See Appendix A for more detail about the data inputs used for the tests in this chapter.

Table 5: Travel Times, US 30 from US 202 to PA 10

Direction	Condition	Travel Time (Minutes)
Eastbound	Free Flow	19
	Daily Average	19
	Peak Average (7-9 AM)	21
	Worst Peak Hour, Average (7 AM)	22
	Worst Day (3/7/12, 7 AM)	▪ 34 (Average) ▪ 74 (95th percentile worst)
Westbound	Free Flow	18
	Daily Average	18
	Peak Average (3-6 PM)	19
	Worst Hour Average (5 PM)	20
	Worst Day (5/30/12, 6 PM)	▪ 26 (Average) ▪ 62 (95th percentile worst)

Note: Travel times rounded to the nearest minute.
Source: DVRPC 2013; VPP Suite, 2013.

The distance from the intersection of the US 30 bypass and US 202 to the PA 10 interchange is about 19 miles. In free-flow conditions, speeds exceed 60 MPH and the trip can be made in about 19 minutes. Peak congested conditions occur in the AM for the eastbound direction, while the PM peak is in the westbound direction. During the AM peak, speeds drop to 57 MPH on average, with an average travel time of 21 minutes. The worst hour of the AM peak is 7:00 AM, when the average travel time increases to 22 minutes. The worst hour of the PM peak is 5:00 PM, when the travel time is about 20 minutes.

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[2] The VPP Suite currently uses the 95th percentile slowest travel time to calculate its Planning Time Index. Recent discussions at the national level have proposed a Reliability Index based on the 85th percentile slowest travel time. Research has shown that 95th percentile travel times usually involve nonroutine events that are difficult to predict and are well outside of an agency's ability to control (for example, extreme weather, law enforcement criminal investigations, and similar events). FHWA's SHRP2 research has shown that, in general, events that contribute to travel times around the 85th percentile are more common events, such as multilane injury crashes and secondary crashes. These travel times are more likely to be affected by agency actions, such as changes in infrastructure, policy actions, and operational strategies. (Source: Cambridge Systematics, Inc. *Analytical Procedures for Determining the Impacts of Reliability Mitigation Strategies*. National Academy of Sciences. 2012.)

Table 6 shows the same general conditions as Table 5, but with numbers that apply to the shorter segment of the US 30 Corridor that would receive ITS improvements in the "Option 2" scenario.

Table 6: Travel Times, US 30 from US 202 to PA 82

Direction	Condition	Travel Time (Minutes)
Eastbound	Free Flow	14
	Daily Average	15
	Peak Average (7-9 AM)	17
	Worst Peak Hour, Average (7 AM)	18
	Worst Day (3/7/12, 7 AM)	**22 (Average)** **80 (95th percentile worst)**
Westbound	Free Flow	13
	Daily Average	13
	Peak Average (3-6 PM)	14
	Worst Hour Average (5 PM)	15
	Worst Day (5/30/12, 6 PM)	**17 (Average)** **57 (95th percentile worst)**

Note: Travel times rounded to the nearest minute.
Source: DVRPC, 2013; VPP Suite, 2013.

It is clear from Tables 5 and 6 that when major incidents occur, travel times and speeds along this section of US 30 can dramatically exceed the average. For example, as seen in Table 5, the 95th percentile worst time of the worst day was 74 minutes during the AM peak and 62 minutes during the PM peak. Accordingly, the strategies developed in the *US 30 Operations Master Plan* are intended to have their greatest impacts during these worst-case situations.

In order to estimate how frequently traffic accidents occur, crash records for US 30 from US 202 to PA 10 were reviewed for the previous five years of available data (2006 to 2010). During that period, there were 344 crashes, of which three were fatal; about half of the crashes involved injuries ranging from minor to severe. By analyzing the number of crashes that occurred during peak hours over the five-year period and assuming that there are usually about 250 work days per year, it was estimated that an incident took place during either the AM or PM peak period approximately once every two weeks, although most of these would not have caused 95th percentile levels of congestion. More in-depth crash analysis should be conducted in conjunction with any capital improvements implemented in the corridor.

Traffic Volumes

In addition to travel speeds and times, volume data was collected. For the purposes of this exercise, a formula was applied to the DVRPC daily volume count. This is the same approach used in the regional CMP. The DVRPC traffic count database could also have been used to obtain more precise peak volume numbers. However, the decision was made to pursue the simplest approach for the purposes of this exercise. The traffic count database includes counts broken down by hour, but to use it for the purposes of this analysis would have required several steps, including some cleaning and verification of this data. Staff determined that the numbers based on the CMP approach were reasonable enough to use for this sketch modeling exercise. In the future, the traffic count database could be queried to obtain more accurate peak volume numbers, as needed.

Software Testing

TOPS-B/C

One strategy that TOPS-BC is capable of testing is deploying DMS throughout a corridor. The first step to test this strategy was to enter life cycle cost estimates into the DMS module of TOPS-B/C.[3] Next, volume and speed data were entered into the B/C analysis module of TOPS-B/C.

As noted in the preceding sections, travel times in the US 30 corridor can vary greatly. The volume of traffic on US 30 during peak periods also varies by location. In general, peak volumes are highest at the eastern end of the corridor and are significantly lower at the western end of the corridor. Simply averaging the data across the entire corridor would not tell the whole story. For this reason, the corridor average, corridor low, and corridor high volume numbers were used for the analysis.

Based on the variation in volume and travel times throughout the corridor, several scenarios were developed for testing in TOPS-B/C. **The advantage of TOPS-B/C and other spreadsheet-based sketch modeling tools is that once the initial parameters are set up, it is relatively simple to vary the key data points to test different scenarios.**

In order to run the test scenarios in TOPS-B/C, it was necessary to generate an estimated post-improvement travel time. Recent research from the Federal Highway Administration (FHWA) has indicated that deploying DMS signs along a freeway corridor typically increases speeds between eight to 13 percent.[4] For the purposes of this test, a flat 10 percent increase in speeds was assumed. This rate of improvement was used to calculate an estimated post-implementation travel time.

The results of the test scenarios are displayed in Tables 7 and 8.

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[3] Some parameters, such as the expected lifetime of DMS equipment, were adjusted to reflect local conditions. For example, staff in the Office of Transportation Operations Management advised reducing the expected lifetime of the DMS from the default parameters included in the spreadsheet. The lifecycle cost module of TOPS-B/C accounts for the need to maintain and replace equipment over time, so it was important to include an appropriate expected lifetime number.
[4] Source: Maccubbin, Robert P., et al. *Intelligent Transportation Systems Benefits, Costs, Deployment, and Lessons Learned: 2008 Update*. US Department of Transportation. September 2008.

Table 7: TOPS-B/C Analysis, Option 1 (Extend ITS coverage on US 30 to PA 10)

Travel Time (Before Improvement)	Travel Time (After Improvement)	B/C Ratio (Low Volume*)	B/C Ratio (Average Volume*)	B/C Ratio (High Volume*)
Eastbound: ▪ 22 minutes (Peak hour, average) ▪ 34 minutes (Worst day, average) ▪ 74 minutes (Worst day, 95th percentile worst trip)	▪ 20 minutes (-2) ▪ 30 minutes (-4) ▪ 63 minutes (-11)	▪ 0.7 ▪ 1.5 ▪ 4.0	▪ 1.1 ▪ 2.2 ▪ 6.0	▪ 1.6 ▪ 3.1 ▪ 8.6
Westbound: ▪ 20 minutes (Peak hour, average) ▪ 26 minutes (Worst day, average) ▪ 62 minutes (Worst day, 95th percentile worst trip)	▪ 18 minutes (-2) ▪ 23 minutes (-3) ▪ 56 minutes (-6)	▪ 0.7 ▪ 1.1 ▪ 2.2	▪ 1.1 ▪ 1.6 ▪ 3.3	▪ 1.6 ▪ 2.3 ▪ 4.7

*Corridor Low Volume = 14,000; Corridor Average Volume = 21,000; Corridor High Volume = 30,000.
Note: Peak Volumes were estimated from average annual daily traffic (AADT) counts and assume a 5-hour peak period to be consistent with the CMP. The 5-hour peak includes 7-9 AM and 3-6 PM.
Source: DVRPC, 2013.

Table 8: TOPS-B/C Analysis, Option 2 (Extend ITS coverage on US 30 to PA 82)

Travel Time (Before Improvement)	Travel Time (After Improvement)	B/C Ratio (Low Volume*)	B/C Ratio (Average Volume*)	B/C Ratio (High Volume*)
Eastbound: ▪ 18 minutes (Peak hour, average) ▪ 22 minutes (Worst day, average) ▪ 80 minutes (Worst day, 95th percentile worst trip)	▪ 16 minutes (-2) ▪ 19 minutes (-3) ▪ 71 minutes (-9)	▪ 1.0 ▪ 1.5 ▪ 4.5	▪ 1.3 ▪ 2.0 ▪ 5.9	▪ 1.6 ▪ 2.4 ▪ 7.3
Westbound: ▪ 15 minutes (Peak hour, average) ▪ 17 minutes (Worst day, average) ▪ 57 minutes (Worst day, 95th percentile worst trip)	▪ 13 minutes (-2) ▪ 15 minutes (-2) ▪ 51 minutes (-6)	▪ 1.0 ▪ 1.0 ▪ 3.0	▪ 1.3 ▪ 1.3 ▪ 4.0	▪ 1.6 ▪ 1.6 ▪ 4.9

*Corridor Low Volume = 18,500; Corridor Average Volume = 24,400; Corridor High Volume = 30,000.
Note: Peak Volumes were estimated from average annual daily traffic (AADT) counts and assume a 5-hour peak period to be consistent with the CMP. The 5-hour peak includes 7-9 AM and 3-6 PM.
Source: DVRPC, 2013.

All of the scenarios tested produced a positive B/C ratio. For Option 1, the B/C ratios ranged from a low of 0.7 to a high of 8.6. For Option 2, the B/C ratios ranged from a low of one to a high of 7.3. Perhaps not surprisingly, the TOPS-B/C results indicate that the DMS strategy would be most successful where volumes are higher and when delays are longer. While this may seem an obvious conclusion, the results could be used to hone in on locations where the strategy would have the most impact.

The B/C ratios obtained by testing the Option 2 scenario with the "worst day average" and "95th percentile worst trip" peak travel times were slightly lower than those obtained by testing the Option 1 scenario, although both test scenarios indicated the potential for significant benefits. However, the results of Tables 7 and 8 also seem to suggest that Option 2 would be the most cost-effective investment across all the travel time scenarios. These sketch-level results should be augmented with more detailed studies before any decisions are made. One important detail to investigate would be to study the proportion of the peak traffic volume that moves through the corridor under each of the various travel time scenarios. Knowing that, a weighting system could be developed to determine an overall B/C ratio for the corridor.

Cal-B/C

The *Selecting Software* report documented an initial test of Cal-B/C in the West Chester Pike (PA 3) corridor, in part because the corridor was also the subject of more detailed modeling work by the DVRPC Office of Modeling and Analysis, using the VISUM software. In coordination with staff from the DVRPC Office of Transit, Bicycle, and Pedestrian Planning and the Office of Project Implementation, project cost and transit ridership data was collected for the test scenarios. The initial Cal-B/C sketch model results were compared to the more sophisticated VISUM modeling results published in the report, *Boosting the Bus: Better Transit Integration Along West Chester Pike* (Publication #10033). VISUM was able to estimate more precise travel time savings numbers than the default values used in Cal-B/C, based on information about the West Chester Pike corridor that was more detailed than what Cal-B/C required. For example, the VISUM model included information about intersection geometry and signal timing. Default travel time savings numbers provided by the Cal-B/C software were replaced with the numbers estimated by VISUM to determine how the results would change. A 15 percent change was observed in the B/C ratio from the result obtained using Cal-B/C's assumptions. The calculated payback period for the project did not change. It was determined that the initial Cal-B/C results were reasonably similar to those obtained after manipulating the default travel time savings value.

In order to compare results with the test of TOPS-B/C described in the previous section, the same data was entered into Cal-B/C. The results are shown in Tables 9 and 10.

Table 9: Cal-B/C Analysis, Option 1 (Extend ITS coverage on US 30 to PA 10)

Congested Condition (Before Improvement)	B/C Ratio (Low Volume*)	B/C Ratio (Average Volume*)	B/C Ratio (High Volume*)	Average Annual Time Saved (Person-Hours)**
Eastbound:				
▪ Peak hour (Average speed=57 MPH)	▪ 3.1	▪ 4.4	▪ 6.1	▪ 81,000 – 167,000
▪ Worst day (Average speed=34 MPH)	▪ 7.2	▪ 10.4	▪ 14.5	▪ 172,000 – 352,000
Westbound:				
▪ Peak hour (Average speed=58 MPH)	▪ 2.9	▪ 4.2	▪ 5.7	▪ 79,000 – 162,000
▪ Worst day (Average speed=44 MPH)	▪ 5.4	▪ 7.8	▪ 10.9	▪ 133,000 – 272,000

*Corridor Low Volume = 14,000; Corridor Average Volume = 21,000; Corridor High Volume = 30,000.
**Range indicates values derived from low to high volume scenarios.
Note: Peak Volumes were estimated from average annual daily traffic (AADT) counts and assume a 5-hour peak period to be consistent with the CMP. The 5-hour peak includes 7-9 AM and 3-6 PM.
Source: DVRPC, 2013.

Table 10: Option 2 (Extend ITS coverage on US 30 to PA 82)

Congested Condition (Before Improvement)	B/C Ratio (Low Volume*)	B/C Ratio (Average Volume*)	B/C Ratio (High Volume*)	Average Annual Time Saved (Person-Hours)**
Eastbound:				
■ Peak hour (Average speed=55 MPH)	■ 2.9	■ 3.7	■ 4.4	■ 76,000 – 121,000
■ Worst day (Average speed=49 MPH)	■ 4.1	■ 5.3	■ 6.4	■ 107,000 – 169,000
Westbound:				
■ Peak hour (Average speed=57 MPH)	■ 2.7	■ 3.4	■ 4.1	■ 72,000 – 114,000
■ Worst day (Average speed=56 MPH)	■ 2.8	■ 3.6	■ 4.4	■ 74,000 – 117,000

*Corridor Low Volume = 18,500; Corridor Average Volume = 24,400; Corridor High Volume = 30,000.
**Range indicates values derived from low to high volume scenarios.
Note: Peak Volumes were estimated from average annual daily traffic (AADT) counts and assume a 5-hour peak period to be consistent with the CMP. The 5-hour peak includes 7-9 AM and 3-6 PM.
Source: DVRPC, 2013.

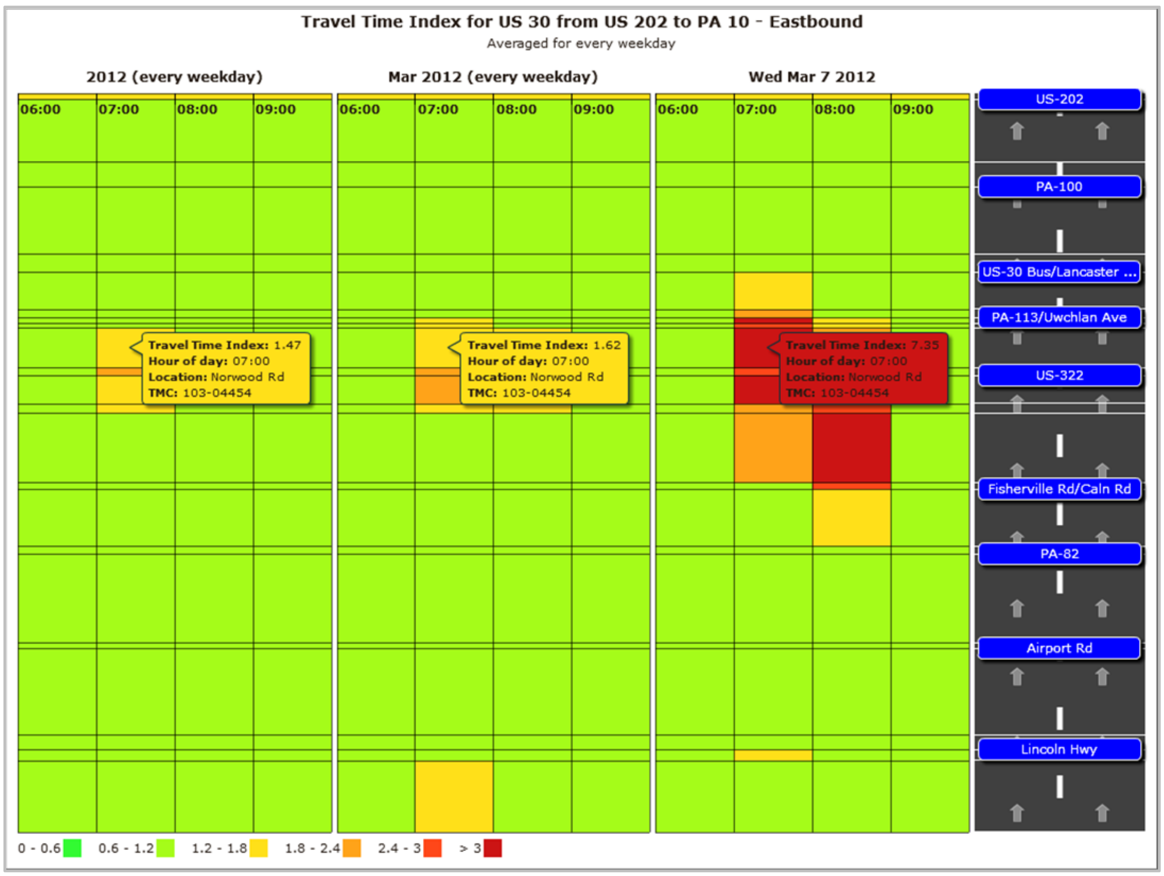
The Cal-B/C results could be further refined if detailed future volume and speed information were available. Estimates were made for the current and future build and no-build speed parameters that paralleled the assumptions made for the TOPS-B/C testing. Comparing Tables 7 and 8 to Tables 9 and 10, the B/C ratios produced by the two tools are similar, though not exactly the same. The TOPS-B/C analysis produced B/C ratio results that ranged from a low of 0.7 to a high of 8.6, while the Cal-B/C results ranged from 2.7 to 14.5. These differences likely result from the fact that TOPS-B/C calculates the benefits of the DMS strategy based primarily on changes in travel time, while Cal-B/C uses changes in speed and also includes emissions factors that are not included in TOPS-B/C. In addition to estimating B/C ratios and person hours of time saved, Cal-B/C estimates impacts on the level of CO_2 emissions. If this was an important factor to consider for the project sponsors, Cal-B/C would likely be preferable, as compared to TOPS-B/C.

Comparing Cal-B/C and TOPS-B/C

Comparing the two tools raises questions about the differences between travel time and speed as measures of congestion. One issue is that speed often varies significantly from one road segment to the next, especially when conditions are congested. Of course, this is also true of travel times. However, travel time across a corridor can be calculated by adding the value for each segment together to determine the cumulative time it takes to traverse the corridor. Indeed, this is the process that the VPP Suite uses to calculate the travel time for a given corridor. But it is not possible to obtain a cumulative speed value in the same way. Instead, an average is used. In other words, the travel time measure more realistically captures the impacts of different travel speeds experienced while driving through a corridor. In addition, the Cal-B/C User's Guide indicates that speed is one of the highest-impact variables in the model, meaning that relatively small differences in speed inputs can result in large changes to the final result.

Another observation is that for this section of the US 30 corridor, improvements that would benefit the eastbound flow appear to be more cost effective both in Cal-B/C and TOPS-B/C, since the eastbound peak conditions are more congested than the westbound peak conditions. In addition, higher B/C ratios were achieved in both tools when volumes were greatest. These observations could be used to target specific locations for improvement. The performance measures from the VPP Suite can help with the analysis of problem locations. For example, Figure 7 shows the TTI for the US 30 Corridor for March 7, 2012, a day when a major incident occurred in the eastbound direction during the AM peak period. It also shows the TTI for March 2012 and for all of 2012 for comparison. The yearly number for 7:00 AM is about 1.5 and the monthly number is slightly higher, at about 1.6. However, on March 7, the TTI for 7:00 AM was over seven. This means that for that hour, the average trip took over 700 percent longer than during free-flow conditions.

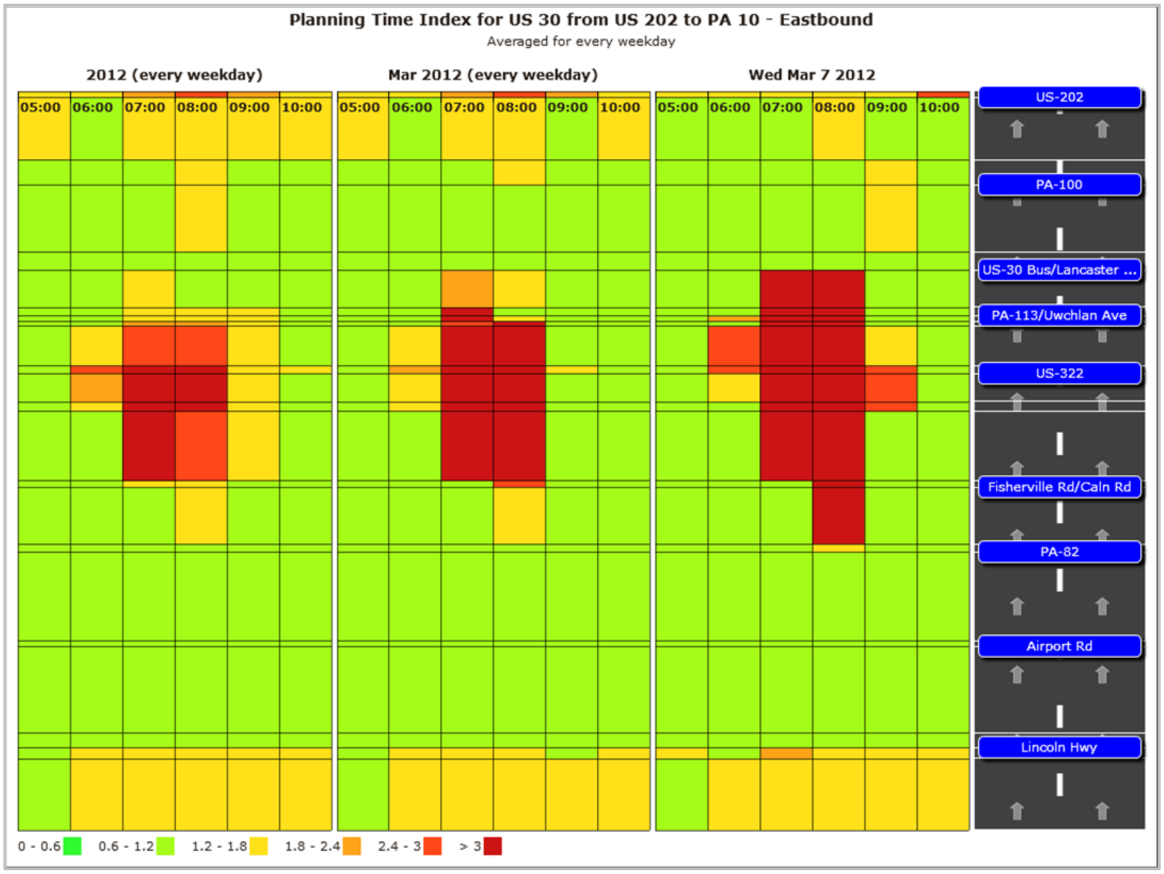
Figure 7: Travel Time Index Comparison – US 30 Eastbound, AM Peak Period



Source: VPP Suite, 2013.

Figure 7 also clearly illustrates the spatial relationship of the congestion on eastbound US 30. Problems seem to concentrate around the PA 113 and US 322 interchanges. Figure 8 shows the PTI for the same time periods. Again, it is clear that there are both temporal and spatial patterns to the areas where reliability is an issue on US 30 eastbound. This data could be used to help figure out the best locations for DMS equipment to warn motorists about incidents and allow them to detour, or at the very least, prepare them for what's ahead.

Figure 8: Planning Time Index Comparison – US 30 Eastbound, AM Peak Period



Source: VPP Suite, 2013.

One aspect that differentiates Cal-B/C from TOPS-B/C is its ability to test alternative improvement scenarios. In discussions that took place during the development of this report, CCPC staff expressed interest in this approach. For example, Cal-B/C could be used to develop scenarios including roadway widening, passenger rail improvements, addition of High Occupancy Vehicle (HOV) lanes, and ITS improvements, in order to compare the costs and benefits of each alternative. While there was interest from CCPC staff in pursuing this approach, it quickly became apparent that to do so would require an extensive effort to obtain the necessary data. Unfortunately, this was outside the scope of the current report. However, CMP staff plans to test and report on these alternative scenarios in the future.

Commuter Model 2.0

The *Selecting Software* report recommended using Commuter Model to analyze the strategies that it can consider. These include Transportation Demand Management (TDM), nonmotorized transportation, and public transportation improvements. **The program has the advantage of being able to analyze multiple strategies together, something none of the other programs selected for testing are capable of doing.** The *Selecting Software* report also recommended that testing take place in a corridor where modeling work was being done in the new VISUM model, in order to compare results. Unfortunately, there was not any concurrent work in VISUM that made sense to use for this effort. Nevertheless, several scenarios were created to test Commuter Model, building on the data used to test TOPS-B/C and Cal-B/C in the US 30 Corridor.

To begin, the model was calibrated with local numbers, including vehicle occupancy, work trip length, and employment data. Locally adjusted mode share and length-of-work trip numbers were obtained from the CCPC's *Annual Report*.[5] Other parameters were adjusted with numbers obtained from internal DVRPC sources.

Scenarios were developed to test various combinations of the strategies in Table 11. The table lists the strategies included in the Commuter Model program and their corresponding strategy from the CMP. From this point forward, the CMP strategy names will be used for consistency.

Table 11: Commuter Model Strategies and Corresponding CMP Strategies

Commuter Model Strategy	Corresponding CMP Strategy
Financial Incentives	Financial Incentives
Employer Support Programs for Alternative Modes	Encourage Use of Fewer Cars
Alternative Work Schedules	Shift Peak Travel

Source: Commuter Model 2.0, US EPA; DVRPC, 2013.

The Shift Peak Travel strategy includes flex-time, telecommuting, staggered work hours, and/or compressed work weeks. Unfortunately, **this strategy illustrates the primary disadvantage of Commuter Model, which is the fact that some strategies require inputs that are not readily available**. For example, the Shift Peak Travel strategy requires the user to either specify the percentages of employees eligible to participate in each of the six types of alternative work schedules (both existing and after implementing the new program), or specify before-and-after participation rates gleaned through a survey. The latter option obviously requires a survey, which is not currently feasible to undertake for all CMP corridors. The former option essentially involves making an educated guess. While national studies could be used, a review of national literature was beyond the scope of this effort and is less useful for planning than an approach that uses local numbers.

Nevertheless, an attempt was made to create a scenario using national numbers. The result was a change in VMT equal to less than one percent. **Without undertaking an in-depth survey of local employers, it is not currently feasible to test the Shift Peak Travel strategy in a meaningful way.**

The Encourage Use of Fewer Cars strategy designates four levels of employer support programs for carpooling, vanpooling, transit, and/or bicycling, each of which is progressively more robust than the last. Level 1 is defined as "Provision of information activities plus a quarter-time transportation coordinator." Level 2 is defined as "Level 1 plus in-house matching services (carpool and vanpool), work-hour flexibility (transit) or bicycle parking and shower facilities (bicycle)." Levels 3 and 4 involve potentially costly programs funded by the employer, so they were not tested. Commuter Model requires the analyst to enter before-and-after numbers for the

[5] Source: www.chesco.org/webapps/planning/flipping_book/anre2011/files/anrep11.pdf; accessed August 30, 2012.

percent of employers participating in each level of the Encourage Use of Fewer Cars strategy. Since there is no way to obtain this information without an extensive survey of local employers, staff is less confident in the accuracy of this test. Relatively low levels of participation (20 percent) were set, as well as a conservative goal of 50 percent participation after the new program is implemented. Table 12 includes the results of these test scenarios.

The Financial Incentives strategy includes parking costs, transit fare/pass subsidies, or other financial incentives. Rather than create a scenario in which employees were penalized by instituting a fee for parking, scenarios were developed for various levels of financial incentives to take transit, carpool, vanpool, bike, or walk to work. Several levels of financial incentives for these alternative modes were tested, beginning with a $30-per-month incentive and ranging up to $100 per month. The high-level scenario was informed by recent reports of a successful incentive program in Kendall Square, a neighborhood in Cambridge, Massachusetts.[6] In general, the Financial Incentives strategy seems to have by far the greatest potential to reduce VMT, even with modest incentives and levels of participation. See Table 12 for more details.

While this test produced more interesting results, it assumed a 25 percent participation rate. Again, the numbers being used in this program could only be obtained through a survey of local employers. There have been some preliminary discussions of coordinating with the region's Transportation Management Associations (TMAs) to conduct such a survey, but nothing is planned at this time.

Table 12: Results of Commuter Model Testing

Strategies Modeled	Employer Participation	Mode Share Change (percent)	Peak VMT Reduction (percent)
■ Financial Incentives ($30/month level) ■ Encourage Use of Fewer Cars	■ 25% ■ 50% Level 1; 50% Level 2	■ Drive Alone = -2.0% ■ Carpool/Vanpool = +1.5% ■ Transit/Bike/Ped = +0.6%	1.7
■ Financial Incentives ($30/month level) ■ Encourage Use of Fewer Cars	■ 50% ■ 50% Level 1; 50% Level 2	■ Drive Alone = -3.0% ■ Carpool/Vanpool = +2.3% ■ Transit/Bike/Ped = +0.9%	2.5
■ Financial Incentives ($60/month level) ■ Encourage Use of Fewer Cars	■ 25% ■ 50% Level 1; 50% Level 2	■ Drive Alone = -3.0% ■ Carpool/Vanpool = +2.3% ■ Transit/Bike/Ped = +0.9%	2.5
■ Financial Incentives ($60/month level) ■ Encourage Use of Fewer Cars	■ 50% ■ 50% Level 1; 50% Level 2	■ Drive Alone = -5.2% ■ Carpool/Vanpool = +4.2% ■ Transit/Bike/Ped = +1.2%	4.3

[6] See www.boston.com/news/local/massachusetts/articles/2012/07/25/in_kendall_square_car_traffic_falls_even_as_the_workforce_soars/?page=full, accessed October, 2012.

Table 12: Results of Commuter Model Testing (continued)

▪ Financial Incentives ($100/month level) **▪ Encourage Use of Fewer Cars**	**▪ 50%** **▪ 50% Level 1; 50% Level 2**	**▪ Drive Alone = -8.3%** **▪ Carpool/Vanpool = +7.1%** **▪ Transit/Bike/Ped = +1.8%**	**6.8**
Financial Incentives ($60/month level)	25%	▪ Drive Alone = -1.8% ▪ Carpool/Vanpool = +1.6% ▪ Transit/Bike/Ped = +0.4%	1.4
Financial Incentives ($60/month level)	50%	▪ Drive Alone = -3.9% ▪ Carpool/Vanpool = +3.3% ▪ Transit/Bike/Ped = +0.8%	3.0
Encourage Use of Fewer Cars	50% Level 1; 50% Level 2	▪ Drive Alone = -1.1% ▪ Carpool/Vanpool = +0.7% ▪ Transit/Bike/Ped = +0.4%	1.0

Source: Commuter Model 2.0, US EPA; DVRPC, 2013.

While Commuter Model shows promise as a sketch modeling tool, especially with its ability to analyze more than one strategy at once, the data gaps are simply too large to overcome at this time. Unless employers within a study area can be surveyed, or specific information about a proposed financial incentive program is known, the program is difficult to use for analyzing the anticipated effects of CMP strategies.

Attempting Multistrategy Analysis

As mentioned in the Previous Software Selections section, the CCAP TEG is a tool that gives rule-of-thumb estimates for VMT reductions on certain strategies. The *Selecting Software* report included an initial attempt at combining these rule-of-thumb estimates with the outputs from Cal-B/C to generate a modified V/C ratio. While the results did not achieve the level of accuracy sought by CMP staff, they at least provided some insight into how a combination of strategies might help mitigate congestion on the West Chester Pike.

The CCAP TEG lists a potential VMT reduction range for Smart Growth, ranging from five to 15 percent, depending on the level of commitment. An average V/C ratio for the US 30 Corridor from US 202 to PA 82, where the most congested conditions are found, was used for the purposes of this test.

Table 13: CCAP TEG Smart Growth Strategy – Predicted VMT Reductions

Strategy	Percent Change	Peak V/C (without Strategy)	Peak V/C (with Strategy)
Limited Smart Growth	5% VMT Reduction	0.94	0.89
Comprehensive Smart Growth	10% VMT Reduction	0.94	0.85
Aggressive Smart Growth	15% VMT Reduction	0.94	0.80

Source: DVRPC, 2013.

In an attempt to take the multistrategy analysis further, the CCAP TEG's Smart Growth strategies were combined with the outputs of testing the Financial Incentives and Encourage Use of Fewer

Cars strategies with Commuter Model. The two combinations of Financial Incentives and Encourage Use of Fewer Cars strategies in Table 12 that predicted a 2.5 percent change in VMT, as shown in the second and third rows in the table, were used to obtain the test results shown in the first row of Table 14. The second row combines the most aggressive smart growth scenario from the CCAP TEG with the most aggressive combination of strategies tested in Commuter Model.

Table 14: Combining Commuter Model and CCAP TEG Results

Strategies	Percent Change	Peak V/C (without Strategy)	Peak V/C (with Strategy)
■ Limited Smart Growth ■ Financial Incentives ■ Encourage Use of Fewer Cars	7.5% VMT Reduction	0.94	0.87
■ Aggressive Smart Growth ■ Financial Incentives ($100/month) ■ Encourage Use of Fewer Cars	22% VMT Reduction	0.94	0.73

Source: DVRPC, 2013.
Note: V/C = Volume-to-Capacity. VMT = Vehicle Miles Traveled.

While the results are interesting, **this method is not able to determine synergistic or duplicative effects of multiple strategies deployed together.**

C H A P T E R 4

Next Steps

Conclusion

DVRPC's *Selecting Software* report (Publication #10023) reviewed 34 transportation software programs that were potentially capable of analyzing the effects of CMP strategies and determined that no one sketch-level program was able to analyze all of the strategy categories or strategies used in the CMP. Furthermore, the ability to analyze multiple strategies together, one of the primary goals of the CMP strategy evaluation effort, was found in very few software packages. Nevertheless, staff has moved forward with testing the most promising tools. Based on the research conducted in this report and the *Selecting Software* report, four programs were short-listed for further testing. These included:

- Cal-B/C – A spreadsheet-based tool to analyze highway, transit, and operations strategies.
- TOPS-B/C – A spreadsheet-based tool to analyze highway and transit operations strategies.
- Commuter Model 2.0 – A spreadsheet-based tool to quantify changes resulting from travel demand management strategies.
- CCAP TEG – A spreadsheet listing rule-of-thumb estimates to determine changes from implementing smart growth and other policies.

Between the four short-listed programs, there is the potential to analyze a majority of the CMP's most-used strategies and the Strategies Appropriate Everywhere. The *Selecting Software* report documented initial tests of Cal-B/C and the CCAP TEG. This report expanded upon that work by testing Cal-B/C, TOPS-B/C, Commuter Model, and the CCAP TEG.

The US 30 Corridor west of the intersection with US 202 in Chester County, Pennsylvania, was selected for testing, in part because a corridor-wide Intelligent Transportation Systems (ITS) master plan was recently developed by the DVRPC Office of Transportation Operations Management. The study was used to develop scenarios to test two potential options for deployment of the DMS strategy on US 30 in TOPS-B/C and Cal-B/C. These scenarios also included varied traffic volumes and travel times throughout the corridor. The advantage of spreadsheet-based sketch modeling tools is that once the initial parameters were set up, it was simple to vary the key data points to test different scenarios. The results are documented in Chapter 3.

One observation about these tests is that due to the nature of the improvement being analyzed, the B/C analysis seemed to either overstate or understate the benefits of the project based on staff experience. This is because the DMS strategy is designed to have the greatest impact during the most extreme conditions. Tests using the worst-case scenario data produced extremely high B/C ratios with both TOPS-B/C and Cal-B/C. When average conditions were used, however, the sketch modeling tools showed less benefit from deploying the DMS strategy, although the B/C ratios were still positive. A range of scenarios were tested for precisely this reason. The strategy's true impact is somewhere between the extremes. Further research could be conducted to determine how frequently each scenario occurs in order to weight the various B/C ratios and determine a representative value for all conditions.

The results from both the Cal-B/C and TOPS-B/C indicated that for the US 30 study corridor, improvements to benefit the eastbound flow would be the most cost effective, since eastbound peak conditions were more congested than the westbound peak conditions. In addition, higher B/C ratios were achieved in both tools when volumes were greatest. These observations could be used to target specific locations for improvement, especially in conjunction with performance measures generated by the VPP Suite, including TTI and PTI.

Data gathered for the tests of Cal-B/C and TOPS-B/C was used to develop additional test scenarios in Commuter Model. While the program shows promise as a sketch modeling tool, especially with its ability to analyze more than one strategy at once, the data gaps are simply too large to overcome at this time. Unless employers within a study area can be surveyed, or specific information about a proposed financial incentive program is known, the program is difficult to use for analyzing the anticipated effects of CMP strategies. Staff will endeavor to close the data gaps if possible and will use the tool in the future where appropriate.

The *Selecting Software* report included an initial attempt at combining the rule-of-thumb estimates from the CCAP TEG with the outputs from Cal-B/C to generate a modified V/C ratio. While the results did not achieve the level of accuracy sought by CMP staff, they at least provided some insight into how a combination of strategies might help mitigate congestion. In an attempt to take the multistrategy analysis further, the current report combined the CCAP TEG's Smart Growth strategies with the outputs of testing the Financial Incentives and Encourage Use of Fewer Cars strategies in Commuter Model. While the results were interesting, this method is not able to determine synergistic or duplicative effects of multiple strategies deployed together, which is an important goal of the CMP strategy evaluation effort.

Next Steps

DVRPC's CMP software evaluation efforts have progressed to the point that staff is now familiar enough with the four short-listed programs to begin exploring further applications of these tools. Although the tools are not capable of meeting all of the goals of CMP strategy evaluation, they have proven to be able to at least provide some insight into the expected benefits of CMP strategies. Staff will continue to develop and enhance the capacity to use these tools.

Next steps include the following:

- Attempt to resolve data issues in order to enhance the ability to use the tools for all locations in the region.
    - Explore querying the DVRPC traffic count database to create a regional dataset of peak and off-peak volumes that could be used with future applications of Cal-B/C and TOPS-B/C.

  - Explore working with the region's TMAs to obtain data on TDM programs that could be used with Commuter Model.

- Select a location, gather appropriate data, and coordinate with planning partners to conduct detailed analysis of multiple transportation improvement alternatives in Cal-B/C. This would be a longer-term item.
  - Select a location and build on previous work to develop alternatives for analysis in Cal-B/C, including: roadway widening, transit rail expansion, ITS deployment, HOV lane additions, etc.
- Test TOPS-B/C and Cal-B/C with a project in New Jersey.
  - Partners have expressed interest in testing the Arterial Signal Management strategy to analyze proposed arterial improvements that would be part of the I-295, NJ 42, I-76 Direct Connect project. Ideally, these tests could be compared with the results of a more in-depth study.
- Test Commuter Model with a project in New Jersey. Attempt to combine this work with the testing of the Arterial Signal Management strategy described above.
- Another ongoing effort by DVRPC's CMP staff is to conduct post-implementation evaluation of projects, in part by using a previously developed multiple regression methodology. In the future, compare the results of the sketch-level software analysis to the ground-truth results obtained from the postimplementation evaluation work.
- To date, CMP staff has based testing of the software tools largely on locations where data was available and has selected strategies that could be readily tested with the available tools. **The long-term goal of CMP staff is to identify CMP subcorridors where improvements are needed to relieve congestion and to have the ability to test proposed strategies and combinations of strategies using the software tools explored in this report.**

Appendix A

Data Inputs

Data Used for Software Testing

TOPS-B/C Analysis, Option 1 (Extend ITS coverage on US 30 to PA 10)

Direction	Condition	Speed (Miles Per Hour)	Travel Time (Minutes)
Eastbound	Free Flow	63	19
	Daily Average	61	19
	Peak Average (7-9 AM)	57	21
	Worst Hour Average (7 AM)	56	22
	Worst Day (3/7/12, 7 AM)	■ 34 (Average) ■ 5 (Worst spot speed)	■ 34 (Average) ■ 74 (95th percentile Worst)
Westbound	Free Flow	63	18
	Daily Average	62	18
	Peak Average (3-6 PM)	60	19
	Worst Hour Average (5 PM)	58	20
	Worst Day (5/30/12, 6 PM)	■ 44 (Average) ■ 5 (Worst spot speed)	■ 26 (Average) ■ 62 (95th percentile Worst)

Source: DVRPC 2013; VPP Suite, 2013.

TOPS-B/C Analysis, Option 2 (Extend ITS coverage on US 30 to PA 82)

Direction	Condition	Speed (Miles Per Hour)	Travel Time (minutes)
Eastbound	Free Flow	63	14
	Daily Average	61	15
	Peak Average (7-9 AM)	57	17
	Worst Hour Average (7 AM)	55	18
	Worst Case (3/7/12, 7 AM)	■ 49 (Average) ■ 5 (Worst spot speed)	■ 22 (Average) ■ 80 (Worst)
Westbound	Free Flow	63	13
	Daily Average	61	13
	Peak Average (3-6 PM)	59	14
	Worst Hour Average (5 PM)	57	15
	Worst Case (5/30/12, 7 PM)	■ 56 (Average) ■ 5 (Worst spot speed)	■ 17 (Average) ■ 57 (Worst)

Source: DVRPC, 2013; VPP Suite, 2013.

Cal-B/C Analysis, Option 1 (Extend ITS coverage on US 30 to PA 10)

Peak Speed (Before Improvement)	Peak Speed (After Improvement)	B/C Ratio (Low Volume*)	B/C Ratio (Average Volume*)	B/C Ratio (High Volume*)	Average Annual Time Saved (Person-Hours)**
Eastbound: ▪ 57 MPH (Peak hour, average) ▪ 34 MPH (Worst day, average)	▪ 61 MPH ▪ 37.4 MPH	▪ 3.1 ▪ 7.2	▪ 4.4 ▪ 10.4	▪ 6.1 ▪ 14.5	▪ 81,000 – 167,000 ▪ 172,000 – 352,000
Westbound: ▪ 58 MPH (Peak hour, average) ▪ 44 MPH (Worst day, average)	▪ 62 MPH ▪ 48.4 MPH	▪ 2.9 ▪ 5.4	▪ 4.2 ▪ 7.8	▪ 5.7 ▪ 10.9	▪ 79,000 – 162,000 ▪ 133,000 – 272,000

Source: DVRPC, 2013.

Cal-B/C Analysis, Option 2 (Extend ITS coverage on US 30 to PA 82)

Peak Speed (Before Improvement)	Peak Speed (After Improvement)	B/C Ratio (Low Volume*)	B/C Ratio (Average Volume*)	B/C Ratio (High Volume*)	Average Annual Time Saved (Person-Hours)**
Eastbound: ▪ 55 MPH (Peak hour, average) ▪ 49 MPH (Worst day, average)	▪ 59 ▪ 54	▪ 2.9 ▪ 4.1	▪ 3.7 ▪ 5.3	▪ 4.4 ▪ 6.4	▪ 76,000 – 121,000 ▪ 107,000 – 169,000
Westbound: ▪ 57 MPH (Peak hour, average) ▪ 56 MPH (Worst day, average)	▪ 61 ▪ 60	▪ 2.7 ▪ 2.8	▪ 3.4 ▪ 3.6	▪ 4.1 ▪ 4.4	▪ 72,000 – 114,000 ▪ 74,000 – 117,000

Source: DVRPC, 2013.

Other Cal-B/C Inputs

Input	Data to Use
Fuel cost per gallon	Regular: $3.34; Trucks (diesel): $4.01
Average vehicle occupancy	1.3
Peak Volumes – US 202 to PA 10 (19-mile corridor)	
Corridor Average	14,000
Corridor Low	21,000
Corridor High	30,000
Peak Volumes – US 202 to PA 82 (13-mile corridor)	
Corridor Average	18,500
Corridor Low	24,400
Corridor High	30,000
Crash data – US 202 to PA 10	
Total crashes	344
Fatal crashes	3
Injury crashes	159
PDO crashes	182
Crash data – US 202 to PA 82	
Total crashes	250
Fatal crashes	1
Injury crashes	114
PDO crashes	135

Source: DVRPC, 2013.

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Key Words: Congestion Management Process (CMP), traffic, reliability, multimodal, goods movement, transportation, corridors, strategies, Single-Occupancy Vehicles (SOV), capacity, incidents, long-range plan, regional transportation planning, software, performance measures, evaluation, benefit-cost (B/C)

Abstract: Since 2006, DVRPC's Congestion Management Process (CMP) staff has researched tools to evaluate the anticipated performance and expected benefits of congestion management strategies. Although none of the programs evaluated to date meet all of the needs of CMP strategy analysis, four programs were short-listed for further testing and evaluation. These programs have the potential to analyze a majority of the most-used strategies in the CMP.

The US 30 Corridor west of the intersection with US 202 in Chester County, Pennsylvania, was selected for testing the short-listed programs, in part because a corridor Intelligent Transportation Systems (ITS) master plan was recently developed by the DVRPC Office of Transportation Operations Management. CMP strategies tested included Dynamic Message Signs, Financial Incentives, Encourage Use of Fewer Cars, and Smart Growth. Four short-listed tools were tested, using archived operations data to develop robust scenarios. Results are detailed and next steps are explored.

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