USING TRAVEL TIME RELIABILITY DATA TO DEVELOP CONGESTION MANAGEMENT STRATEGIES IN THE TRANSPORTATION PLANNING PROCESS

by

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The selection of different congestion management process (CMP) strategies for a specific corridor by a Metropolitan Planning Organization (MPO) is an important step in the transportation planning process. The selection of strategies and prediction of improvements using simple sketch planning methods based on travel time reliability data would be a useful tool.

The congestion management strategies (CMS) and travel time reliability data, which are available for many MPOs including the Southwestern Pennsylvania Commission (SPC), are used to select projects to address congestion problems. A model is needed that can predict travel time reliability indices changes. Two travel time reliability indices that were used in this research are the posted speed reliability index and expected travel time reliability index, which are used by SPC. The goal of this research was to develop a CMS model that can select one or several optimum strategies for a corridor. The results are then used to calculate the changes in predicted travel time reliability indices for a corridor, which can be used to indicate the expected impact of the strategies.

The research results provide a combined qualitative and quantitative method which could be used to select CMS projects and predict CMS improvements. This methodology will help MPOs to select CMS strategies and identify projects during transportation planning process.

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PREFACE

This thesis is made as a completion of the master's degree education in Transportation Engineering, which is the conclusion part of the transportation curriculum at University of Pittsburgh, Swanson School of Engineering, Civil and Environmental Engineering Department.

Several persons have contributed academically, practically and with support to this thesis.

Firstly, I would like to thank my advisor, Dr. Mark Magalotti. He gave me lots of trust and flexibility on this research. Also, he gave me a large number of suggestions which are not only in the professional aspect but also in the language aspect. Only with his help, this challenging research could finish in time. I really appreciate his help.

Also I would like to thank Domenic D'Andrea, Josh Spano and Josh Grimm, who are working at SPC. They gave me some suggestions from MPO planners' aspect that were really useful to determine the thesis research direction.

Furthermore, I would like to thank the planners who responded to the survey for this thesis. Their responses provided a lot of help for this thesis.

Last but not least, I would like to thank my family and friends for being helpful and supportive during the time that I studied at University of Pittsburgh.

I will continue to study in the future, even though I finished my thesis. This is not the end but the start.

1.0 INTRODUCTION

This chapter introduces the background, hypothesis, objectives and methodology of research about MPOs selecting congestion management strategies and selecting among transportation planning projects by using travel time reliability and safety data.

1.1 BACKGROUND

Nowadays society is highly developed, people are relying on transportation system much than ever before. Commuting, recreation and almost everything are related to transportation systems. This situation makes transportation systems become more developed and complex, especially roadway systems. As the number of vehicles traveling on the roadway network increases, the networks become larger and larger. One of the serious problems on a roadway transportation system is traffic congestion, especially in an urban area. Congestion is the level at which transportation system performance is no longer acceptable due to traffic interference. Congestion not only reduces travel time reliability but also increases the crash rate at some locations. There are two types of congestion: recurring congestion and non-recurring congestion. Recurring congestion occurs during peak travel periods because the number of vehicles trying to use the highway system exceeds the available capacity. Non-recurring congestion occurs because of temporary disruptions that take away part of the roadway from use.

In order to reduce congestion, federal transportation legislation requires that each metropolitan planning area in the United States have a “Congestion Management Process” (CMP) [1] which is required by the Safe Accountable Flexible Efficient Transportation Equity Act 2005. The CMP is a broad, regional level planning tool designed to help manage and reduce congestion by identifying congested corridors and recommending multimodal strategies for congestion mitigation. Typical metropolitan planning organizations (MPO) have several CMP strategies for different corridors. Those can be classified to four major categories: demand management, modal options, operational improvements and capacity projects. Within these four major categories, the CMP may include many different types of strategies. The MPO in southwestern Pennsylvania, Southwestern Pennsylvania Commission (SPC) uses the following twenty-five different strategies for addressing congestion, which was developed according to FHWA report [2]. The following Table 1-1 shows the congestion management strategies that are in the SPC’s toolbox.

Table 1-1. CMP Strategies in the SPC's toolbox

CATEGORIES	STRATEGIES
Demand Management	Employer-Based Programs
	Parking Management
	Congestion Pricing
	Public Relations and Education for Travel Demand Management
	Growth Management
	Transit-Oriented Development Policies
Modal Options	Improved Transit Service
	Rideshare Programs
	Park-n-Ride and Other Intermodal Facilities
	HOV and HOT Lanes
	Pedestrian Facilities and Information
	Bicycle Facilities and Information
	Transit Capital Improvements
Operational Improvements	Traffic Signal Improvements
	Intersection and Geometric Improvements
	Elimination of Bottlenecks
	One-Way Streets
	Reversible Lanes
	Ramp Management
	Incident Management Systems
	Access Management
	Intelligent Transportation Systems
Capacity Projects	Lane Additions
	New Single-Occupancy Vehicle (SOV) Facilities

In summary, demand management programs attempt to address congestion at the root of the problem by reducing the number of vehicles on the road. Modal options include techniques to give people transportation choices beyond just driving alone in their cars, these also reduce number of vehicles on road. Operational improvements are geared toward improving the "supply side" of the transportation system. These efforts are intended to enhance the operation of the transportation system and make it as efficient as possible. Capacity projects can include new roadways and roadway widening for additional SOV lanes. Capacity improvements are typically

the last measures transportation professionals consider to address congestion problems due to the cost and impacts of such projects.

When considering these CMP strategies, planners need tools to identify which strategies should be applied to specific corridors given the characteristics of the corridors. Predicting impact of the strategies is one of the needed tools to identify projects in the transportation planning process. Data and information from the CMP, such as travel time reliability and crash history, could be used to predict the benefits of specific strategies available in a CMP. These predictions could benefit the transportation planning process by helping the region focus limited transportation dollars where they can have the greatest impact to reduce congestion.

1.2 HYPOTHESIS

The hypothesis of the research is that a methodology can be developed for the prediction of the improvement of travel reliability and can be used as a sketch planning or screening tool to select congestion management strategies and project types in the project planning process. An improvement index can be developed and the applicability and impact of specific strategies can be calculated by researching each strategy's impact based upon similar situations where the strategies have been implemented and benefits measured.

Some states and MPOs have begun using travel time reliability data to select projects in the planning process and a survey will be conducted of those agencies to determine how those strategies are selected to improve travel time reliability.

Guidelines for use of those strategies will be based upon the current congestion management process of an MPO (SPC) and will be developed by the researcher. The results will

be applicable to other MPO processes to develop CMP strategies. Once the methodology is developed it will be used and applied to a corridor in the MPO region to help select strategies. After the guideline is completed, the MPO can then use it to identify which strategy should be used to make travel more reliable and improve safety for any corridor by predicting the improvement.

1.3 RESEARCH OBJECTIVES

The objectives of this thesis were to develop a methodology to predict improvements of each CMP strategy, such as travel time reliability and safety improvements and to determine what kinds of strategies should be applied to specific corridor. Then a guideline of selecting strategies was developed. The methodology then guides the MPO transportation project selection were identify to where they can have the greatest impact.

1.4 METHODOLOGY

The existing data and information for many MPO transportation CMS plans includes corridor identification, travel time and safety data for each corridor and potential CMP strategies. The core of this research is improvements in prediction methods. In other words, when the corridor, the data and the potential strategies are given, how to determine the most useful and efficient strategies for a specific corridor. The considered method is to predict the improvement of specific strategies if they are implemented to the corridor. This is the reason why this research

focused on predicted improvements for strategies as well as the implement ability of strategies. The method of research for this hypothesis includes data collection which includes a review of current academic research on the topic and a survey of state DOTs and MPO case studies relating to CMP projects. The data and information, which was found on data collection process, was then classified and analyzed. Finally the predicted improvement index was determined. Figure 1-1 presents a framework model for the methodology and Table 1-1, Table 1-2, Table 1-3 and Table 1-4 present matrixes showing the expected results for the methodology.

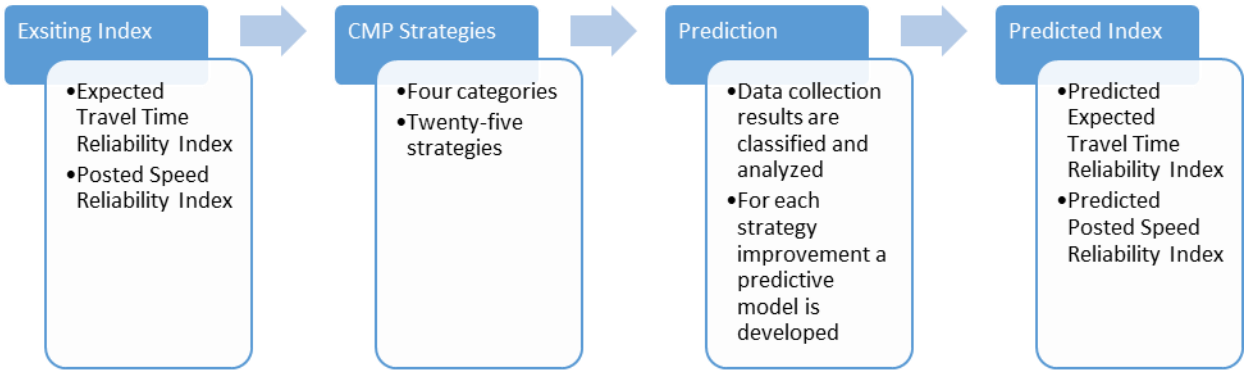


Figure 1-1. The frame model of methodology

Table 1-2. Expected result of methodology for demand management strategies

Categories	STRATEGIES	APPLICABILITY OF STRATEGY	PREDICTED IMPROVEMENT IN INDEX AND RATE
Demand Management	Employer-Based Programs		
	Parking Management		
	Congestion Pricing		
	Public Relations and Education for Travel Demand Management		
	Growth Management		
	Transit-Oriented Development Policies		

Table 1-3. Expected result of methodology for modal options strategies

Categories	STRATEGIES	APPLICABILITY OF STRATEGY	PREDICTED IMPROVEMENT IN INDEX AND RATE
Modal Options	Improved Transit Service		
	Rideshare Programs		
	Park-n-Ride and Other Intermodal Facilities		
	HOV and HOT Lanes		
	Pedestrian Facilities and Information		
	Bicycle Facilities and Information		
	Transit Capital Improvements		

Table 1-4. Expected result of methodology for operational improvements strategies

Categories	STRATEGIES	APPLICABILITY OF STRATEGY	PREDICTED IMPROVEMENT IN INDEX AND RATE
Operational Improvements	Traffic Signal Improvements		
	Intersection and Geometric Improvements		
	Elimination of Bottlenecks		
	One-Way Streets		
	Reversible Lanes		
	Ramp Management		
	Incident Management Systems		
	Access Management		
	Intelligent Transportation Systems		

Table 1-5. Expected result of methodology for capacity projects strategies

Categories	STRATEGIES	APPLICABILITY OF STRATEGY	PREDICTED IMPROVEMENT IN INDEX AND RATE
Capacity Projects	Lane Additions		
	New Single-Occupancy Vehicle (SOV) Facilities		

2.0 LITERATURE REVIEW

2.1 INTRODUCTION

This literature review evaluated the current practice and research in this area to determine guidelines for the identification of transportation planning strategies and projects by using travel time reliability and safety data, and methodologies currently used to identify transportation planning projects during CMP. The literature review also evaluated some case studies that state DOTs and MPOs completed relating to incorporating reliability performance measures into the transportation planning and programming processes.

2.2 FHWA

The second Strategic Highway Research Program (SHRP2) was created to find strategic solutions to three national transportation challenges: improving highway safety, reducing congestion, and improving methods for renewing roads and bridges. Several reports in SHRP2 are relating to identifying transportation planning projects by using reliability and safety data, including *Incorporating Reliability Performance Measures into Operations and Planning Modeling Tools (S2-L04-RR-1), Guide to Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes (S2-L05-RR-2), Incorporating*

Reliability Performance Measures into the Transportation Planning and Programming Processes Technical Reference (S2-L05-RR-3), and *Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes (S2-L05-RW-1)*. Those reports contain research on developing the capability of producing measures of reliability performance as output in traffic simulation models and planning models [3], developing a high-level reference document for transportation planners, operators, and system managers [4], and providing guidance for transportation planning agencies to help them incorporate travel time reliability performance measures and strategies into the transportation planning and programming process [5] [6].

2.2.1 Measures to describe travel time reliability

There are six common measures used to describe travel time reliability. There are Planning-Time Index (PTI), Buffer-Time Index (BI), Standard Deviation, Semi-Standard Deviation, Failure Measure, and Misery Index. Table 2-1 presents calculation and description of those measures. These measures are complex to calculate. It should be considered if there is a large number of travel time data available. Because of limited travel time data support, this thesis will use SPC existing indices to develop methodology.

Table 2-1. Travel time reliability measures [4]

Measure	Calculation	Description
Planning-Time Index (PTI)	$\frac{95th\ Percentile\ of\ TT}{Free\ Flow\ TT}$	The extra time required to arrive at a destination on time 95% of the time.
Buffer-Time Index (BI)	$\frac{95th\ Percentile\ of\ TT - Average\ T}{Average\ TT}$	The extra time required to arrive at a destination on time 95% of the time, compared with average or median travel time.
Standard Deviation	$\sqrt{\frac{1}{N}\sum_{i=1}^{N}(TT_i - Average\ TT)^2}$	The variation in travel time compared with the average.
Semi-Standard Deviation	$\sqrt{\frac{1}{N}\sum_{i=1}^{N}(TT_i - Free\ Flow\ TT)^2}$	The variation in travel time compared with free flow.
Failure Measure	$\frac{Trips\ with\ TT < 1.1 * Median}{Total\ Trips}$	The percentage of trips arriving on time.
Misery Index	$\frac{Average\ of\ the\ Highest\ 5\ percent}{Free\ Flow\ TT}$	How much longer it takes to travel on the worst 5% of all trips.

2.2.2 Tools and methods for estimating reliability

There are four types of reliability tools and broadly defined methods for conducting analyses are considered in technical reference report: Sketch-Planning Methods, Model Post-Processing, Simulation or Multiresolution Methods, and Monitoring and Management Tools Methods.

Sketch-Planning Methods, which intend to provide quick assessment of reliability (and the impacts of projects affecting reliability) using generally available data as inputs to the analysis. Model Post-Processing Methods, which focus on applying customized analysis routines to data from a regional travel demand model to generate more specific estimations of travel time reliability measurements. Simulation or Multiresolution Methods make use of an advanced traffic simulation model's ability to test and assess the driver's behavior and reactions to nonrecurring events. For reliability assessments, these simulation and multiresolution methods are often combined with several alternative conditions that represent logical variations in travel demand, weather conditions. Incident occurrence, presence of work zones, or other factors influencing nonrecurring congestion. Monitoring and Management Tools and Methods intend to provide analysis of real-time and archived traffic data. These tools and methods may play a significant role in providing data for forecasting methods [5]. Travel time data which are obtained by Monitoring and Management Tools and Methods will be used in this research. Sketch-Planning Methods will be used in travel time reliability analysis.

2.3 ACADEMIC RESEARCH

Due to congestion problem becoming more and more serious, State DOTs and MPOs are pay much attention on congestion management. There is some research recently completed to help State DOTs and MPOs develop congestion management strategies, but few are related to strategies improvement predict methods and strategy selection methods. The most recent research in this area is summarized below.

2.3.1 Villanova University

A study of identifying congestion factors to estimate the likelihood of the occurrence of congestion in the Greater Philadelphia, Pennsylvania, area was conducted by Villanova University. The methodology of this research was performing an analysis to identify congestion contribution factors by examining several traffic data sources. Weekly speed data on a segment of I-95 per month in 2012 were analyzed. For the recurrent congestion, the researchers found it showed slightly higher recurring congestion levels than national average values. For the nonrecurring congestion factors, the researchers found crash occurrences and holidays were two major elements contributing to total congestion [7]. This research gives an idea of congestion contribution factors, especially for the non-recurring congestion. It is helpful for congestion management strategies improvement prediction, and for developing congestion management strategies.

2.3.2 University of Central Florida

A study of evaluation of the big data applications in real-time traffic operation and safety monitoring and improvement on an expressway network in Orlando, Florida was conducted by the University of Central Florida. The research focus on expressway operation and safety monitoring by using the data from ITS systems. The real-time congestion measurement based on Big Data was developed for this research. It was found that congestion on the urban expressways is highly time and location specific. It also evaluated how the congestion has an impact on rear-end crashes. It then developed the real time crash prediction model [8]. This research gives a possible method to determine the benefits of ITS equipment on expressway operation and safety monitoring. Also it is potentially beneficial on the prediction of an improvement index when ITS projects are implemented to reduce congestion during CMP.

2.4 CASE STUDIES

Several DOTs and MPOs have incorporated reliability performance measures into operations and planning process. The following cases are provided to illustrate how this planning methodology is being implemented.

2.4.1 Denver, Colorado

Colorado Department of Transportation (CDOT) conducted a before-and-after analysis to assess benefits of operations strategies using an arterial performance monitoring system. The pilot

project on Hampden Avenue in Denver proved that reliability data can be calculated with a small amount of equipment (in this case three Bluetooth readers) over a relatively short period of time (two months). Finally, the study documents the CDOT's efforts in selecting and incorporating operations (including reliability) performance measures into their long-range planning process. CDOT's experience in their LRTP (Long-range Transportation Plan) update process indicates that reliability data can provide transportation agencies with opportunities to enhance following steps within the statewide transportation plan development process: (1) assessing program or strategy performance toward meeting mobility goals and objectives, (2) determining needs-based investment levels for corridors, (3) determining and evaluating the strategies that are best suited to improve travel in a corridor, (4) selecting and prioritizing projects for inclusion in the STIP and (5) providing detailed data used in the design of specific projects [6]. The study provided data on benefits and improvement of some strategies. However, CDOT didn't predict the improvement of the operations strategies before they were applied. Most of the studies were done as a before-and-after analysis to assess benefits of the strategies. Therefore, the study cannot provide any guidance on the methodologies for the prediction of strategies' impacts.

2.4.2 Knoxville, Tennessee

The Knoxville Region Transportation Planning Organization conducted a study to develop a process for estimating reliability performance measures and identifying reliability deficiencies based on traffic flow and incident duration data. At same time, this study also estimated the impacts of operations projects. The data of this study was from the regional ITS freeway management system. The study demonstrated how various reliability performance indices and incident duration information can be calculated using those data. This is the foundation for

identifying potential traffic operations strategies for improving reliability. Finally the study showed how agencies can use sketch-planning methods and the data poor reliability prediction equations to assess the reliability benefits for operations strategies within a regional ITS architecture [6]. Both travel time and incident data were used in this study. It also had some prediction process. However it predicted the reliability of specific corridors for operations strategies, most of them were related to ITS. It only focused on operations strategies not all the congestion management process strategies.

2.4.3 Joint Base Lewis-McChord, Washington

Washington State Department of Transportation (WSDOT) conducted a study to identify reliability deficiencies along a key segment of the Interstate 5 (I-5) corridor near the Joint Base Lewis-McChord military base. The sketch-planning methods were applied to assess the impacts of implementing a package of reliability mitigation strategies within the corridor [6]. This study demonstrated how agencies can use sketch-planning methods to assess the reliability impacts for a package of operations strategies within a corridor and then advance these projects into the region's long range transportation plan. The first step is collecting data and selecting appropriate analytical techniques; the second step is dividing corridor into subsections; the third step is identifying reliability deficiencies; the final step is applying sketch-planning methods using travel-demand-model data and the SHRP 2 L03 report results, which developed data poor reliability prediction equations [9]. The strategies impacts and benefits which were analyzed are all operations strategies.

2.5 SUMMARY

In summary, the FHWA research program SHRP2 gives an overview, technical reference and some validation case studies for incorporating reliability performance into the transportation planning and programming processes. It didn't develop special guidelines or instructions on how to select CMP strategies during the CMP and LRTP.

Most of the academic research studies are related to data collection and analysis methods development, congestion factor analysis, and special strategies especially for operational strategies impacts analysis. Also much of the research was conducted on the prediction of operation changes by using the data for traffic monitoring system. However, few research studies were conducted on the prediction of the CMP strategies improvement or how to select CMP strategies. A review of the DOTs and MPOs studies showed, only a limited number of state DOTs and MPOs have incorporated reliability performance into their CMP. All of them are operational strategies applied to operation projects. The selection of CMP strategies seems to be limited to operational strategies. Through analyzing impacts and benefits from the finished operation projects, the state DOTs and MPOs select the operation strategies that should be applied for a corridor. Most of them didn't include a strategies improvement process for selecting projects. The only prediction methodology that were used is data poor reliability prediction equations developed in SHRP 2 L03 report [9].

The literature review gives a conclusion that an improved method of selecting CMP strategies is needed, which should include all strategies, impacts and benefits. The FHMA research, academic research and state DOTs and MPOs experience are very useful and helpful in developing a method of selecting CMP strategies. This research and experience gives some ideas on how data collection, reliability analysis and strategies impacts analysis could be used in

developing a methodology. Those elements are foundations to the prediction and selection of methods. Also the prediction and selection of methods should be easy to apply for the CMP process so that MPOs can develop the LRTP in an efficient manner. For example, it should use the data that MPOs have available.

3.0 DATA COLLECTION AND PREDICTION METHODOLOGY

This chapter introduces the available data for planning, that typical MPOs use in the congestion management process and proposed strategies for selecting projects to address CMS identified problems. Currently there is no well-developed methodology for MPOs to select strategies. A survey was developed to obtain information, beyond the literature research, to determine how they select different strategies for a specific corridor. Information was requested from all MPOs in the United States that have a CMP.

3.1 AVAILABLE DATA FOR PLANNING

3.1.1 Travel time reliability data

Typical MPOs have travel time and speed data for corridors they manage. After obtaining these original data, planners for MPOs have developed methodologies to calculate indices which can report travel time reliability. The indices go beyond reporting travel times by time of day, day of week and month of year. The indices used by the Southwestern Pennsylvania Commission (SPC) are introduced in the section and were used for this research.

SPC's CMP determines the posted speed reliability index and expected travel time reliability index to indicate travel time reliability for freeways corridors. This information is developed from travel time information from their DOT ITS system.

Posted speed reliability index is the percentage of time that the measured average speed for a corridor is at or near (within 5 mph) of the average posted speed limit for that corridor. In general, average travel speed in free flow condition is 5-10 mph higher than average speed limit. Therefore, the delay caused by congestions in short period (less than half hour) cannot decrease the average travel speed to 5 mph lower than average posted speed limit, which means only recurring congestion and long-period (more than an hour) non-recurring congestion could influence the index. Since the chance of long-period non-recurring congestion happening is much lower than that of recurring congestion, the non-recurring congestion influence could be ignored. Therefore, posted speed reliability index could indicate the influence of recurring congestion of a corridor. Furthermore, this index can directly showed the period of recurring congestion. For example, the index at 95% means that 5% of the analysis period has recurring congestion.

Expected travel time reliability index is the percentage of time that the measured travel time for a corridor is below or within 10% of the median weekday travel time for that corridor. The median weekday travel time for a corridor is a variable value as a result of recurring congestion happening. During recurring congestion period, the travel time increases as well as the median weekday travel time, still the travel time is within 10% or below the median weekday travel time to a great extent. Therefore the delay caused by recurring congestion cannot influence the index, which means the reduction of recurring congestion will not influence the index. Since only the unexpected congestion, which can be regarded as non-recurring congestion, can

influence the value of the index, expected travel time reliability index could indicate the influence of non-recurring congestion of a corridor. This index indicates the period of non-recurring congestion. For example, if the index at 95% means that 5% of the analysis period has non-recurring congestion.

These two indices have been developed to measure the reliability of travel time for the public. Other MPOs by only measuring average travel speeds and not the variability of speeds information provided to the public does not consider how reliable reported travel times might be. These indices can also have a role in addressing CMS problems by considering solutions that do not necessary decrease travel times but increase the reliability of travel times.

Additional performance measures such as peak hour of delay per vehicle and total peak hour delay can also be calculated. Figure 3-1 shows typical SPC's corridor travel time data, which is the raw data used to calculate the indices. The vertical axis is travel time; the horizontal axis is time of day. It shows annual average weekday every hour travel time data. Figure 3-2 shows a typical SPC's corridor performance measures summary table which translates the raw data into the indices shown.

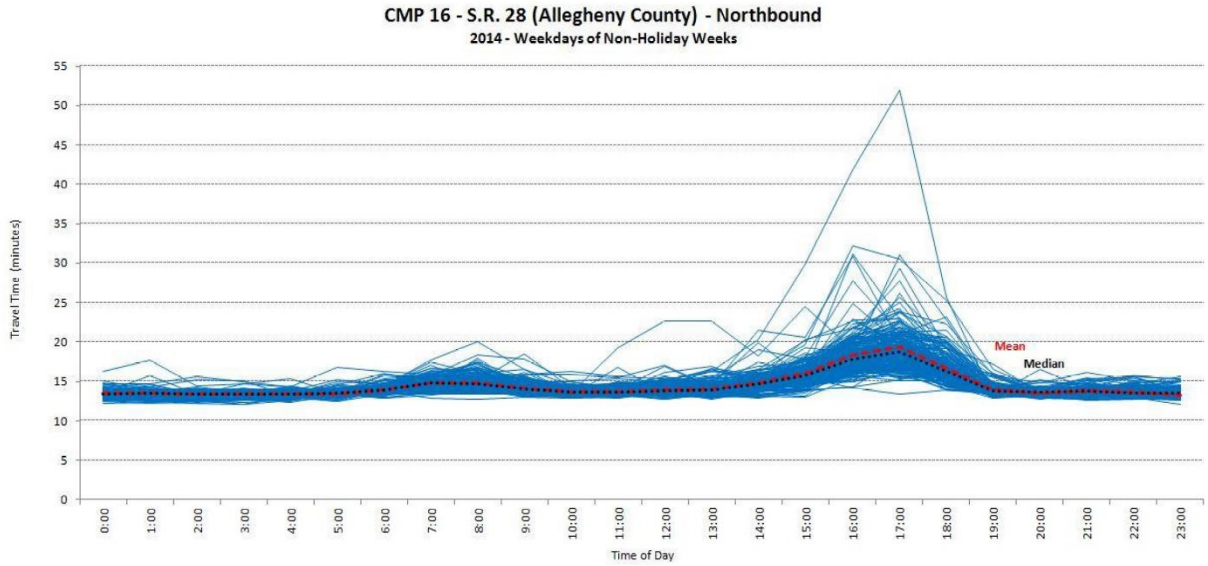


Figure 3-1. PA-28 northbound travel time data [10]

CMP 16 - S.R. 28 (ALCO) - Northbound 2014	
Corridor Length (miles)	12.4
Avg. Speed @ Posted Speed Limit (mph)	51.1
Travel Time @ Posted Speed Limit (min)	14.6
AM Delay per Vehicle (min)	0.3
AM Delay per Vehicle / Mile (min/mi)	0.0
Estimated AM Peak Hour Volume (vehicles)	1200
AM Total Delay (veh-hrs)	6
AM Total Delay per Mile (veh-hrs/mi)	0
PM Delay per Vehicle (min)	4.8
PM Delay per Vehicle / Mile (min/mi)	0.4
Estimated PM Peak Hour Volume (vehicles)	2100
PM Total Delay (veh-hrs)	168
PM Total Delay per Mile (veh-hrs/mi)	13
Total Peak Hour Delay (veh-hrs)	173
Total Peak Hour Delay per Mile (veh-hrs/mi)	14

	Posted Speed Reliability Index	Expected Travel Time Reliability Index
January	84.0%	95.8%
February	80.7%	94.2%
March	89.5%	97.0%
April	87.6%	93.5%
May	84.8%	92.5%
June	85.6%	95.3%
July	88.3%	96.1%
August	88.6%	94.8%
September	87.6%	96.8%
October	84.5%	93.1%
November	88.1%	96.3%
December	91.3%	97.3%
ANNUAL	86.8%	95.2%

Figure 3-2. PA-28 northbound performance measures summary table [10]

This research used the indices that SPC used when developing methods to select strategies to address CMS issues.

3.2 SURVEY OF MPOS CONGESTION MANAGEMENT PROCESS PROJECT

3.2.1 Developing the survey

A survey was developed in order to obtain additional information about selecting strategies and using travel time reliability data during the CMP evaluation process for MPOs. There were three sections of this survey. The first section was the screening questions section, those questions screened respondents who had experience relating to CMP projects. If the respondent had no experience, the survey was ended. The second section was developed to obtain data for selecting strategies and predicting improvement during CMP projects. The third section was obtaining data, from MPOs, on how they use travel time reliability data during the selection of CMP projects. The complete survey questions are shown on Appendix A.1.

This survey was sent to MPOs with populations over 200,000. An MPO with a jurisdiction of this size should have a CMP process. Analyzing the survey results provided information on how MPOs select strategies and identify projects during the CMP. It also provided a framework and guideline for developing a methodology, which is the subject of this thesis. Table 3-1 shows the survey questions. Figure 3-3 shows the survey flow chart. This chart explains how the questions were structured to screen and solicit responses based on the respondent's experience with the subject.

Table 3-1. Survey questions

Number	Question
1	What is your position?
2	Have you been involved in developing solutions and projects that relate to congestion issues identified in the Congestion Management Process CMP?
3	Did the solutions or projects you were involved with have a formal institutional process for selecting different strategies based on the CMP?
4	What institutional process did you use for selecting different strategies for a specific project to address a CMP issue? (multiple selections)
5	What process did you use for selecting different strategies for an individual project to address a CMP issue? (multiple selections)
6	How did you predict the impact of each candidate strategy?
7	What issues, if any, were identified during the evaluation of multiple strategies for a specific problem or corridor? (multiple selections)
8	How did your agency use travel time reliability data to select a strategy? (multiple selections)
9&10	If you have a report or method that you have developed to use this data please attach a document or provide a link.

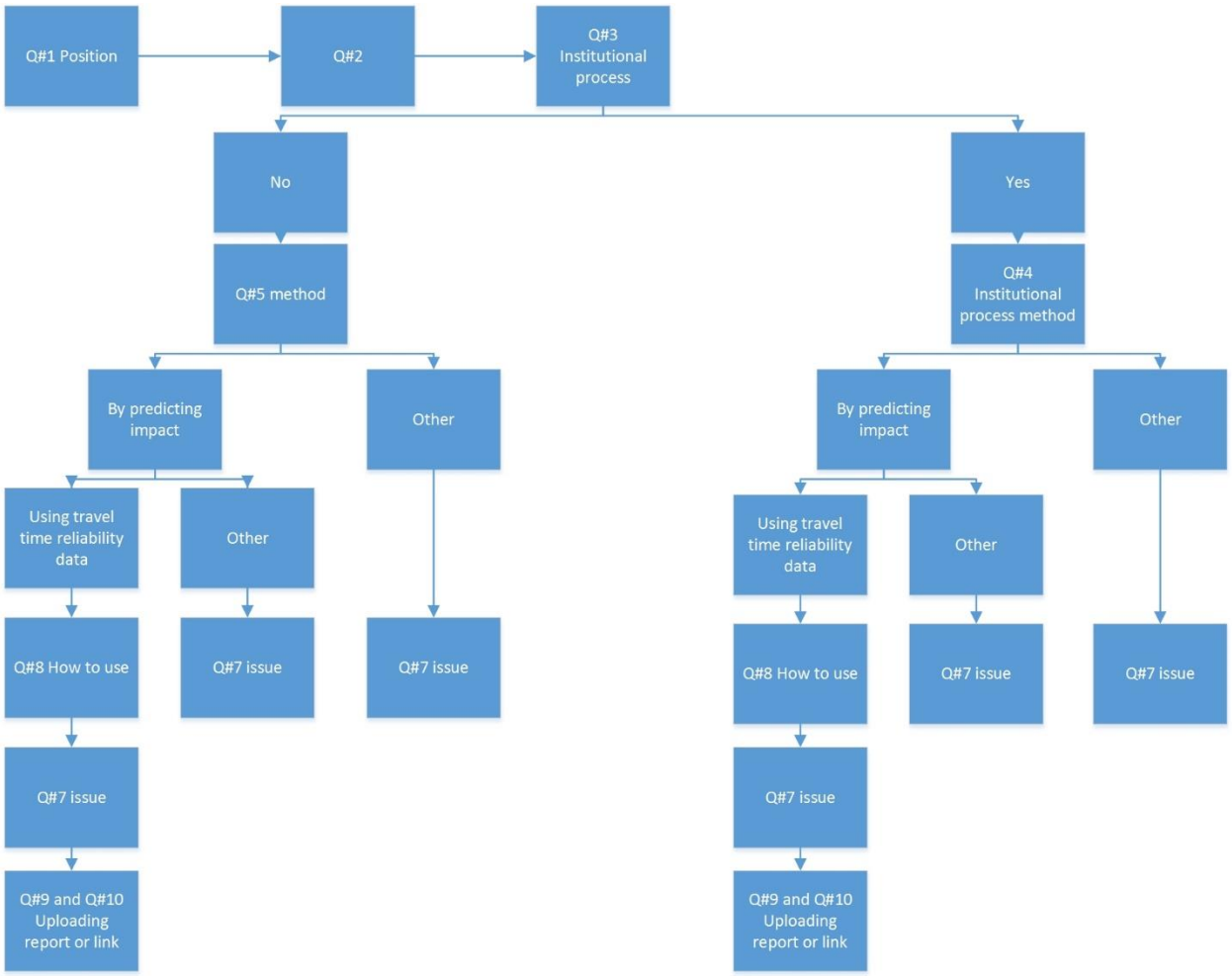


Figure 3-3. Survey flow chart

3.2.2 Survey results

The following is a brief summary of the survey results. This is based upon a review of the final survey results. The final survey results are provided in Appendix A.2.

This survey was sent to MPOs in the United States with populations over 200,000. MPOs of this size were selected because they should have a CMP, according to the 2005 Federal Safe, Accountable, Flexible, and Efficient Transportation Equity Act [1]. The contact list was obtained from the MPO Database on the USDOT Transportation Planning Capacity Building website (https://www.planning.dot.gov/mpo.asp). It was distributed through the survey tool Qualtrics and was active for 18 days.

There were 41 responses received from the 195 requests sent. This is a response rate of 21% which is considered acceptable. The respondents were all MPO Engineers/Planners. The survey identified if the respondents' MPOs have an institutional process for selecting different strategies to address congestion problems based on the CMP. It also requested the MPOs to indicate how they select different strategies, if they use travel time reliability data to select strategies, and any issues in the existing process for project selection.

The respondents confirmed that many were involved in developing solutions and projects that relate to congestion issues identified in the CMP.

The majority of the respondents confirmed that the MPOs have a process for selecting different strategies based on the CMP data. 50% of them have a methodology for selecting project types; others select solutions to CMS problems on a project-by-project-basis process for selecting CMP strategies. Only 23 percent of MPO respondents do not use a process to select projects relevant to the CMP data.

Of the methods used for selecting different strategies, the most common method is using MPO or DOT committees, mentioned by 70 percent of respondents. The second most common method is using staff recommendations, mentioned by 60 percent of respondents. Additionally 32 percent of the respondents indicated that their MPOs predicted possible impacts of different strategies. Of the respondents who predict a strategy's impact, 75 percent of the respondents have used results from planning or simulation models. Only 38 percent of the respondents have determined how different strategies would impact travel time reliability data after implementation. Of those who have used travel time reliability data, 67 percent (2 respondents) have used travel time reliability data to quantify the current level of congestion and rank corridors based on this type of an index of congestion. Only one respondent used travel time reliability data to predict congestion reduction.

The specific issues encountered in the evaluation of multiple potential strategies for corridor improvement included: having only one suitable strategy; the evaluation of diverse strategies proving too complex; and the expected improvement turning out to be inaccurate. These three issues were each reported by 15 percent of the respondents. 50 percent of the respondents have no issues on the process, the process is adequate for their needs.

In summary the survey results revealed that while many MPOs use a process to select projects to address CMS problems few have used travel time reliability indices for this purpose. The most commonly used methods were selecting strategies using staff or similar project experience. These survey results reaffirmed the hypothesis that a methodology is needed that can screen and predict the impact of the most appropriate strategy to solve a congestion problem. In addition a methodology is needed that not only predicts increases in speeds but also changes to travel time reliability. The following section suggests such a methodology.

3.3 TYPICAL MPO CONGESTION MANAGEMENT PROCESS STRATEGIES

There are four major categories of strategies that MPOs consider during the selection of projects during the congestion management process. These include demand management strategies, modal options (public transportation) strategies, traffic operational strategies and road capacity strategies. The following provides a description of each these types of strategies.

3.3.1 Demand management strategies

The central goal of demand management strategies is to reduce trip generation thus reducing congestion. These types of strategies are designed to reduce congestion by reducing the number of vehicles traveling on the roadway. Most sub strategies under demand management strategies are public policies strategies, including employer based program strategies, parking management strategies, congestion pricing strategies, growth management strategies, and transit-oriented development strategies.

An employer based programs strategy refers to a policy that reduces employee trip generation by setting flexible work schedules, providing vanpool programs, and promoting public transit usage. A parking management strategy could be implemented to adjust the parking price according to vehicle occupancy, which discourages single occupancy vehicle travel, or reduce parking supply. A Congestion pricing strategy is intended to encourage public travel at non-peak hours by pricing transportation services by time of day or congestion conditions. Growth management strategies are used to implement public policies to manage the location and nature of new development that optimizes transportation system efficiency. Last but not least,

transit-oriented development strategies encourages the public to use transit by improving transit accessibility and increasing density.

In summary, demand management strategies are policies related to actions that reduce congestion by reducing trip generation and increasing trip efficiency.

3.3.2 Modal options strategies

The central goals of modal options strategies are to promote high occupancy vehicle trips and non-motorized vehicle trips. In order to enhance high occupancy vehicle trips, improved transit service strategies and transit capital improvements strategies are developed to encourage the public to use transit by increasing transit accessibility. In addition, rideshare programs and HOV (High Occupancy Vehicle) lanes are developed to encourage the public to utilize carpools or vanpools to commute. Also, in order to enhance non-motor vehicle trips, pedestrian facilities and bicycle facilities are developed to encourage the public to walk and bike by improving roadway conditions.

In summary, modal options strategies are those that reduce congestion by increasing vehicle occupancy and encouraging non-motorized vehicle travel.

3.3.3 Traffic operational strategies

The core goal of traffic operational strategies is increasing traffic operational efficiency and decreasing travel time through reduced congestion. Traffic operational strategies are most likely the most common types of projects that MPOs implemented during CMP. Also, they are the improvements that are most easily implemented when being compared with other CMP

strategies. For instance, traffic signal improvements and intersection geometric improvements are able to reduce delay at intersections immediately when implemented. Elimination of bottlenecks is an operational strategy that is also significantly effective to reduce recurring congestion, though this type of project usually needs a greater amount of funding than other types of operational improvements. One-way streets is another method implemented in urban areas, which can in some instances control traffic flow direction and optimize road network efficiency. In addition, a reversible lanes strategy is very beneficial for congested corridors where most of travel demand is commuting and directional. Additionally, ramp management strategies can relieve freeway congestion by controlling the entry flow. However, it may increase local road network congestion.

Other than those mentioned previously only incident management system strategies can reduce non-recurring congestion. Furthermore, access management strategy is developed for reducing arterial roads congestion by controlling the access, like minimizing the number of driveways and intersection, which can reduce the delay due to traffic control facilities. Finally intelligent transportation systems strategies have become very popular in the recent twenty years as methods of addressing CMS. Many ITS facilities are developed to improve the roadway operational efficiency. Some ITS facilities which are relevant to incident management could also address non-recurring congestion issues. Most of strategies mentioned previously incorporate some type of ITS facilities into their implementation plan. Therefore, many traffic operational strategies can also be regarded as ITS strategies.

In summary, traffic operational strategies reduce congestion by increasing operational efficiency, allowing more traffic to operate on the same congested roadway by increasing efficiency but not adding significant capacity.

3.3.4 Road capacity strategies

Road capacity strategies are the most direct type of CMP strategies to address congestion issues. These strategies directly increase roadway capacity by constructing new travel lanes and new roadways. Road capacity strategies should be considered, when the traffic operational efficiency has increased and number of single occupancy vehicle trip has reduced, but the congestion degree is still at an unaccepted degree. However, implementing road capacity strategies' projects has many concerns because it usually requires significant funds to support and may have environmental impact issues.

In summary, road capacity strategies are the final strategies selected and implemented to reduce congestion. If the traffic demand is significantly higher than the existing capacity, road capacity strategies might be the only effective strategies to solve the congestion problem.

3.4 DEVELOPING THE METHODOLOGY

The methodology of the model for selecting strategies and predicting their impact model was developed based on typically available corridor strategy categories for MPO. The following is a summary of how the methodology was developed.

3.4.1 Selecting CMP strategies model

For a specific corridor, the first step is to identify its characteristics such as if it is a freeway or an arterial road and whether it is located in an urban, suburban or rural area. Based upon the first

categorization some CMP strategies are obviously unsuitable for this type of corridor and cannot be considered.

The second step is to identify the type of congestion that is occurring in the corridor by using travel time reliability data. If posted speed reliability index is about 5% higher than the expected travel time reliability index, the dominant type of congestion is non-recurring congestion. Similarly if the dominant type of congestion is recurring congestion, the travel time reliability index will be about 5% higher than the travel time reliability index. If any of the index is lower than 95%, the congestion that the index indicated should also be considered. For example, a corridor has 82% of posted speed reliability index and 91% of expected travel time reliability index. The dominant type of congestion in that corridor is recurring congestion. The non-recurring congestion also needs to be considered because the expected travel time reliability index is lower than 95%.

The third step is to identify possible factors that could influence the type of congestion and either decrease travel time or make travel times more reliable. For example for recurring congestion, possible factor could be the demand of the road is much higher than the capacity during peak hours. Another example would be for non-recurring congestion, possible factors could be a car crashes or a special event that increases traffic volume of using the road for short periods that are unpredictable.

The fourth step in the proposed methodology, is to select candidate strategies corresponding to possible factors that result in recurring or non-recurring congestion.

This final step is to determine the optimal strategies that could be implemented in this corridor among those candidate strategies by considering both economic and environmental

factors and comparing their predicted benefits, if they can be predicted. The proposed model is shown on Figure 3-4.

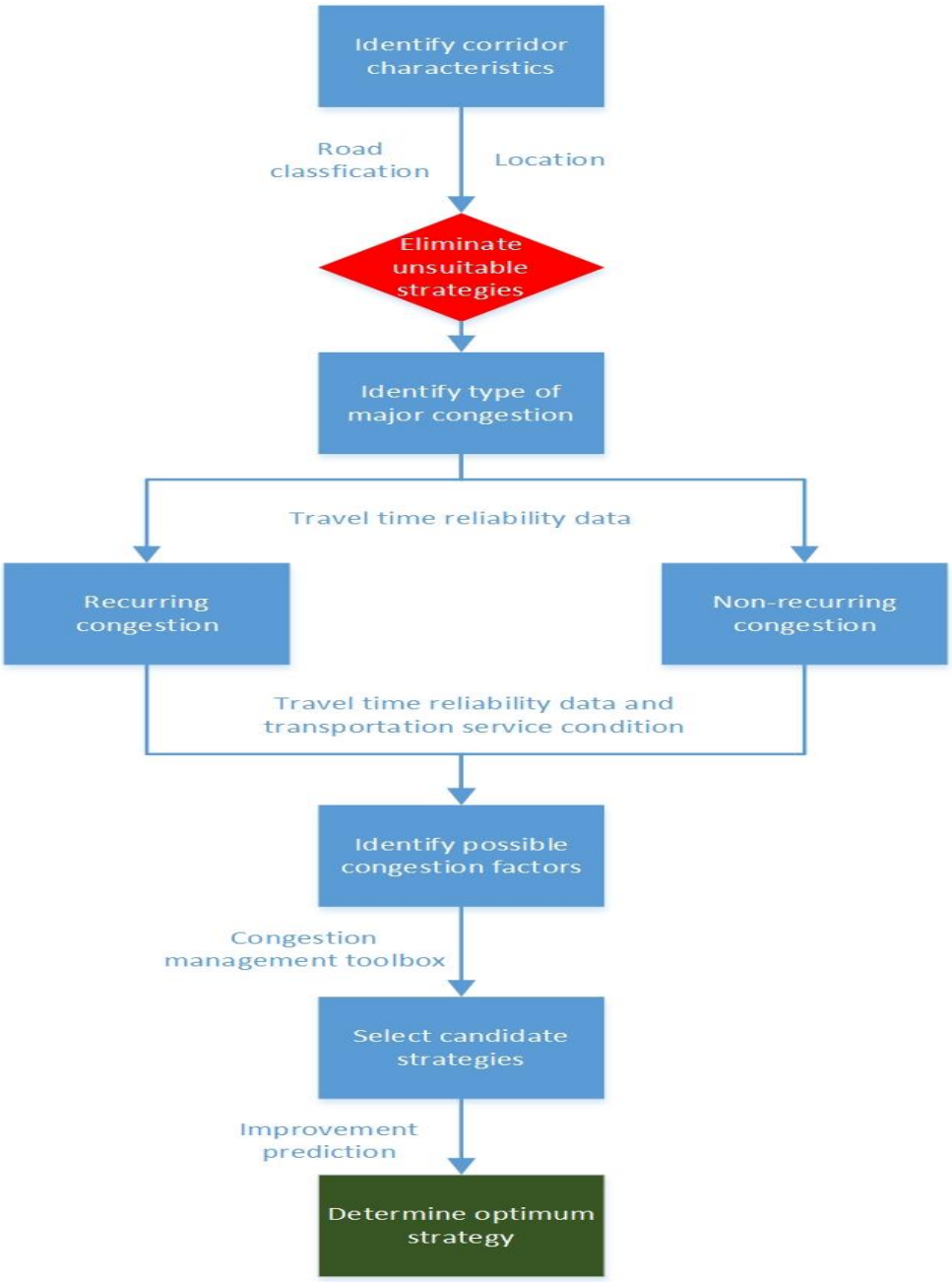


Figure 3-4. Selecting CMP strategies model

3.4.2 Calculating predicted indices model

The first step, for this model, is to obtain the annual travel time data and optimum strategy's predicted improvement for a corridor. The second step is to calculate typical daily congestion hours by using indices. The third step is to acquire strategy improvement prediction estimates from simulation models, finished projects, and a study of the potential projects for this specific corridor or by using academic research. The fourth step is to calculate daily congestion period reduction by using the strategy improvement prediction estimates. The final step is to calculate predicated and improved posted speed reliability expected travel time reliability indices according to the reduction of congestion periods. The model is shown on Figure 3-5 and the equations used in the model is shown in Table 3-2. A calculation example is shown on Figure 3-6.

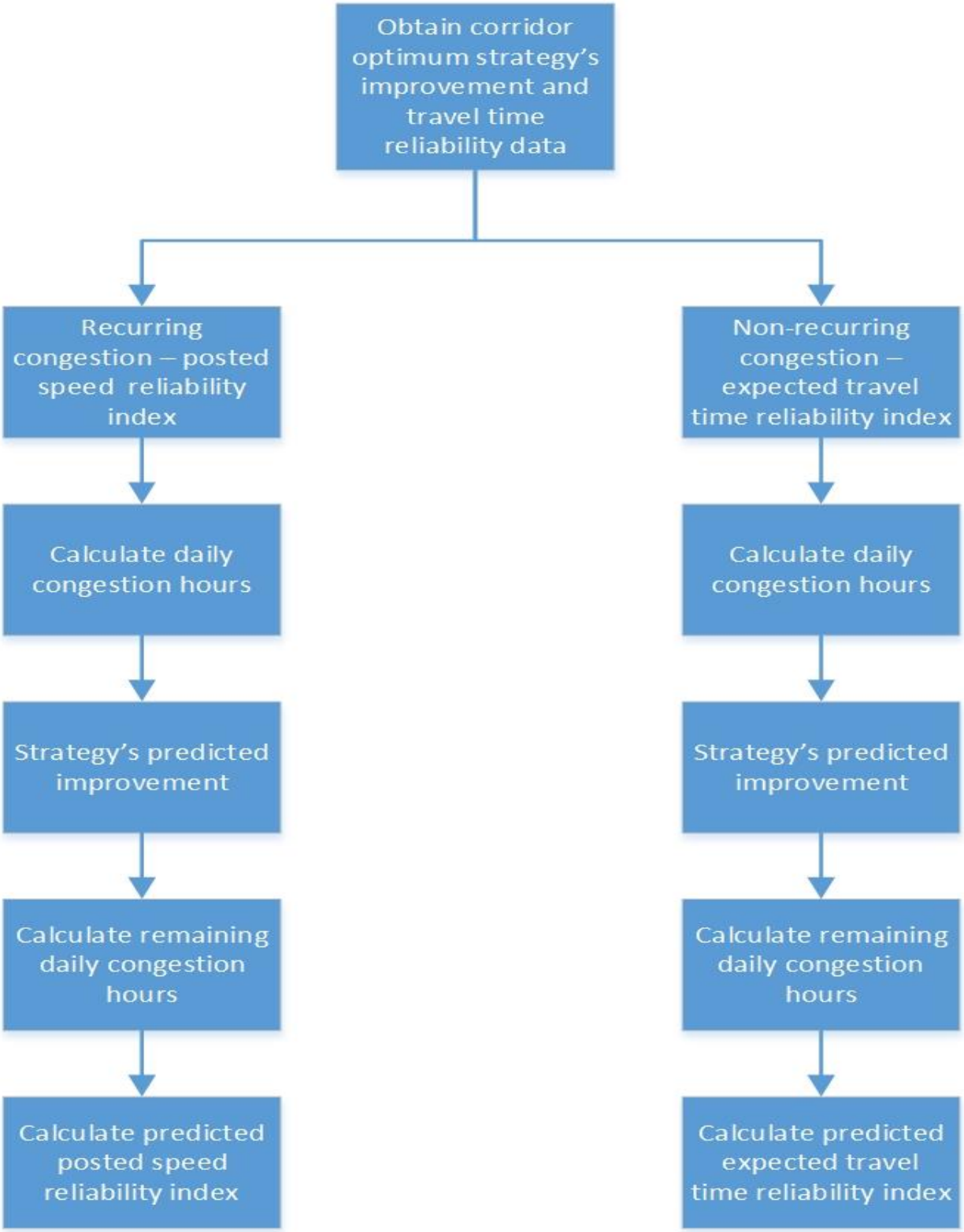


Figure 3-5. Calculating predicted indices model

Table 3-2. Equations used in calculating predicted indices model

Equation	Description
$24 - 24 \times \text{indices (in decimal)}$	Calculate number of daily congested hours
$\text{Daily congestion hours } \times [1 - \text{improvement (in decimal)}]$	Calculate remaining number of daily congested hours
$\text{Remaining daily congestion hours} \div 24$	Calculate predicted indices

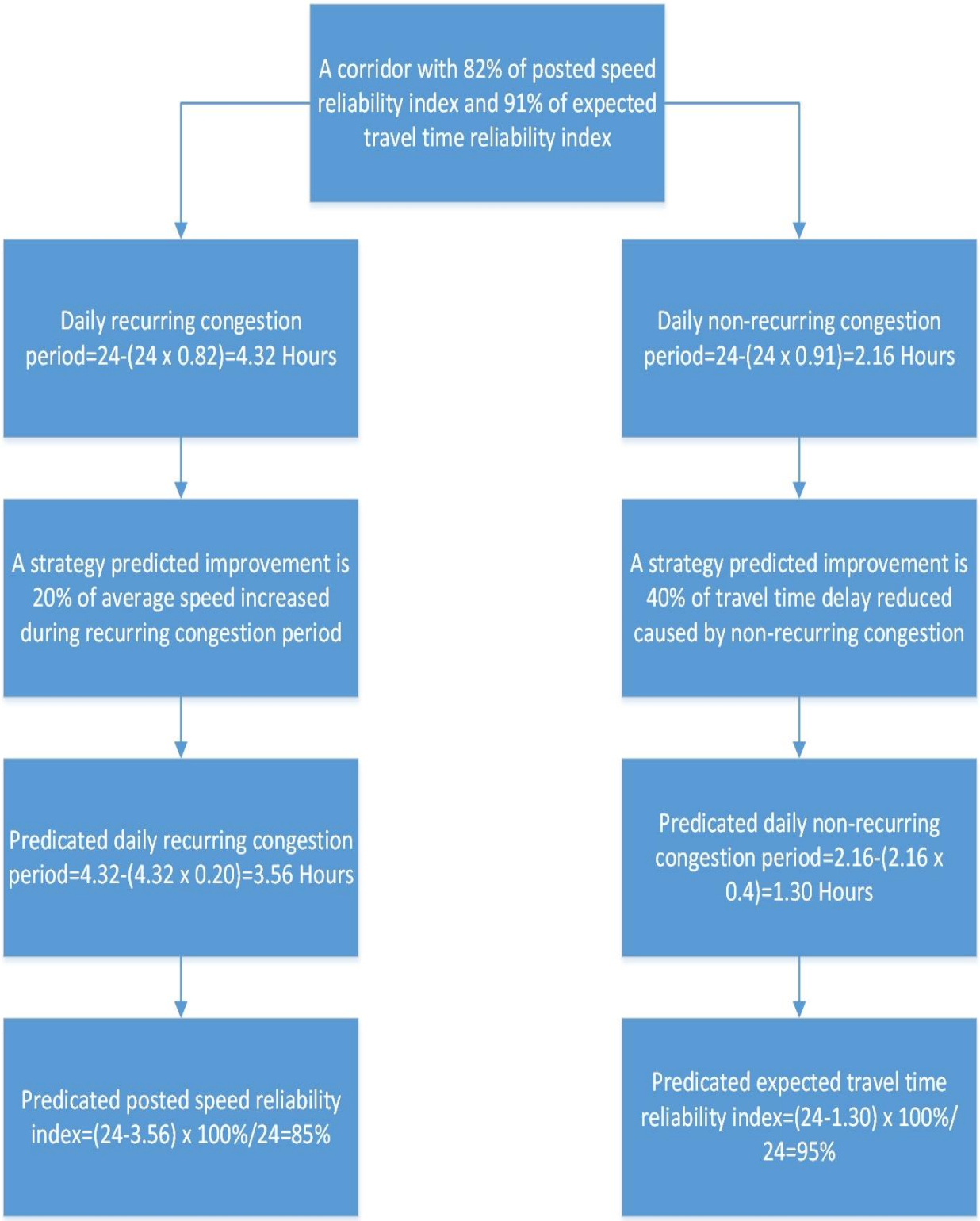


Figure 3-6. Calculation example

3.5 SUMMARY

In summary, the survey results showed that the existing processes and methods that MPOs use to select strategies during the process include travel demand models, simulation software and models to predict strategies' improvements. However these models do not consider the type of congestion being evaluated nor measure it with some type of reliability index.

The selecting CMP strategies and calculating predicted indices model was designed to use results from those models but expand upon the results to predict impacts on travel time reliability. The model is a sketch planning model that directs the process of selecting strategies and predicting improvements while incorporating travel time reliability into the process. The model can, for specific time periods, incorporate the results from travel demand or simulation models such as travel time reductions and average travel speed increase into the travel time reliability index through simple calculations. In next chapter, each CMP strategy is reviewed based on selecting the CMP strategies and calculating predicted indices model.

4.0 REVIEW OF CMP STRATEGIES AND DEVELOPMENT OF SELECTION MODELS

In this chapter, every strategy in the CMP toolbox was reviewed according to the model for the type of congestion (recurring or non-recurring) that it can potentially solve, and the appropriate situation (location) where the congestion occurs. For the strategies whose improvement in the indices can be predicted, the measure of the improvement is provided. General guidance is provided for the strategies whose predictive improvement is variable, and cannot be easily predicted, based on conditions in different corridors, such as travel demand management strategies.

4.1 DEMAND MANAGEMENT STRATEGIES

This type of strategy is designed to reduce recurring congestion by reducing vehicle travel on the roadways. Specific types of demand management strategies might have different impacts in different regions of MPOs. In this research, the types of strategies from SPC's CMP toolboxes are examined as an example of how an MPO might consider these various types of demand management strategies.

4.1.1 Employer-based programs

Employer-based program is a policy-related strategy, which require employer to encourage employees to make fewer single occupancy vehicle trips by means of enacting policies like company-run carpool or vanpool programs, promotion of transit usage and parking management at the work site. These types of strategies should use travel demand models based on corridor trip generating characteristics in order to predict increase in travel times for specific periods of the day. These types of strategies typically impact only peak hours of congestion and the change that results can be predicted for individual hours by models. This information can then be incorporated into a revised index. Finally, this model can be used for both freeways and arterial roads.

4.1.2 Parking management

Parking management is also a policy-related strategy. It discourages single occupancy vehicles (SOV) by adjusting the price and availability of parking. This strategy can reduce recurring congestion by reducing vehicle travel on the roadways. Furthermore, the improvement of parking management could use a travel demand model and parking demand model based on corridor characteristics.. Because these types of strategies can reduce both peak and off-peak travel, methods maybe needed to estimate off-peak impacts by evaluating reduce for in total daily traffic volumes, not just peak hour volumes. Same as employer-based programs, parking management impacts can be predicted for both freeways and arterial roads.

4.1.3 Congestion pricing

Congestion pricing is also a policy-related strategy. It encourages travel at non-peak hours by pricing of transportation services including fares and tolls during peak hours. Also this strategy can be used to distribute traffic to other routes on the network from the congestion routes by tolling some sections of the network. It also contributes to reducing recurring congestion by reducing vehicle travel on the roadways and distributing traffic to other routes on the network. In the study of Lake Washington network, the researcher demonstrated a 5-15% increase of average speeds on SR-520 by using simulation model to simulate the impact of tolling the route [11]. In the study of the Hong Kong cross-harbor-tunnel, the researcher reported a result of a 19.6% reduction of traffic volumes by increasing the pricing of the tunnel [12]. More detailed studies should be done on specific corridors. Generally speaking, it should reduce congestion 5-20% based upon available studies. However, at same time, planners should also consider its impact on other routes on the system.

4.1.4 Public relations and education for travel demand management

Public relations and education for travel demand management is also a policy-related strategy. It encourages the public to travel in fewer single occupancy vehicles during peak hours by educating them and providing them with information about alternate modes such as public transit. It also contributes to reducing recurring congestion by reducing vehicle travel on the roadways. The impact of these types of strategies are difficult to predict. This strategy works on both freeways and arterial roads as the first two strategies.

4.1.5 Growth management

Growth management is also a policy-related strategy. It manages regional land use and development in order to optimize transportation efficiency. This strategy can be used to develop a regional strategy when the planner develops the LRTP (long range transportation plan). It reduces congestion by increasing transportation services efficiency through well-developed land use planning and transportation planning. It contributes to reducing both recurring and non-recurring congestion. It is a strategy that can only reduce future increases in congestion and not address current congested conditions. Also, its improvement is complex to predict. To get a predictive improvement, one needs to use a travel demand model and adjust future growth and use assumptions.

4.1.6 Transit-oriented development policies

Transit-oriented development policies is also a policy-related strategy that is similar to growth management. It involves development planning considering public transit usage and accessibility. For example, for a new residential area development, the location should be close to transit service routes so that residents will be willing to take transit, and ultimately the single occupancy vehicle travel demand will reduce. It also contributes to reducing recurring congestion by reducing vehicle travel on the roadways. In order to get predicted results, travel demand models should be used. This strategy also only addresses future congestion and not current congestion.

4.1.7 Summary

Since demand management strategies are policy-related strategies, it is difficult to predict their quantitative improvement in reducing congestion. Most of these strategies affect public travel or commuting habits. Some strategies can impact current congestion problems while other can help reduce future predicted problems. Since CMPs are studying current problems the selection of these strategies should consider the more immediate impact. Table 4-1 shows a summary of demand management strategies.

Table 4-1. Summary of demand management strategies

STRATEGIES	APPLICABILITY OF STRATEGY		PREDICTED IMPROVEMENT METHOD
	Congestion Type	Corridor Classification	
Employer-Based Programs	Recurring	Freeways and arterial roads	Travel demand models
Parking Management	Recurring	Freeways and arterial roads	Travel demand models
Congestion Pricing	Recurring	Freeways	Travel demand models
Public Relations and Education for Travel Demand Management	Recurring	Freeways and arterial roads	Travel demand models
Growth management	Recurring	Freeways and arterial roads	No discuss, address future congestion
Transit-oriented development policies	Recurring	Freeways and arterial roads	No discuss, address future congestion

4.2 MODAL OPTIONS STRATEGIES

These strategies are developed to reduce recurring congestion by increasing carpool/vanpool and public transit usage. Furthermore, they encourage the public to make fewer vehicle trip by using

other modes such as walking and biking. In the following research, the sub strategies from SPC's CMP toolbox are provided as an example.

4.2.1 Improved transit service

An improved transit service strategy encourages the public to use public transit by adding new routes and expanding schedules. It also improves the accessibility of transit service, which affects travel model choice. It reduces recurring congestion by decreasing the number of single occupancy vehicle trips in the corridor. These types of strategies should use travel demand models to predict their impacts. However most travel demand models only measure congestion during the typical peak hours. This type of strategy could improve travel speeds in off peak periods and some type of estimation method is needed to quantify these changes to supplement the mode.

4.2.2 Rideshare Programs

A rideshare programs strategy facilitates carpool/vanpool services. It is helpful to reduce single occupancy vehicle commuting trips. It can be implemented with assistance of employer-based programs strategy. It can reduce recurring congestion during peak periods by decreasing the number of single occupancy vehicle commuting trips. To improve this strategy, travel demand models should be used to predict improvements in travel times but only peak period improvements most likely will result.

4.2.3 Park-and-Ride and other intermodal facilities

Park-and-Ride and other intermodal facilities strategies improve intermodal facilities accessibility and service levels. This strategy advocates commuting travelers to use public transit, carpool/vanpool services. The more these services are used, the less single occupancy vehicle are in the congested corridor. This strategy can also be implemented when coordinated with parking management strategies, rideshare programs strategies and congestion pricing strategies. It can reduce recurring congestion during peak periods by decreasing the number of single occupancy vehicles. In order to improve this strategy, travel demand models should be used to predict the impact during peak periods.

4.2.4 HOV and HOT lanes

HOV (high occupancy vehicle) and HOT (high occupancy toll) lanes strategies are developed to encourage travelers to travel in high occupancy vehicles by creating restricted lanes that only open to high occupancy vehicles. Generally, the use of HOV lanes could increase the congestion of single occupancy vehicle, if it uses a lane that was previously available to single occupancy vehicles. . It's a strategy that benefits high occupancy vehicles. The benefits of traveling on HOV lanes increase the number of travelers who are willing to travel in high occupancy vehicles. These types of strategies typically only impact peak periods of travel. The difference between a HOT lane and a HOV lane is that single occupancy vehicles are allowed to use HOT lanes by paying fees. The HOT lanes strategy is like a combination of HOV lanes strategy and congestion pricing strategy. It can optimize the usage of lanes capacity, but sometimes it may cause some level of congestion on the HOV lanes if not managed properly. HOV and HOT lanes strategy can

ultimately reduce recurring congestion by increasing the percent of high occupancy vehicle trips and decreasing high occupancy vehicles' travel time during peak hours. A case study of I-394 in Minnesota PASS clarified that the number of crashes was reduced by 5.3% after converting the HOV lanes to HOT lanes [13]. Therefore HOT lanes may have more benefits in reducing non-recurring congestion. They may also have the benefit of increasing travel speeds during off peak periods. The toll prices are varied by congestion and during off peak periods speeds may increase on the general lanes if most traveler chose a lower cost HOT lane. Travel demand models are used to predict usage of HOVs and HOT lanes however these types of traveler choices are difficult to model. These types of strategies should consider using travel demand models to predict the increase in travel speeds in both peak and off-peak periods.

4.2.5 Pedestrian facilities and information

A pedestrian facilities and information strategy advocates for the public to walk as a mode of transportation by improving walking facilities service condition and adding new facilities such as sidewalks, crosswalks and pedestrian signals. It contributes to reducing urban area recurring congestion by reducing the usage of vehicles in localized areas. To date most travel demand models cannot predict the impact of this strategy. This should not be considered a CMS option for facility that carries long distance trips such as freeways, unless one considers improved walking to access transit, in which case it could assist the CMS.

4.2.6 Bicycle facilities and information

A bicycle facilities and information strategy encourages the public to ride bikes as a mode of transportation by improving biking facilities service conditions and adding new facilities such as bike lanes, paths and bicycle signals. It contributes to reducing localized urban area recurring congestion by reducing the usage of vehicles. Similar to pedestrian facilities it is difficult to predict the impact on congested facilities and should not be consider a CMS strategy for freeway congestion. The strategy could work on arterial roads.

4.2.7 Transit capital improvements

A transit capital improvements strategy is an expanded strategy from improved transit service strategy. It has new facilities adding projects such as new bus lanes, busways, and rapid transit lines. It encourages the public to use transit by increasing transit capacity, accessibility and reliability. It also contributes to reduce recurring congestion by reducing the usage of single occupancy vehicles. This type of improvement should focus on using travel demand models to predict peak and off peak travel speeds on highways.

4.2.8 Summary

The impact of modal options strategies may vary for different congestion situations. After all, many of these strategies attempt to influence public travel model choice habits. A good transit service or non-motorized vehicle modal facilities are foundations to reaching the final goal: reducing single occupancy vehicle trips. Therefore, it is difficult to make general quantitative

improvement prediction for some of these strategies. The prediction of their impact on travel speeds may use travel demand models to predict impact for some strategies. Others are difficult to predict or may not be appropriate as CMP strategies. The results could vary based upon different locations, areas, weather conditions and even local culture. Table 4-2 shows the summary of modal options strategies.

Table 4-2. Summary of modal options strategies

STRATEGIES	APPLICABILITY OF STRATEGY		PREDICTED IMPROVEMENT METHOD
	Congestion Type	Corridor Classification	
Improved Transit Service	Recurring	Freeways and arterial roads	Travel demand models
Rideshare Programs	Recurring	Freeways and arterial roads	Travel demand models
Park-and-Ride and Other Intermodal Facilities	Recurring	Freeways and arterial roads	Travel demand models
HOV and HOT Lanes	Recurring	Freeways	Travel demand models
Pedestrian Facilities and Information	Recurring	Arterial roads	Specific studies
Bicycle Facilities and Information	Recurring	Arterial roads	Specific studies
Transit Capital Improvements	Recurring	Freeways and arterial roads	Travel demand models

4.3 OPERATIONAL IMPROVEMENTS STRATEGIES

Most of these types of strategies are developed to reduce recurring congestion by increasing traffic operational efficiency. Some strategies are developed to reduce non-recurring congestion by decreasing incident reaction time and the number of stops due to traffic control devices on a facility that can impact crash frequency. This type of strategy improvement on travel times can be predicted by using specific software and models. The prediction of the impact on non-

recurring congestion due to improved safety is more difficult to predict. Also its benefits can be predicted by comparing the proposed strategy with results from similar projects since this kind of strategy is commonly used for MPOs. Sub strategies might have some differences due to different MPO situations. In this research, the sub strategies from SPC's CMP toolbox are used as examples.

4.3.1 Traffic signal improvements

A traffic signal improvements strategy is designed to reduce intersection delay and improve the level of service of intersection by upgrading signals hardware and software, changing signals timing and improving signals coordination capability. Also it can coordinate with modal options strategies, for example a transit priority traffic signal plan can reduce the delay of transit. Traffic signal improvements strategy contributes to reducing recurring congestion. Traffic simulation software and specific case studies should be used to predict for improvement. This strategy works on arterial roads. These simulation models should be used to predict travel time changes for all hours of the day to truly determine the change in each periods travel time.

4.3.2 Intersection geometric improvements

An Intersection geometric improvement strategy is developed to reduce intersection delay and improve the level of service of an intersection by optimizing intersection geometry including addition or reconfiguration of turning lanes, realignment of intersecting streets and construction of roundabouts. Also an optimal intersection geometry improvement may reduce the chance of crash frequencies. Intersection geometric improvements strategy contributes to reducing

recurring congestion. Also in some conditions it may contribute to improving non-recurring congestion. In order to study the strategy, MPOs should use traffic simulation software and specific case studies to predict reductions in travel times. A case study was performed for the intersection of Van Voorhis Road and Chestnut Ridge Road in Morgantown, West Virginia, along the WV-705 corridor. The simulation results from VISSIM showed that the roundabout design can reduce travel delay by 50% compared with the existing configuration [14]. Intersection geometric improvements strategy could work on arterial roads.

4.3.3 Elimination of bottlenecks

Elimination of bottleneck strategies are developed to reduce traffic delay by removing a physical constriction which is the most congested section of the entire corridor. It can significantly reduce the delay. It also contributes to reducing recurring and non-recurring congestion depending upon how many hours of the day the eliminated bottleneck will improve travel speeds. The prediction of its improvement should use simulation software and models to predict. It may be possible to use the Highway Capacity Manual to predict changes. Elimination of bottlenecks strategy could work on freeways and arterial roads.

4.3.4 One-way Streets

A one-way streets strategy is designed to optimize traffic flow on a regional network by establishing pairs of one-way streets instead two-way streets. This kind of strategy can reduce the influence of street width limitations in urban area. It also contributes to reducing recurring

congestion in both peak and off peak periods. In order to predict the impact of this strategy, simulation models and specific studies are needed. This strategy could work on arterial roads.

4.3.5 Reversible lanes

A reversible lanes strategy is developed to add travel lanes in the predominant direction of congestion during peak hours by using variable travel lanes system. It appropriately works for the corridor that congestion is caused by commuting traffic. It can significantly reduce the congestion in inbound direction on the AM peak hours and the congestion in outbound direction on the PM peak hours. It contributes to reduce recurring congestions on arterial roads. Traffic simulation software should be used to predict for its improvement.

4.3.6 Ramp Management

A ramp management strategy is developed to reduce the delay on freeways by controlling traffic entered flow. It can reduce the delay of vehicles traveling on freeway by maintaining relatively smooth traffic flow. However at the same time, it may increase the delay of vehicles that want to enter the freeway. Also it might increase the delay of vehicles traveling on the arterial roads that connect to freeways. It contributes to reducing recurring congestion and non-recurring congestion on freeways. In terms of its improvement impacts, traffic simulation software and models should be used to predict them. A study obtained many years of before and after field data from Auckland, New Zealand for a Sydney Coordinated Adaptive Traffic System Ramp Metering System project. It demonstrated that an average of 25% decrease in congestion duration

as well as increase in traffic speed is achieved and a total of 22% reduction in crashes is achieved [15].

4.3.7 Incident management systems

An incident management systems strategy is developed to reduce the incident reaction time and incident solution time by building traffic incident management system and team for detecting crashes, disabled vehicles and other incidents that impede travel. It contributes to reducing non-recurring congestion. Its improvement can be accomplished by using specific studies of other systems or studying crash data and evaluating the reduction in the response time to crashes and how that may impact the time of congestion during a crash event. It is typically applied to freeways.

4.3.8 Access management

An access management strategy is developed to reduce delay on arterial roads by minimizing the number of driveways and intersections. It is similar to the ramp management on freeways. Its improvement could be estimated by using traffic simulation software and models to predict.

4.3.9 Intelligent transportation systems

An Intelligent transportation systems (ITS) strategy is developed to reduce delay on freeways and arterial roads by using ITS equipment such as adaptive traffic signal control, operational monitoring systems and dynamic message signs. It makes information flow more efficiently. The

operational managers can receive information on roadways' real-time operational situations, and also the travelers can get real-time travel information. It makes the transportation facilities more intelligent: the transportation facilities can exchange information with travelers and managers on both recurring and non-recurring congestion. There are a large number of traffic signal improvements strategy, reversible lanes strategy, ramp management strategy and incident management systems strategy projects are regarded as ITS strategy projects. Therefore an ITS strategy contributes to reducing recurring congestion and nonrecurring congestion both on freeways and arterial roads. Its improvement can be difficult to predict using traffic simulation software and models. Before and after studies of specific ITS strategies may be the only method to predict impacts on travel times.

4.3.10 Summary

The impacts of some traffic operational strategies are easy to predict. Also there are traffic simulation software, models and case studies related to it. Therefore, its improvement can be predicted accurately on a small range based upon the specific corridor. Table 4-3 shows the summary of traffic operational strategies.

Table 4-3. Summary of traffic operational strategies

STRATEGIES	APPLICABILITY OF STRATEGY		PREDICTED IMPROVEMENT METHOD
	Congestion Type	Corridor Classification	
Traffic Signal Improvements	Recurring	Arterial roads	Traffic simulation software
Intersection Geometric Improvements	Recurring	Arterial roads	Traffic simulation software
Elimination of Bottlenecks	Recurring	Freeways and arterial roads	Traffic simulation software and models
One-Way Streets	Recurring	Arterial roads	Traffic simulation software and models
Reversible Lanes	Recurring	Arterial roads	Traffic simulation software
Ramp Management	Recurring	Freeways	Traffic simulation software and models
Incident Management Systems	Non-recurring	Freeways and arterial roads	Specific studies
Access Management	Recurring	Arterial roads	Traffic simulation software and models
Intelligent Transportation Systems	Recurring and non-recurring	Freeways and arterial roads	Specific studies

4.4 CAPACITY ADDING PROJECTS STRATEGIES

This type of strategy is developed to reduce recurring congestion by increasing roadway network capacity. This type of strategy is the last choice for many MPOs if the level of congestion is still unacceptable after travel demand reducing and roadway operational efficiency actions are used. Capacity projects strategies improvements can be predicted by using traffic simulation software and Highway Capacity Manual. Its improvement can be easily obtained once a capacity projects strategies project finished. Sub strategies might have some differences due to different MPO situations. In this research, the sub strategies from SPC's CMP toolboxes are used.

4.4.1 Lane additions

A lane additions strategy is developed to increase the roadway capacity by adding new travel lanes on an existing roadway. It contributes to reducing recurring congestion on freeways and arterial roads. Its improvement can be estimated by using traffic simulation software and Highway Capacity Manual to predict travel time changes, however both peak and off peak periods should be studied.

4.4.2 New single occupancy vehicle facilities

A new single occupancy vehicle facilities strategy is developed to increase the roadway network capacity by building new roadways and freeways. It contributes to reducing recurring congestion on freeways and arterial roads by diverting trips from congested highways in the system. Its improvement can be accomplished by using traffic simulation software and travel demand models to predict impacts.

4.4.3 Summary

The impacts of road capacity projects can be obvious and direct as long as there is a suitable situation to implement them. The lane addition strategy's impact could be predicted. For example, it might attract more trips after its travel times are reduced resulting in increasing traffic congestion. Also additional lanes might influence traffic flow efficiency since more merging and dividing could happen. Any new single occupancy vehicle facilities strategy needs

to consider impacts on an entire regional roadways network. Table 4-4 shows the summary of road capacity projects strategies.

Table 4-4. Summary of road capacity projects strategies

STRATEGIES	APPLICABILITY OF STRATEGY		PREDICTED IMPROVEMENT METHOD
	Congestion Type	Corridor Classification	
Lane Additions	Recurring	Freeways and arterial roads	Traffic simulation software and Highway Capacity Manual
New SOV Facilities	Recurring	Freeways and arterial roads	Traffic simulation software and travel demand models

4.5 SUMMARY

Table 4-5 shows the summary of four types of strategies. For demand management strategies, the travel demand models and specific studies could be used to predict the improvements, the general improvement could be 10-30%. For modal options strategies, the travel demand models and specific studies could be used to predict the improvements, the general improvement could be 5-30%. For operational improvements strategies, the traffic simulation software, models and specific studies could be used to predict the improvements, the general improvement could be 5-40%. For capacity projects strategies, the travel demand models, traffic simulation software and Highway Capacity Manual could be used to predict the improvements, the general improvement could be 40-100%.

Table 4-5. Summary of four types of strategies

Categories	IMPROVEMENT PREDIECTION METHOD	GENERAL PREDICTED IMPROVEMENT IN REDUCTION OF HOURS OF CONGESTION
Demand Management	Travel demand models and specific studies	10-30%
Modal Options	Travel demand models and specific studies	5-30%
Operational Improvements	Traffic simulation software and specific studies	5-50%
Capacity Projects	Travel demand models, traffic simulation software and Highway Capacity Manual	40-100%

5.0 TESTING THE METHODOLOGY

In this chapter, methodology was tested at two SPC's CMP corridor: Corridor 5 I-376, Parkway West and Corridor 31 I-376, Parkway East. This evaluation was conducted to illustrate how the methodology might be applied to select strategies and predict the change in the indices.

5.1 BACKGROUND OF TESTING CORRIDORS

5.1.1 Parkway West

The Parkway West section being studied is a section of I-376 (Interstate 376) from I-79 (Interstate 79) to Ft. Pitt Bridge. The figure 5-1 shows the aerial map of Parkway West being studied section. According to SPC travel time reliability data, the worst direction is eastbound/inbound, which has 77.3% (average of 2012, 2013 and 2014 annual values) of annual posted speed reliability index and 82.1% (average of 2012, 2013 and 2014 annual values) of annual expected travel time reliability index [16] [17] [18]. For that direction of travel, the AM peak hour traffic volume from the Banksville interchange to PA-51 interchange is the maximum, which is 5,590 vehicles with a truck percentage of 5%; the PM peak hour traffic volume from Banksville interchange to PA-51 interchange is also the maximum, which is 4,620 vehicles, and a truck percentage of 5%. This section has three travel lanes in each direction with merging and

diverging rid ramps. For the eastbound/inbound direction, the AM peak hour traffic volume in the Fort Pitt Tunnel is 4,750 vehicles with 5% truck percentage; the PM peak hour traffic volume in the Fort Pitt Tunnels is 3,560 vehicles with 5% trucks [19]. This section has two travel lanes in each direction. The Fort Pitt Tunnels section of Parkway West eastbound/inbound direction is the most congested segment of the CMP corridor. The ramp density of that section is 1.7 ramps per mile for the total corridor.

There are 6 routes of SPC's vanpool program that use the Parkway West. [16] There are 12 public transit routes that travel in the corridor that residents may use for the Parkway West to commute, two of the routes use Fort Pitt Tunnels to reach downtown Pittsburgh. Other bus routes use the West Busway or local roads to reach downtown [21].

There are also several traffic incident management teams serving this corridor [22].

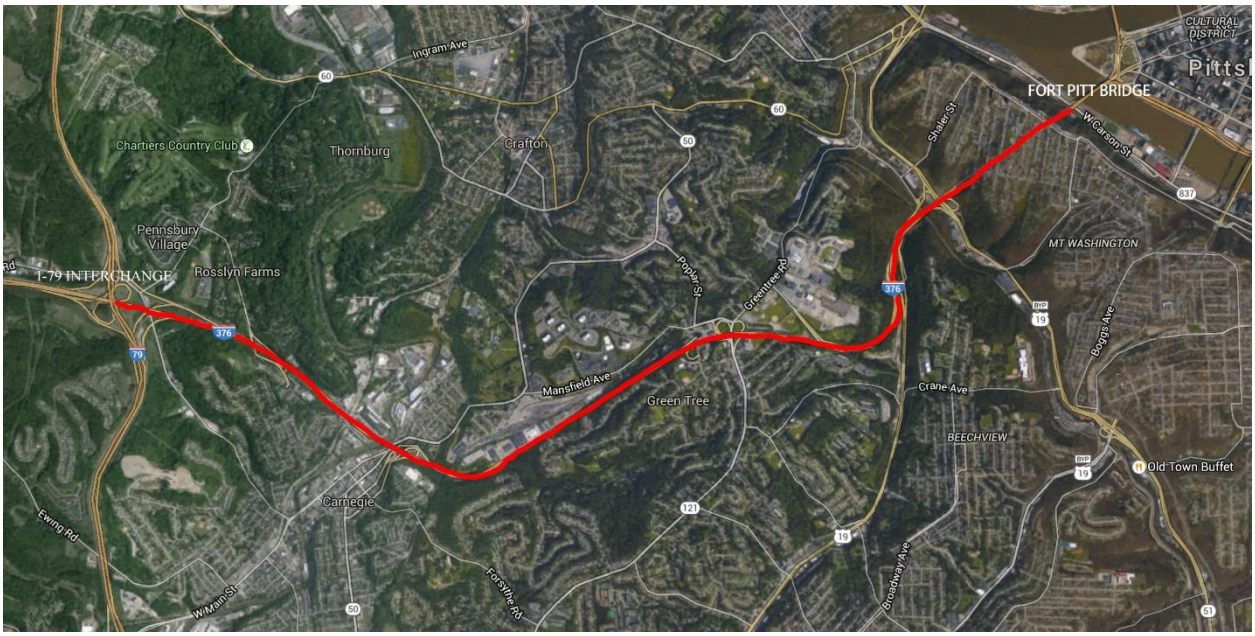


Figure 5-1. Aerial map of Parkway West being studied section

5.1.2 Parkway East

The Parkway East section being studied is a section of I-376 (Interstate 376) from the Fort Pitt Bridge to I-76 (Interstate 76). The figure 5-2 shows the aerial map of Parkway East being studied section. According to SPC travel time reliability data, the worst direction is westbound/inbound, which has 91.1% (average of 2012, 2013 and 2014 annual values) annual posted speed reliability index and 85.7% (average of 2012, 2013 and 2014 annual values) annual expected travel time reliability index [23] [24] [25]. For that direction, the AM peak hour traffic volume from the Squirrel Hill interchange to the PA-885 interchange is the maximum, which is 5,991 vehicles; the PM peak hour traffic volume from Squirrel Hill interchange to PA-885 interchange has a maximum volume of 4,646 vehicles. This section has three travel lanes in each direction with merging and diverging rid ramps. For the eastbound/inbound direction, the AM peak hour traffic volume in the Squirrel Hill Tunnel is 4,316 vehicles; the PM peak hour traffic volume in Squirrel Hill Tunnels is 3,594 vehicles [26]. This section has two travel lanes in each direction. The Squirrel Tunnels section of Parkway East in the eastbound/inbound direction is the most congested.

There are 7 routes of SPC's vanpool program that use the Parkway East [20]. There are 27 public transit routes that cover the area that residents may use Parkway East to commute, none of the routes use Squirrel Hill Tunnels to reach downtown or Oakland. All of them use East Busway or local roads to reach downtown or Oakland [21].

There are several traffic incident management teams also serve this corridor [22].

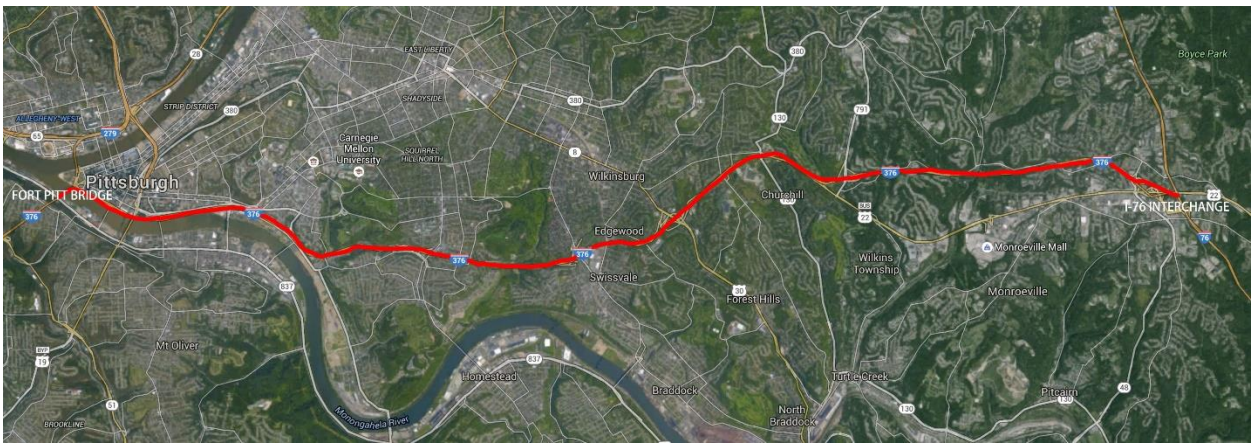


Figure 5-2. Aerial map of Parkway East being studied section

5.2 TESTING OF SELECTING STRATEGIES PROCESS MODEL

5.2.1 Parkway West

First step: identify corridor categories. The Parkway West is urban freeway. Pedestrian facilities and information, bicycle facilities and information, traffic signal improvements, one-way streets, reversible lanes and access management strategies can be exempted from consideration due the nature of the strategies.

Second step: identify the majority congestion type. The posted speed reliability index is 77.3% and the expected travel time reliability index is 82.1% (Data was obtained from Section 5.1.1). The posted speed reliability index is 4.8% lower than expected travel time reliability index. Therefore, the majority of congestion of this corridor is recurring congestion. The expected travel time reliability index is lower than 95%, which indicates that the non-recurring

congestion also needs to be reduced. This means that every strategy that can be implemented to freeways should be considered.

Third step: identify possible congestion factors. For recurring congestion, the demand capacity is higher than the existing roadway capacity. For non-recurring congestion, short periods could be the result of car crashes and special events.

Fourth step: select candidate strategies. For recurring congestion, a congestion pricing strategy may have little benefit in this corridor. This is because there is no alternative freeway for commuting travelers. HOV and HOT lanes strategies also cannot be implemented because some sections of this corridor are only two-lanes in one direction. Other demand management and modal options strategies may not have much influence because the region for this corridor is a well-developed region and vanpool and public transit service is already provided for the residents that use this corridor to commute. Therefore, the strategies that should be considered are operational improvements strategies. Ramp management, intelligent transportation systems and elimination of bottlenecks are three candidate strategies for recurring congestion. For non-recurring congestion, incident management systems strategy may not have much impact because there are traffic incident teams already serving this corridor. Intelligent transportation systems strategies appear to be efficient candidate strategy.

Fifth step: predict improvement. In selecting strategies for the process model, the general improvement is use strategies that improvement are not too complex to predict. For recurring congestion, ramp management strategy could reduce 20% of the delay. ITS strategy could reduce 10% delay (General number from Table 4-5 was used). Elimination of bottlenecks is another strategy, in this corridor, which is to build additional travel lane in Fort Pitt Tunnels. The free flow speed and base capacity methods in the Highway Capacity Manual [27] can be used to

calculate impacts of eliminating the bottleneck. For the Fort Pitt Tunnels section, the free flow speed is 60 mph; the base capacity is 2,300 pc/h/ln (passenger cars per hour per lane). The free flow capacity could use the equations from the Life-Cycle Cost Analysis Procedures Manual [28] to calculate improved flow conditions. For the Fort Pitt Tunnels section, the free flow capacity is 2,100 pc/h/ln. The capacity with three lanes would be 6,300 pc/h. It is larger than the demand capacity, which is 4,750 pc/h. Therefore, the elimination of the bottlenecks strategy could address the recurring congestion. For non-recurring congestion, intelligent transportation systems strategies could reduce 40% delay.

Sixth step: determine optimize the strategy. For recurring congestion, the priorities of the strategies based on their effectiveness should be elimination of bottlenecks strategy, ramp metering strategy and ITS strategy. For non-recurring congestion, the optimum strategy is the ITS strategy. The results are shown in Table 5-1.

Table 5-1. The candidate strategies result of Parkway West

Congestion type	Strategy	Predicted improvement in reduction of hours of congestion
Recurring	Elimination of bottlenecks	100%
Recurring	Ramp metering	20%
Recurring	ITS	10%
Non- recurring	ITS	40%

5.2.2 Parkway East

First step: identify corridor categories. The Parkway East is urban freeway. Pedestrian facilities and information, bicycle facilities and information, traffic signal improvements, one-way streets, reversible lanes and access management strategies could be exempted.

Second step: identify majority congestion. The posted speed reliability index is 91.1% and the expected travel time reliability index is 85.7% (Data was obtained from Section 5.1.2). The expected travel time reliability index is 5.4% lower than posted speed reliability index. Therefore, the majority congestion of this corridor is non-recurring congestion. The posted speed reliability index is lower than 95%, which indicates that the recurring congestion also needs to be reduced. This means that every strategy that can be implemented to the freeways should be considered.

Third step: identify possible congestion factors. For non-recurring congestion, short periods may include car accidents and special events. For recurring congestion, the demand capacity is higher than the existing roadway capacity.

Fourth step: select candidate strategies. Similar to the Parkway West conditions for non-recurring congestion, incident management systems strategies may not have much impact because there are some traffic incident teams serving this corridor already. Intelligent transportation systems strategy appears to be the efficient candidate strategy. For recurring congestion, congestion pricing strategy, HOV and HOT lanes, demand management and modal options are not viable similar to the Parkway West conditions. Therefore, the strategies that should be considered are operational improvements strategies. Because the majority congestion of this corridor is non-recurring congestion and the recurring congestion is not really serious, elimination of bottlenecks strategy should not be considered as it needs a large amount of

funding to implement. Ramp management and intelligent transportation systems are two candidate strategies for recurring congestion.

Fifth step: predict improvement. For non-recurring congestion, intelligent transportation systems strategies could reduce 40% of the delay. For recurring congestion, there is a ramp management study of the Parkway East conducted in 2011 [26], it indicated that during the AM peak hours the travel time in westbound/inbound could reduce delays by 334 seconds, which is about a 40% reduction of delay. ITS strategies could reduce the delay by 10%.

Sixth step: determine optimize strategy. For non-recurring congestion, the optimum strategy is the ITS strategy. For recurring congestion, the priorities should be the ramp metering strategy and the ITS strategy. The results are shown in Table 5-2.

Table 5-2. The candidate strategies result of Parkway East

Congestion type	Strategy	Predicted improvement in reduction of hours of congestion
Recurring	Ramp metering	40%
Recurring	ITS	10%
Non- recurring	ITS	40%

5.3 TESTING OF CALCULATING PREDICTED INDICES MODEL

5.3.1 Parkway West

The first step: calculate daily congestion period. For recurring congestion, it is 5.4 hours. For non-recurring congestion, it is 4.3 hours (Use the equations in Table 3-2 to calculate).

The second step: obtain the predicted improvement of each candidate strategy. The predicted improvement is obtained from Table 5-1.

The third step: calculate remaining daily congestion period. The results are shown in Table 5-3.

Table 5-3. The remaining daily congestion hours of Parkway West

Congestion type	Strategy	Remaining daily congestion hours
Recurring	Elimination of bottlenecks	0 hour
Recurring	Ramp metering	4.3 hours
Recurring	ITS	4.9 hours
Non- recurring	ITS	2.6 hours

The fourth step: calculate predicted indices. The results are shown in Table 5-4.

Table 5-4. Predicted indices of Parkway West

Congestion type	Strategy	Current indices	Predicted indices
Recurring	Elimination of bottlenecks	77.3%	100%
Recurring	Ramp metering	77.3%	82.1%
Recurring	ITS	77.3%	79.6%
Non- recurring	ITS	82.1%	89.2%

5.3.2 Parkway East

The first step: calculate daily congestion period. For recurring congestion, it is 2.1 hours. For non-recurring congestion, it is 3.4 hours (Use the equations in Table 3-2 to calculate).

The second step: obtain predicted improvement for each candidate strategy. The predicted improvement are obtained from Table 5-2.

The third step: calculate remaining daily congestion period. The result is shown in Table 5-5.

Table 5-5. The remaining daily congestion hours of Parkway East

Congestion type	Strategy	Remaining daily congestion hours
Recurring	Ramp metering	1.3 hours
Recurring	ITS	1.9 hours
Non- recurring	ITS	2.1 hours

The fourth step: calculate predicted indices. The result is shown in Table 5-6.

Table 5-6. Predicted indices of Parkway East

Congestion type	Strategy	Current indices	Predicted indices
Recurring	Ramp metering	91.1%	94.8%
Recurring	ITS	91.1%	92.1%
Non- recurring	ITS	85.7%	91.3%

5.4 SUMMARY

As all results have shown, the ITS strategy is the optimized strategy that could be implemented for the section of I-376 from I-79 to I-76 to solve the non-recurring congestion problem. The elimination of bottlenecks strategy (lane addition strategy) is the optimized strategy that could be

implemented for the Parkway West to solve the recurring congestion issues. The ramp metering strategy is the optimized strategy that could be implemented for the Parkway East to solve the recurring congestion issues. Because they all have the bigger impact on the index.

6.0 SUMMARY AND CONCULTIONS

This chapter summaries the survey results, the development of the two models and states the viewpoint on the future research for this topic.

6.1 SUMMARY OF RESULTS

6.1.1 Review of MPOs survey results

In order to obtain data from MPOs of how they select CMP strategies and predict strategies' improvement, a survey was distributed to MPOs. In summary, the survey results indicated that most of the MPOs have a process for selecting strategies based on committee and staff recommendations; some of them select strategies by predicting strategies' improvement; the most common method is that they predict strategies' improvement through simulation models; few of them use travel time reliability data during selection process.

6.1.2 Review of selecting strategies and calculating predicted indices model

Based on the survey results and the travel time reliability data that SPC has, the selecting CMP strategies model was developed. From the survey results, a complex process to select strategies is

not an appropriate model for MPOs since the method they current use is are committees and staff recommendations. This research developed a methodology of selecting strategies process that provides some logic to screen alternatives. The travel time reliability data is also included in the model to classify congestion type. For the improvement prediction section of the model, the hourly reductions in delay can be obtained from simulation models, software and detailed studies, which should be accurate. However for some improvements planners can also use a general number or range of numbers to predict reductions in delays.

The calculating predicted indices model was developed to estimate the change of two indices that SPC uses. The equations were developed based on the definition of these two indices. The inputs for the equations were obtained from the selecting CMP strategies model and SPC existing indices.

In summary, these two models are an improvement on current methods that are using committee and staff recommendations to selecting strategies and do not consider the type of congestion for which the strategies should address. The models developed in this research are qualitative and quantitative combined models.

6.2 CONCLUSIONS

The hypothesis that a methodology can be developed for the prediction of the improvement of travel reliability and can be used as a sketch planning or screening tool to select congestion management strategies and project types in the project planning process was confirmed by the development of the selecting CMP strategies model and calculating predicted indices model. These two models also can be regarded as a guidelines for MPOs to identify and select CMP

strategies and projects. They are well combined with the existing methods that MPOs currently use.

6.3 FUTURE RESEARCH

Based upon this research and the limitations in this research, there are several recommendations that the researcher provides.

First, the number of characteristic that describe a corridor could be expanded. In this research, there were only roadway classifications used. If more characteristics of a corridor be identified such as percent of travel via alternative modes there could be more screening of strategies.

Second, the threshold of acceptable travel time reliability data could be conducted by more some detail studies. For example, what is the acceptable change in an index for a strategy to acceptable or what index defines the need to consider any strategy.

Thirdly, the predicting improvement impacts of strategies could be more accurate. For example, the general predicted improvement could be more accurate by classifying all similar studies and completed projects in a data base that could be used for specific corridor characteristics. It could make the process more accurate.

Fourthly, the thesis is focus on roadway travel time reliability, other modes reliability such as transit reliability could also be considered.

Finally, the two models developed in this researcher do not incorporate the cost-benefit analysis in the methodology. The costs and benefits of each strategy could be considered in the selecting strategies model.

APPENDIX A

MPO SURVEY AND RESULT

In this chapter, the MPO survey and result are presented.

A.1 MPO SURVEY

The whole survey is presented.

Email Request:

The selection of different strategies during the Congestion Management Process (CMP) for a specific corridor by a Metropolitan Planning Agency (MPO) can be very important step in the project development process. The selection and prediction of strategies and improvements using simple sketch planning methods based on travel time reliability data would be a useful tool. The purpose of this research is to develop methods of selecting strategies during the CMP by using available data for MPOs such as travel time reliability data. Please follow this link to take a survey to help identify how the selection of projects is made currently to assist in the development of planning methods using travel time reliability data. Participation is voluntary and

all responses will be confidential. Responders will not be identified in the results. There will be no payment for participating.

Survey Introduction:

Because travel time reliability data in most urban areas is now available using this information to predict future performance of specific types of congestion mitigation strategies may be possible. This survey has been developed to help identify agencies' experience with issues and solutions on the selection and prediction of strategy and improvements during the congestion management process (CMP).

Please complete this survey if you or your agency has experience with these types of projects that involved the selection of different strategies during the CMP strategy selection process or phase. If you feel that you are not the appropriate person to complete the survey please forward this request to the most appropriate person in your agency or DOT. Thanks for your assistance.

Screening Questions

1) What is your position?
   A. State DOT Engineer/ Planner
   B. MPO Engineer/ Planner
   C. Other _____

2) Have you been involved in developing solutions and projects that relate to congestion issues identified in the Congestion Management Process CMP?
   A. Yes
   B. No (If no end survey)

3) Did the solutions or projects you were involved with have a formal institutional process for selecting different strategies based on the CMP?
   A. Yes (Go to question 4)
   B. No, however our MPO does select strategies on a project by project basis based on the CMP data (Go to question 5)
   C. No, we do not select projects based on the CMP data (If no end survey)

Selecting Strategies Questions

4) What institutional process did you use for selecting different strategies for a specific project to address a CMP issue? (multiple selections)

   A. Based on staff recommendations
   B. MPO or DOT committee
   C. Public involvement process
   D. Predicting strategy impact for an improvement
   E. Other, please simply describe:
   If choice was D, go to question 6. Otherwise, please go to question 7.

5) What process did you use for selecting different strategies for an individual project to address a CMP issue? (multiple selections)

   A. Based on staff recommendations
   B. MPO or DOT committee
   C. Public involvement process
   D. Predicting strategy impact for an improvement
   E. Other, please simply describe:
   If choice was D, go to question 6. Otherwise, please go to question 7.

6) How did you predict the impact of each candidate strategy?
   A. Based on results from a planning or simulation model
   B. A detailed study of alternative strategies impacts for the corridor
   C. Based on results from similar projects that have been implemented
   D. Determined the impact on travel time reliability data (if Yes to go question 8)

E. No specific method was used-based on experience of staff or a committee
F. Other, please simply describe:

7) What issues, if any, were identified during the evaluation of multiple strategies for a specific problem or corridor? (multiple selections)

A. There was only one suitable strategy therefore the solution was obvious
B. The evaluation of diverse strategies is too complex for analysis therefore only a qualitative evaluation can be performed
C. The expected improvement prediction using available tools is not anticipated to be accurate
D. None, the process is adequate for the needs
E. Other, please simply describe:

Using Travel Time Reliability Data Questions

8) How did your agency use travel time reliability data to select a strategy? (multiple selections)
A. Quantifying the current level of congestion
B. Ranking corridors based upon an index of congestion, using the time reliability data
C. Predicting the reduction in the congestion using the data , if this is done please describe how the data is used _____
D. Using as a travel time reliability index to predict the strategy results and the resultant change in the index, if this is done please describe how the prediction is done _____
E. Other, please simply describe:

If you have a report or method that you have developed to use this data please attach a document or provide a link

Thank you for completing the survey, if you have any questions please contact Dr. Mark Magalotti, University of Pittsburgh mjm25@pitt.edu

A.2 SURVEY RESULT INITIAL REPORT

The survey result initial report is presented.

Initial Report

Last Modified: 02/20/2016

1. What is your position?

Answer	Response	%
A. State DOT Engineer/ Planner	0	0%
B. MPO Engineer/ Planner	40	98%
C. Other	1	2%
Total	41	100%

C. Other
B

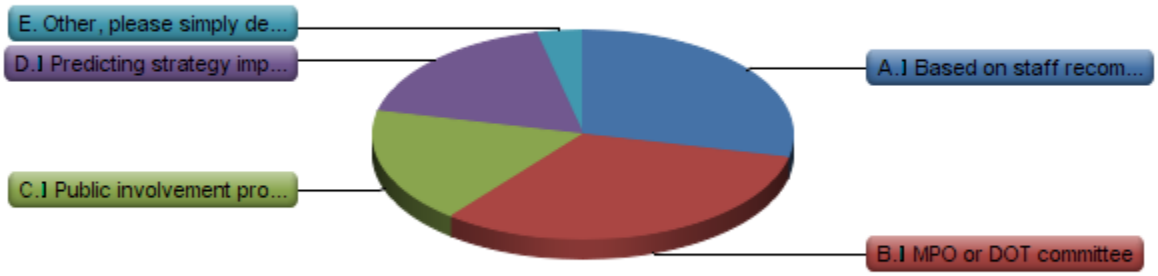
2. Have you been involved in developing solutions and projects that relate to congestion issues identified in the Congestion Management Process CMP?

Answer	Response	%
A. Yes	40	98%
B. No	1	2%
Total	41	100%

3. Did the solutions or projects you were involved with have a formal institutional process for selecting different strategies based on the CMP?

Answer	Response	%
A. Yes	15	38%
B. No, however our MPO does select strategies on a project by project basis based on the CMP data	15	38%
C. No, we do not select projects based on the CMP data	9	23%
Total	39	100%

4. What institutional process did you use for selecting different strategies for a specific project to address a CMP issue? (Multiple selections)

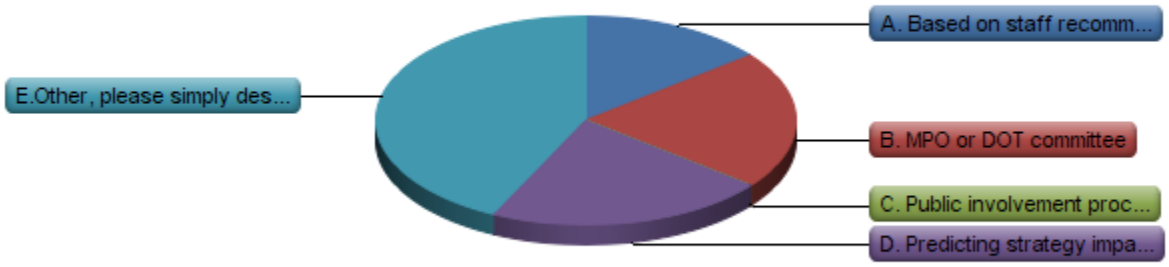


Answer	Response	%
A. Based on staff recommendations	8	57%
B. MPO or DOT committee	9	64%
C. Public involvement process	5	36%
D. Predicting strategy impact for an improvement	5	36%
E. Other, please simply describe:	1	7%

E. Other, please simply describe:
New TMA. CMP in place, but has not been utilized in new MTP yet.

Statistic	Value
Total Responses	14

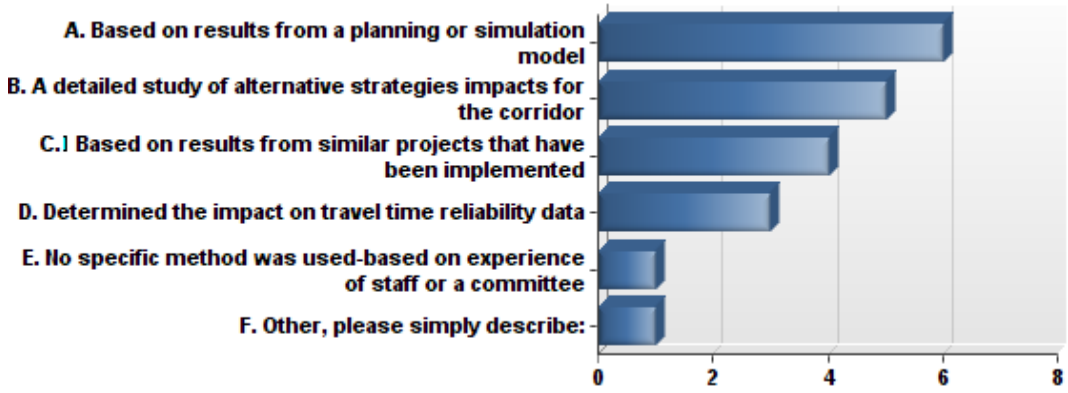
5. What process did you use for selecting different strategies for an individual project to address a CMP issue? (Multiple selections)



Answer	Response	%
A. Based on staff recommendations	2	14%
B. MPO or DOT committee	3	21%
C. Public involvement process	0	0%
D. Predicting strategy impact for an improvement	3	21%
E. Other, please simply describe:	6	43%
Total	14	100%

E. Other, please simply describe:
we had a scoring process delineated in our CMP
A, B, C, E and E: Regional Best Practices
a combination of A, B and D
We use of Project Prioritization Process Guidebook which incorporates CMP attributes.
Recently developed first CMP. Have not used CMP yet. Doing CTP update now.
All of the above

6. How did you predict the impact of each candidate strategy? (Multiple selections)



Answer	Response	%
A. Based on results from a planning or simulation model	6	75%
B. A detailed study of alternative strategies impacts for the corridor	5	63%
C. Based on results from similar projects that have been implemented	4	50%
D. Determined the impact on travel time reliability data	3	38%
E. No specific method was used-based on experience of staff or a committee	1	13%
F. Other, please simply describe:	1	13%

F. Other, please simply describe:
varies on a project-by-project basis

Statistic	Value
Total Responses	8

7. What issues, if any, were identified during the evaluation of multiple strategies for a specific problem or corridor? (Multiple selections)

Answer	Response	%
A. There was only one suitable strategy therefore the solution was obvious	3	12%
B. The evaluation of diverse strategies is too complex for analysis therefore only a qualitative evaluation can be performed	4	15%
C. The expected improvement prediction using available tools is not anticipated to be accurate	3	12%
D. None, the process is adequate for the needs	13	50%
E. Other, please simply describe:	5	19%

E. Other, please simply describe:
CMP strategies are oftentimes more programmatic or operational in nature - MPO funding does not align with these needs or responsibilities
we consult with CMP when preparing our LRTP and considering projects
See previous answer.
Most major corridor investments or investment strategies are both multi modal and dependent on operational management.
Haven't used it yet.

Statistic	Value
Total Responses	26

8. How did your agency use travel time reliability data to select a strategy? (Multiple selections)

Answer	Response	%
A. Quantifying the current level of congestion	2	67%
B. Ranking corridors based upon an index of congestion, using the time reliability data	2	67%
C. Predicting the reduction in the congestion using the data, if this is done please describe how the data is used:	1	33%
D. Using as a travel time reliability index to predict the strategy results and the resultant change in the index, if this is done please simply describe how the prediction is done:	1	33%
E. Other, please simply describe:	0	0%

Statistic	Value
Total Responses	3

9. If you have a report or method that you have developed to use this data please attach a document or provide a link. Attach a document: (If not, just click next button)

File Upload	File Type	File Size

Statistic	Value
Total Responses	0

10. If you have a report or method that you have developed to use this data please attach a document or provide a link. Provide a link:

Text Response
http://www.gtcmpo.org/Docs/PlansStudies/CMP-Final%20Report%20(062813).pdf

Statistic	Value
Total Responses	1

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