Congestion Management Process Update

prepared for

Houston-Galveston Area Council

prepared by

Cambridge Systematics, Inc.

with

Alliance Transportation Group

January 2015

report

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Table of Contents

List of Tables

List of Figures

Executive Summary

WHAT IS THE CONGESTION MANAGEMENT PROCESS?

The Congestion Management Process (CMP) is a systematic process of identifying congestion and its causes, applying congestion mitigation strategies to improve transportation system performance and reliability, and evaluating the effectiveness of implemented strategies. All metropolitan areas with populations greater than 200,000 residents, known as Transportation Management Areas (TMAs), are required by the *Moving Ahead for Progress in the 21st Century (MAP-21) Act* to develop a CMP.

The CMP is required to include the following elements:

- Performance measures to monitor and evaluate recurring and nonrecurring congestion;
- Definition of congestion management objectives;
- Establishment of data collection and system performance monitoring efforts;
- Identification of anticipated performance and benefits of congestion management strategies;
- Identification of an implementation schedule, responsibilities, and potential funding sources for strategies; and
- A process for periodic assessment of the effectiveness of implemented strategies, in terms of established performance measures.

Consistent with the 2040 Regional Transportation Plan (RTP) Update, the goals of the CMP are to:

- Reduce the rate and severity of crashes for all system users;
- Improve transportation system reliability across all modes and systems of travel in the region;
- Reduce the impacts of incidents on traffic flow;
- Increase opportunities for travelers to use regional and local transit services and participate in Transportation Demand Management (TDM) programs to provide more travel choices;
- Improve system operational efficiency and accessibility to accommodate freight movement within the region; and
- Reduce emissions through congestion management.

Due to expected future population and employment growth trends in the region, it is not feasible to completely eliminate transportation system congestion through implementation of the CMP. Rather, the expectation is for the CMP to provide a framework of tools and processes to better manage transportation system congestion into the future through strategies, projects, and programs to implement a comprehensive set of transportation demand management (TDM), transportation system management (TSM), operations/ITS, transit, and pedestrian and bicycle strategies.

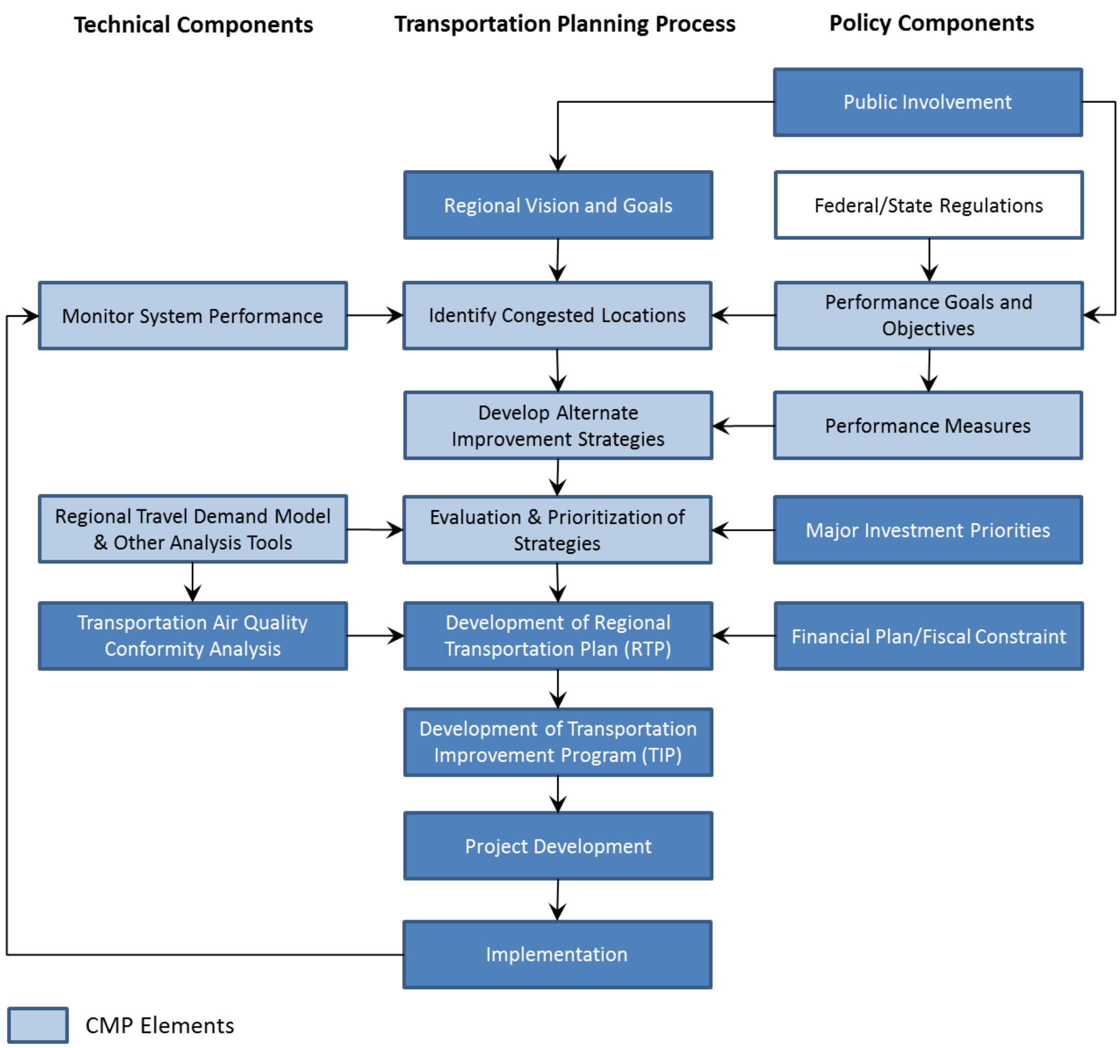
The CMP is an integral part of the metropolitan transportation planning process and defines a process for programming and implementing congestion management strategies either independently or as part of larger programs and projects programmed in H-GAC's Regional Transportation Plan (RTP) and Transportation Improvement Program (TIP). Figure ES.1 shows how the CMP is integrated into various technical and policy components of the transportation planning process:

- The RTP's vision statement and goals provide a foundation for the development of congestion management objectives and performance measures that are applied through the CMP.
- The CMP provides information the location, duration, and extent of congestion, which can be used by H-GAC and its planning partners to identify congested corridors or segments in need of detailed analysis as part of Corridor or Major Investment Studies.
- The CMP Toolbox provides a framework for developing and evaluating transportation projects and strategies that maintain or reduce recurring and non-recurring congestion. It also suggests analysis tools such as travel demand modeling, corridor analysis, and traffic simulation to assess how congestion mitigation strategies contribute to achieving regional goals and objectives related to congestion management.
- The CMP defines a process for programming and implementing the most cost-effective strategies by introducing them into the RTP process and subsequently for programming into the TIP. The CMP does not directly obligate funds, but rather it presents a toolbox of congestion mitigation strategies that can be implemented independently or as part of larger projects and programmed in future RTPs and TIPs.
- Since the Houston-Galveston transportation management area is in nonattainment for National Ambient Air Quality Standards, federal funds may not be programmed for projects that result in a significant increase in carrying capacity for single-occupant vehicles (SOV), unless the project is addressed in the region's CMP. Therefore, a CMP analysis must be conducted to assess how capacity expansion projects will reduce congestion. Congestion mitigation strategies are evaluated as an alternative to the added capacity improvement. If operational management strategies are shown to be insufficient with regard to congestion reduction and the additional SOV

capacity is warranted, then the CMP must be used to identify strategies to manage the SOV facility safety and effectively.

- Once projects are implemented, the CMP provides a mechanism for ongoing system monitoring, both to assess the performance of the system and to evaluate the effectiveness of the congestion management strategies that have been implemented.

Figure ES.1 Integration of the Congestion Management Process in the Transportation Planning Process



Source: Adapted from *The Transportation Planning Process: Key Issues - A Briefing Book for Transportation Decisionmakers, Officials, and Staff*, Updated September 2007, Publication No. FHWA-HEP-07-039, http://www.planning.dot.gov/documents/BriefingBook/BBook.htm

HOW IS CONGESTION MEASURED?

Multimodal performance measures are used in H-GAC's CMP to understand congestion problems, assess potential solutions, and monitor the effectiveness of implemented congestion management strategies. The initial set of recommended performance measures are shown in Table ES.1. The CMP Update report includes a performance monitoring plan for acquiring, analyzing, and monitoring the data needed to implement these multimodal performance measures.

Table ES.1 Initial Recommended CMP Performance Measures

	Tier Categories of Performance Measures		
Goal Area	Tier 1	Tier 2	Tier 3
Safety	• Traffic, bus, rail crash rate per VMT	• Same as RTP Measure	• Traffic, bus, rail crash severity
Congestion	• Planning time index (80th, 95th percentile)	• Lane-miles severely congested on highways • Traveler hours of delay on highways	• Percent lane-miles severely congested on arterials • Traveler hours of delay on arterials
Asset Management & Operations	• Incident clearance time on highways	• Same as RTP Measure	• Incident clearance time on arterials
Accessibility	• N/A	• Percent of population and jobs with access to transit (within one-quarter mile) • Percent of freight terminals/intermodal facilities (air, rail, truck cargo) located within 5 miles of a freeway	• N/A
Economic Competitiveness	• Total truck congestion costs relative to commodity value • Commute split	• See measures above for Accessibility	• Benefit/cost analysis
Natural/Cultural Resources	• Ground level ozone levels	• PM 2.5 Emissions	• GHG Emissions

The CMP Update report includes an analysis of congestion problems and needs in the Houston-Galveston region with a focus on the following congestion and operations related performance measures: change in travel times; average incident clearance time; travel time index; and percent of time with average speeds below 30 mph, 40 mph and 50 mph.

CONGESTION MANAGEMENT STRATEGIES

One of the key components of the CMP is to identify a set of recommended solutions to effectively manage congestion and achieve regional congestion management goals and objectives. Selecting appropriate strategies requires an understanding of the nature of the need and current operating characteristics of the system/corridor/project location, as well as their ability to support regional congestion management objectives, meet local context and relevance, contribute to other regional goals and objectives, and jurisdictional responsibility for implementing the strategies.

A CMP Toolbox was developed to provide a framework for identifying and evaluating transportation projects, programs, and strategies that maintain or reduce recurring and non-recurring congestion. The toolbox identifies a variety of potential strategy types, as well as relevant performance measures and analysis tools to assess how congestion mitigation strategies contribute to achieving regional goals and objectives related to congestion management. The following nine categories of congestion management strategies are included in the CMP Toolbox:

1. **Transportation Demand Management (TDM) Strategies**, such as alternative work hours, telecommuting, ridesharing, road pricing, and toll roads, that eliminate or reduce the need to make trips by motor vehicle,. The costs of these strategies tend to be low to moderate and have benefits such as reducing peak period travel and reducing single-occupant VMT. These, in turn, can provide a number of environmental benefits including improved air quality and reduce greenhouse gas emissions.

2. **Land Use Strategies**, such as infill development, transit oriented development, densification efforts, and Transportation Management Associations, that promote mixed-use and transit-oriented development and allow for reduced use of motor vehicles for some discretionary trips. Generally, land use strategies have low to moderate costs and tend to involve the establishment of ordinances and the potential need for economic incentives that will encourage developer buy-in.

3. **Public Transportation Strategies** that expand public transportation and promote the use of higher occupancy modes. Strategies include increasing route coverage and frequency, constructing new fixed guideway travelways, employer incentive programs, signal priority, intelligent transit stops, and other technological improvements. These strategies range in cost from low to high.

4. **Intelligent Transportation Systems (ITS) and Operational Improvement Strategies** that make the best use of existing capacity. Strategies include signal coordination, ramp metering, traveler information systems, incident management, and service patrols. Costs of these strategies vary but tend to be low to moderate. Large scale ITS and operations strategies that involve the

construction of new infrastructure and devices tend to be higher in cost than other projects. Benefits include reduced travel time, reduced stops, reduced delays, and improved safety.

5. **Pricing Strategies** that reduce vehicle demand. Pricing strategies are regulatory in nature but may also relate to parking systems. Carbon pricing, VMT fees, pay as you drive insurance, and auto and truck restriction zones are all regulations that can be instituted to help alleviate congestion and generate revenue for additional strategies. Beyond this, a number of parking pricing strategies can help to reduce congestion. These include preferential or free parking for HOVs and local regional excise taxes, both of which provide an incentive for workers to carpool. Other strategies include dynamic pricing, higher fees on free parking lots, and parking permits. Additionally, a local flat fee per space on parking spaces provided by businesses can discourage automobile-dependent development. Pricing strategies may result in a reduction in VMT and increased vehicle capacity. They also generate revenue to maintain the strategy and system and promote transit, biking, and walking as other forms of travel. These are relatively low cost strategies.

6. **Bicycle and Pedestrian Strategies** that shift trips to bicycling and walking modes. Strategies include new sidewalks and bicycle lanes, improved facilities near transit stations, bike sharing, and exclusive non-motorized rights of way. Abandoned rail rights-of-way and existing parkland can be used for medium to long distance bike trails improving safety and reducing travel times. Bicycle and pedestrian policies may work well when grouped with other strategies such as implementation of a complete streets policy, land use and environmental strategies that promote densification, and improved safety strategies. Costs of bicycle and pedestrian strategies tend to be low to moderate. Benefits of bicycle and pedestrian strategies related to decreasing auto mode share, which in turn reduces VMT and improves regional air quality.

7. **Roadway/Mobility (Non-ITS) Strategies** that are designed to help improve operations and relieve bottlenecks on existing facilities through non-capacity adding improvements. Strategies include access management improvements; turn restrictions at key intersections; converting streets to one-way operations; geometric design improvements to roadways, interchanges, and intersections; non-added capacity grade separations; addition of acceleration or deceleration lanes; and adoption of a Complete Streets policy. These strategies range in cost low to high based on the type and complexity of strategy implemented.

8. **Roadway Capacity Expansion Strategies** such as adding additional capacity to existing roadway facilities or constructing new roadway facilities that serve newer developed or rapidly developing areas, or where gaps exist in the existing freeway or arterial network. Strategies include the construction of a new roadway or bypass, major or minor road widening to add additional

through lanes on an existing highway, major roadway reconstruction, adding capacity to a corridor by improving many related intersections, new interchange, adding capacity to an existing interchange, or grade separation of existing intersections (that add capacity). Adding capacity should be considered the strategy of last resort due to issues related to sprawl, land preservation, promotion of alternative transportation modes, and cost considerations. These strategies range in cost from moderate to high based on the type of strategy implemented, with new right-of-way resulting in higher costs than design improvements. Predominant benefits of these strategies include increased capacity as well as improved mobility and traffic flow.

CMP Analysis Process

The CMP Update report also describes the CMP analysis process for assessing the congestion reduction potential of strategies in terms of established congestion management objectives and performance measures. A CMP analysis process is defined for each of the following types of transportation investments:

- **Major Investments.** These are Federal and State assisted regionally significant added capacity projects located on the CMP network. Significant added capacity projects tend to have a substantial cost and significantly impact regional or corridor travel patterns. Project descriptions typically include a new roadway or bypass, major or minor road widening to add additional through lanes on an existing highway, major roadway reconstruction, adding capacity to a corridor by improving many related intersections, new interchange, adding capacity to an existing interchange, grade separation of existing intersections (that add capacity), etc.

- **Other Investment Types.** These are Federal and State assisted projects that encompass the following improvement types: transportation demand management, land use, public transportation, bicycle/pedestrian, ITS and operations, roadway/mobility (non-ITS), or added capacity projects located off the CMP Network.

- **Accelerated Projects.** These are projects that are introduced late in the RTP planning cycle due to accelerated growth or congestion relief, connection with an existing project, or new funding opportunities. As a result, the implementation of the projects does not correspond with the typical evaluation process and timeline required for projects already documented in the RTP.

- **Exempted Projects.** Projects are exempt from a CMP analysis if the proposed project solves a safety or bottleneck problem. The criteria for determining whether a project is categorized as a safety or bottleneck project is described in Section 8 of the CMP Update report.

The CMP analysis process involves conducting either a quantitative or qualitative assessment of the extent to which congestion mitigation strategies can alleviate travel demand and congestion in the corridor. The level of analysis varies depending on the type of transportation investment:

- **Major Investments.** The CMP analysis process for major investments consists of conducting a quantitative analysis of corridor alternatives to assess the extent to which congestion mitigation strategies can alleviate travel demand and congestion in the corridor. Congestion mitigation strategies must be considered as an alternative to capacity. Project sponsors are required to report on the specific strategies that will be implemented as part of the project, as well as quantitatively document the benefits of the project's ability to relieve congestion, improve trip reliability, and/or to define how it meets one or more of the CMP goals and objectives.
- **Other Investment Types.** The CMP analysis process for other investment types is less rigorous compared to that for major investments and consists of a qualitative assessment of the congestion reduction impacts of the project in terms of CMP objectives and performance measures. The assessment criteria are similar to those established for H-GAC's Transportation Improvement Program.
- **Accelerated Projects.** The CMP analysis process for accelerated projects may be quantitative or qualitative, depending on whether the project is categorized as a major investment or other investment type.
- **Exempted Projects.** Safety and bottleneck projects are exempt and do not require a CMP analysis to be conducted.

Project sponsors are required to submit the CMP analysis results to H-GAC using the *CMP Project Analysis Form*, which is provided in Appendix C of the CMP Update report. Instructions for completing the form are provided in Appendix D

An overview of the CMP analysis process for each investment type is summarized in Table ES.2 and Figure ES.2. The table identifies the criteria used to define each investment type (i.e., major investments, other investment types, accelerated projects, exempted projects), an overview of the CMP analysis process for the investment type, *CMP Project Analysis Form* Requirements, and the timing of the CMP analysis within the overall project development process. The figure graphically depicts the criteria for determining investment type, type of CMP analysis, and CMP Project Analysis form requirements.

Figure ES.2 CMP Analysis Process

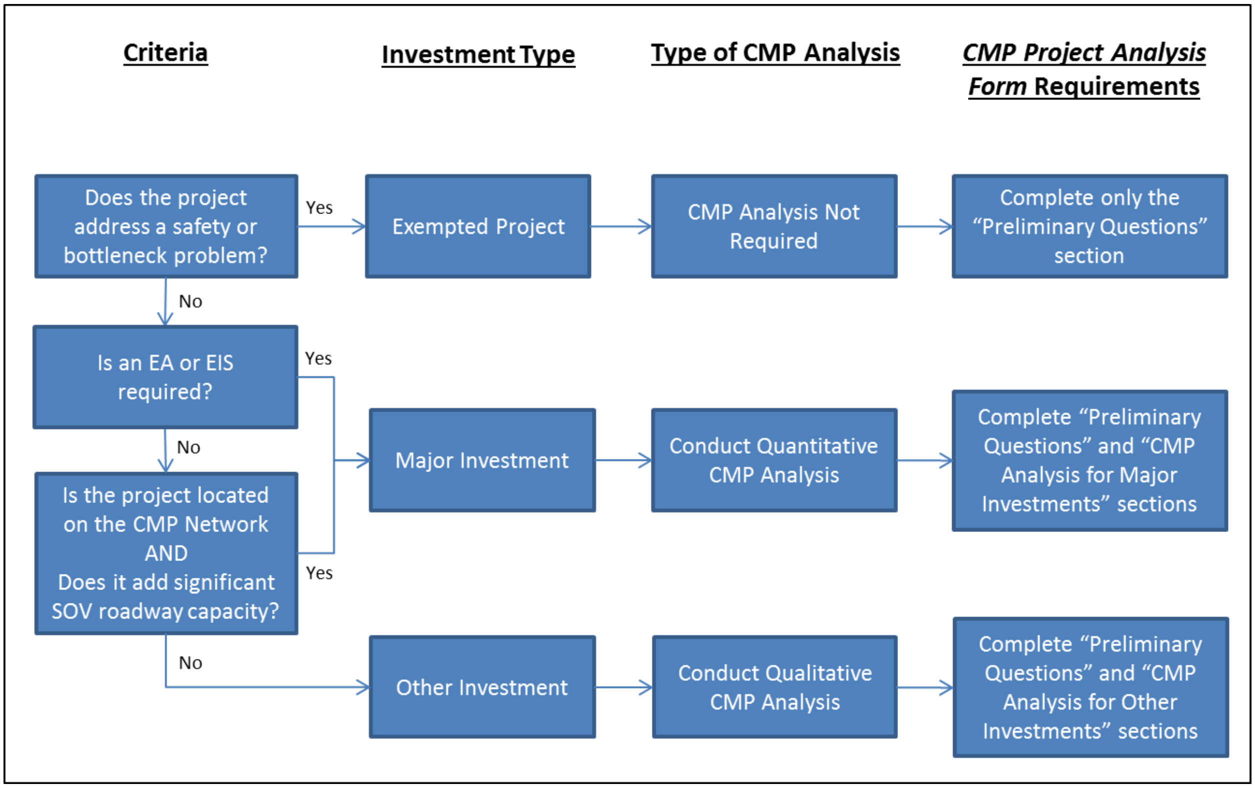


Table ES.2 CMP Analysis Process

	Investment Type			
	Major Investments	**Other Investments**	**Accelerated Projects**	**Exempted Projects**
Criteria for Defining Investment Type	• Environmental Assessment (EA) or Environmental Impact Statement (EIS) required, OR • Project located on CMP Network AND adds significant SOV capacity	• Project not on CMP Network, OR • Project does not add significant SOV capacity • NOTE: Other investment type could include capacity-adding projects not on the CMP Network	• The same criteria as Major Investments or Other Investment Types applies	• Project solves a safety or bottleneck problem, as defined by the Criteria in Table 8.3
CMP Analysis Process	• CMP serves as warrant for justifying additional SOV capacity • Quantitative CMP analysis • Use CMP Report to identify deficiencies on project corridor • Use CMP Toolbox to identify congestion mitigation strategies and/or suggested analysis tools for inclusion in the corridor alternatives analysis and/or NEPA documentation. Consider CMP strategies as an alternative to capacity, and/or bundle CMP strategies into the added capacity project. • Quantitatively document congestion reduction impacts in terms of CMP objectives and measures • Justify reasons for not implementing congestion mitigation strategies	• Other investment projects are subject to less rigorous congestion analysis • Qualitative CMP analysis • Use CMP Toolbox to identify congestion mitigation strategies and/or suggested analysis tools • Conduct qualitative analysis of congestion impacts based on planning factors • Qualitatively document congestion reduction impacts of the project in terms of CMP objectives and measures	• The same CMP analysis process as Major Investments or Other Investment Types applies • H–GAC reviews the CMP analysis process results • H-GAC conducts a scoping meeting with the consultant/project sponsor to discuss alternatives analysis and incorporate CMP strategies into the preferred project alternative • A kickoff meeting is convened, and accelerated environmental assessment, design, and implementation process schedules are defined and implemented	• Project does not require a CMP analysis
CMP Project	• Project sponsors complete both	• Project sponsors complete both	• Project sponsors complete the	• Project sponsors complete only

	Investment Type			
	Major Investments	Other Investments	Accelerated Projects	Exempted Projects
Analysis Form Requirements	the "Preliminary Questions" and "CMP Analysis for Major Investments" sections of the *CMP Project Analysis Form*	the "Preliminary Questions" and "CMP Analysis for Other Investments" sections of the *CMP Project Analysis Form*	"Preliminary Questions" and either the "CMP Analysis for Major Investments" OR the "CMP Analysis for Other Investments" sections of the *CMP Project Analysis Form* (depending on investment type)	the "Preliminary Questions" section of the *CMP Project Analysis Form*
Timing of CMP Analysis	• Conduct CMP analysis as part of corridor alternatives analysis orNEPA document preparation • Pre-requisite for TIP project application	• Conduct CMP analysis as part of mobility study, traffic operations analysis, or local/regional study • Pre-requisite for TIP project application	• The same timing of CMP analysis as Major Investments or Other Investment Types applies (depending on investment type)	• CMP analysis not required • Submit *CMP Project Analysis Form* to H-GAC as part of TIP project application

1.0 Introduction

1.1 Overview of the Congestion Management Process

The Congestion Management Process (CMP) is a systematic process of identifying congestion and its causes, applying congestion mitigation strategies to improve transportation system performance and reliability, and evaluating the effectiveness of implemented strategies. The CMP is an integral part of the metropolitan transportation planning process and provides a mechanism for funding and implementing congestion management strategies either independently or as part of larger programs and projects programmed in H-GAC's Regional Transportation Plan (RTP) and Transportation Improvement Program (TIP).

The Federal Highway Administration's (FHWA) Congestion Management Process Guidebook provides comprehensive guidance in implementing the CMP using an objectives-driven, performance-based approach. The following eight steps represent critical elements to a successful CMP:

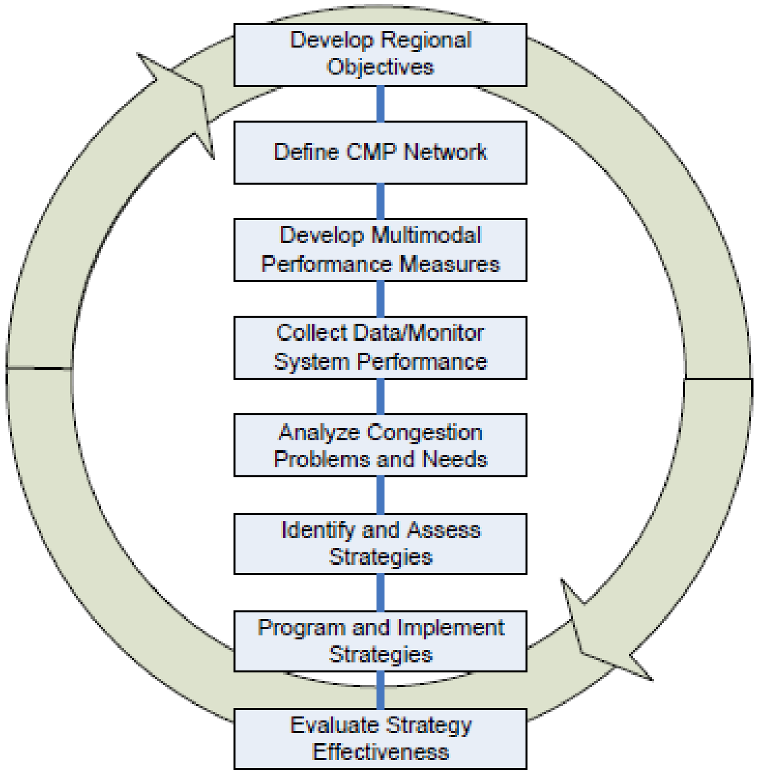
- **Step 1: Develop Regional Objectives for Congestion Management.** Congestion management objectives should be developed with meaningful stakeholder participation and an understanding of the needs and desires of the public related to congestion. Ideal objectives should focus on outcomes and be SMART: Specific, Measureable, Agreed, Realistic, and Time-bound.
- **Step 2: Define CMP Network.** Define the geographic boundaries and the system components/network of facilities. Although the CMP has traditionally focused primarily on the road network, the network should consider the transit, bicycle, and pedestrian networks as well as their interface with the highway network.
- **Step 3: Develop Multimodal Performance Measures.** Performance measures should be developed and used at the regional level to measure the performance of the system and at the local level (corridor, segment, intersection) to identify specific locations with congestion problems and measure the performance of individual segments and system elements. They may be adapted and adjusted over time.
- **Step 4: Collect Data/Monitor System Performance.** Numerous agencies must collaborate to collect data and monitor system performance.
- **Step 5: Analyze Congestion Problems and Needs.** Raw data is translated into meaningful measures of performance to analyze congestion problems and needs. The analysis should include locations of major trip generators,

seasonal traffic variations, time-of-day traffic variations, and separation of trip purpose.

- **Step 6: Identify and Assess Strategies.** The data and analysis can then be used to identify and assess CMP strategies to effectively manage congestion and achieve congestion management objectives. Important considerations include contribution to meeting regional congestion management objectives, local context, contribution to other goals and objectives, and jurisdiction over CMP strategies.
- **Step 7: Program and Implement Strategies.** Next, these strategies should be programmed and implemented through inclusion of congestion management strategies in various components of the metropolitan transportation planning process, including the RTP, TIP, corridor plans, and the Regional ITS Architecture.
- **Step 8: Evaluate Strategy Effectiveness.** After implementation, agencies should evaluate strategy effectiveness through system-level performance evaluation and strategy-effectiveness evaluation. Ongoing monitoring of transportation system performance provides a feedback loop designed to inform future decision making about the effectiveness of transportation strategies.

These elements, depicted in Figure 1.1, are designed to help guide successful CMP implementation.

Figure 1.1 Elements of the Congestion Management Process



Source: FHWA, Congestion Management Process: A Guidebook.

A well-designed CMP can help H-GAC:

- Manage regional travel demand and congestion issues in a consistent, coordinated manner through implementation of the structured 8-step CMP framework;
- Implement an objectives-driven, performance-based approach to congestion management through the development of congestion management goals, objectives, and performance measures and ensuring investment decisions are made with a clear focus on desired outcomes;
- Promote cost effective, diverse transportation choices such as travel demand management, land use, and transit strategies that eliminate or reduce travel, while leaving high-cost capacity improvements that primarily serve single occupant vehicle travel as a last resort;
- If additional single occupant vehicle capacity is warranted, justify these capacity improvements through CMP analyses and inclusion of congestion management strategies to manage the facility safely and effectively;

- Improve the project development and environmental review process by proving information to support corridor analysis and environmental analysis conducted under the National Environmental Policy Act (NEPA);
- Improve H-GAC's project programming and implementation process by providing a mechanism for identifying strategies to address congestion on a system-wide, corridor-level, and site-specific basis and programming these strategies either independently or as part of larger programs and projects in H-GAC's RTP and TIP; and
- Provide a feedback loop in which ongoing monitoring and evaluation of implemented projects and programs is used to inform future decision making about the effectiveness of transportation strategies.

1.2 NEED FOR A CONGESTION MANAGEMENT PROCESS

All metropolitan areas with populations greater than 200,000 residents, known as Transportation Management Areas (TMAs), are required by the *Moving Ahead for Progress in the 21st Century (MAP-21) Act* to develop a CMP.

H-GAC's Congestion Management System (CMS) Plan was adopted in 1997 and revised in 1998, 2004, and 2005. The most current 2009 CMP was developed and adopted as part of the 2035 RTP. This 2015 CMP Update addresses the congestion management needs of the region that have emerged since 2005 and incorporates consistent methods to support the region's Annual Mobility Report, the 2040 Regional Transportation Plan Update (in progress), and ensure MAP-21 compliance.

The CMS was first introduced as part of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 and was outlined as a systematic process for state departments of transportation (DOT) and metropolitan planning organizations (MPO) to provide information on transportation system performance and alternative strategies to alleviate congestion and enhance mobility of people and goods.[1] The *Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU)* of 2005 did little to change requirements, but changed the name of the CMS to the CMP. While the CMS was often used as a stand-alone data analysis/planning exercise, the CMP is intended to be an ongoing process, fully integrated into the overall transportation planning process of both states and regions.[2] MAP 21 preserves the existing law related to CMPs,

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[1] Framework of the Capital Region Transportation Planning Agency (CRTPA) Congestion Management Process Report.

[2] Federal Highway Administration (FHWA) CMP Guidebook.

with an enhanced focus on performance measures, monitoring, reporting, target setting, and data collection and use.

Federal regulations are provided in the 23 Code of Federal Regulations (CFR) Section 450.32 – congestion management process in transportation management areas. The federal regulations define the CMP components as follows:

- Performance monitoring and evaluation, identification of causes of recurring and nonrecurring congestion, and strategy identification and effectiveness;
- Definition of congestion management objectives and performance measures;
- Coordinated data collection and system performance monitoring efforts;
- Identification of anticipated performance and benefits of congestion management strategies;
- Implementation schedule, responsibilities, and potential funding for strategies; and
- Implementation of a process for assessment of strategies, in terms of established performance measures.

Federal requirements also explicitly outline the CMP implementation and development process to be part of an overall metropolitan transportation planning process that involves coordination with transportation system management and operations activities. In addition, regions that are in nonattainment for ozone or carbon monoxide cannot program projects that result in a significant increase in carrying capacity for single-occupant vehicles (SOV), unless the project is addressed in the region's CMP. If operational management strategies are shown to be insufficient with regard to congestion reduction, and additional SOV capacity is warranted, then the CMP must identify strategies to manage the SOV facility safely and effectively.

The CMP does not have an update cycle established by Federal regulations, though the four-year certification review cycle and the four- or five-year Regional Transportation Plan (RTP)/Metropolitan Transportation Plan (MTP) update cycle for each TMA provide a baseline for a reevaluation/update cycle in the absence of an identified requirement.

1.3 Organization of the CMP

The remainder of this report is structured according to the 8 steps of the CMP from the FHWA CMP Guidebook.

Section 2.0 Regional Objectives for Congestion Management (Step 1)

Section 3.0 CMP Network (Step 2)

Section 4.0 Performance Measures (Step 3)

Section 5.0 Performance Monitoring Plan (Step 4)

2.0 Regional Objectives for Congestion Management

This section presents the regional objectives of the Houston-Galveston Area Council's (H-GAC) Congestion Management Process (CMP) Update. The outlined objectives are designed to:

- Meet the Federal requirements for congestion management planning;
- Provide the technical foundation for the development of the CMP Update;
- Integrate the CMP with H GAC's current 2040 Regional Transportation Plan (2040 RTP); and
- Address the public and agency stakeholder goals for congestion management as defined through H-GAC's ongoing 2040 RTP process.

The CMP objectives were primarily defined through detailed discussions with H GAC staff at the project's kickoff meeting in February 2014; and through ongoing discussions with the agency about their need to better link congestion management planning, performance measures, and the overall CMP with the ongoing 2040 RTP.

The objectives for the CMP Update are consistent with the overall congestion management-related goals and objectives currently being defined in the 2040 RTP Update. These, while subject to change based on the ongoing development of the RTP, included:

- 2040 RTP Goal #1 – Improve Safety, including the objective to reduce the rate and severity of crashes for all system users;
- 2040 RTP Goal #2 – Manage and Mitigate Congestion, including the objective to increase reliability across all modes and systems of travel in the region;
- 2040 RTP Goal #3 – Ensure Strong Asset Management and Operations, including the objective to preserve and enhance system functionality to maintain transportation system capacity and efficiency;
- 2040 RTP Goal #4 – Bolster Regional Economic Competitiveness, including the objective to improve the cost competitiveness of goods movement in the region; and
- 2040 RTP Goal #5 – Conserve and Protect Natural and Cultural Resources, including the objective to reduce emissions to improve air quality and meet air quality standards in the region.

The 2040 RTP goals and associated objectives defined above, not just Goal #2 – Manage and Mitigate Congestion, each relate to congestion management in some way. For example, Goal #3 – Ensure Strong Asset Management and Operations (develop lower cost strategies to better manage demand and system impacts); and #5 – Conserve and Protect Natural and Cultural Resources of the region (reduce mobile source emissions) each relates to the development and evaluation of transportation demand management strategies (e.g., telecommuting, alternative work days, ridesharing, transit marketing, others) and transportation system management and operations strategies (e.g., access management, advanced traveler information systems, ramp metering, others). Among other examples, the implementation of strategies and projects specifically designed to enhance the movement of goods on the transportation system will effectively help better manage transportation system congestion related to truck movements, and also will help Bolster the Economic Competiveness of the region (Goal #4) by providing better transportation system access for goods movement.

The CMP objectives also follow the Federal Highway Administration's (FHWA) concept of SMART characteristics. As defined in the FHWA CMP Guidance, objectives should be **S**pecific enough to guide the development of the CMP process; **M**easurable enough to identify and track plan success; **A**greed upon by regional and local agency stakeholders; **R**ealistic and supported by available tools, data, and overall agency resources; and **T**ime-bound or achievable in a specific timeframe (e.g., 2040 RTP time horizon).

2.1 CMP Goals, Actions, and Objectives

The objectives for the H-GAC CMP Update are presented in Table 2.1, which includes the following descriptions:

- **H-GAC's 2040 RTP Goals.** As described above, the 2040 RTP Goals are presented as the guiding principles for the CMP goals, actions, and objectives.
- **H-GAC CMP Goals and Actions.** CMP goals and actions are defined to support congestion management principles outlined in the 2040 RTP Goals. In some cases, the 2040 RTP and CMP Goals are the same, and in all cases, both are similar to one another. The actions shown in the table represent the approach to be applied in the CMP to achieve both the goals and objectives.
- **H-GAC CMP Objectives.** As presented above, the CMP objectives were identified to address both the 2040 RTP and CMP Goals; and were defined to represent specific, measurable, agreed upon, realistic, and time-bound principles.

Table 2.1 CMP Goals, Actions, and Objectives

2040 RTP Goals & Objectives	CMP Goals and Actions	CMP Objectives
Improve Safety: Reduce the rate and severity of crashes for all system users	Goal: Reduce the rate and severity of crashes for all system users Action: Assess the safety benefits of TDM, TSM, operations/ITS, transit, and roadway strategies, projects, and programs	Reduce the rate of traffic, bus, and rail crashes
Manage and Mitigate Congestion: Increase reliability across all modes and systems of travel in the region	Goals: Improve transportation system reliability across all modes and systems of travel in the region Emphasize TDM, TSM, Operations, and ITS Solutions Increase opportunities for travelers to use regional and local transit services Actions: Develop tools and processes to better manage transportation system congestion into the future by implementing a comprehensive set of TDM, TSM, operations/ITS, transit, and pedestrian/bicycle strategies Link transit strategies, programs, and projects directly with Houston Metro's ongoing Reimagining Study for evaluation within the CMP	Maintain or reduce the percentage of lane-miles (highway, arterial) that are severely congested during the peak period Maintain or reduce traveler hours of delay (highways, arterials) on all modes including transit, truck, and auto Reduce transit vehicle crowding during peak hours
Ensure Strong Asset Management and Operations: Preserve and enhance system functionality to maintain capacity and efficiency; Promote a state of good repair to facilitate the movement of people and goods	Goal: Reduce the impacts of incidents on traffic flow Action: Implement operations/ITS strategies that enhance the region's traffic incident management program	Reduce average clearance time for incidents on highways and arterials
Bolster Regional Economic Competitiveness: Improve cost competitiveness of goods movement; attract a highly skilled workforce	Goals: Accessibility – Increase opportunities for travelers to use regional and local transit services and participate in TDM programs to provide more travel choices Goods Movement – Improve system operational efficiency and accessibility to accommodate freight movement within the region Actions: Accessibility - Emphasize TDM	Increase alternative (non-SOV) mode share for commuter trips Increase access to transit (within ¼ mile) to specified percentage of the population and jobs Increase accessibility to freight terminals/intermodal facilities from freeways/tollways

2040 RTP Goals & Objectives	CMP Goals and Actions	CMP Objectives
	strategies to better manage congestion across the transportation system Accessibility – Identify/link transit strategies, programs, and projects from Metro's Re-Imagining Study in the CMP Goods Movement – Emphasize reliability/operational efficiency on major freight corridors in the region	
Conserve and Protect Natural and Cultural Resources: Minimize loss of wetlands, natural and historic resources due to transportation project development; Reduce emissions to improve air quality and meet air quality standards	Goal: Reduce emissions through congestion management Action: Assess the air quality benefits of TDM, TSM, and operations/ITS strategies, projects, and programs	Reduce ground-level ozone and GHG emissions

2.2 CMP Guiding Principles

As stated earlier, the guiding principles used to prepare the CMP goals, actions, and objectives presented in Table 2.1 were defined through meetings and conversations with H-GAC. The primary guiding concepts include:

- Improve transportation system reliability into the future by identifying and implementing a mix of strategies and projects designed to best manage congestion. Due to expected future population and employment growth in the region, H-GAC will not be expected to eliminate transportation system congestion through its CMP and 2040 RTP processes. This will not be feasible, currently or into the near- and long-term future. Rather, the expectation will be for H-GAC to develop tools and processes to better manage transportation system congestion into the future by using a combination of multimodal projects, strategies, and programs.
- Consistent with the 2040 RTP, focus the CMP on strategies, projects, and programs that assess and implement a comprehensive set of transportation demand management (TDM), transportation system management (TSM), operations/ITS, transit, and pedestrian and bicycle strategies. These projects will compliment roadway capacity enhancement projects in both the CMP and 2040 RTP.
- Design and apply performance measures to provide H-GAC with an objectives-driven approach to planning and to evaluate/assess the congestion relief impacts of multimodal strategies, in addition to roadway capacity expansion projects.

- Develop a CMP toolbox and analytical approaches to better identify single-occupant vehicle and emission reductions; and the congestion relief potential of demand and system management strategies, projects, and programs.
- Increase opportunities for travelers to use regional and local transit services to provide alternative travel choices. Transit strategies, programs, and projects will be identified from Houston Metro's ongoing Reimagining Study for evaluation within the CMP to identify alternative transportation modes that help to better manage major corridor and subarea congestion in the region. Transit projects, strategies, and programs will be linked directly, and be as consistent as possible, with Houston Metro's Reimagining Study that is focusing on a restructured transit service plan for the region.

3.0 CMP Network

The CMP network provides a framework for analyzing congestion problems within the H-GAC transportation management area, including freeway corridors, arterial streets, transit facilities and services, and bicycle and pedestrian facilities. The CMP network described in this section is not necessarily intended to be comprehensive or all-inclusive, as it is anticipated that new and revised corridors will be defined over time as the CMP is applied to emerging congestion challenges.

3.1 Criteria to Define the CMP Network

The CMP network includes all roadways contained in the H-GAC air quality conformity network. This network was developed in accordance with federal requirements for monitoring air quality. The following criteria were used to develop the CMP / Air Quality Conformity network:

- Include all freeways and tollways included in the MTP;
- Include all fixed guideway transit systems in the MTP;
- Include all other current principal arterial highways; and
- Include select minor arterials that:
  - serve significant interregional and intraregional travel, and connect rural population centers not already served by a principal arterial; or
  - connect with intermodal transportation terminals not already served by a principal arterial

Through coordination with H-GAC and regional entities, the decision was made to also develop a Tier 2 network for performance monitoring purposes. The H-GAC travel demand model network was compared to the CMP network to identify any additional facilities that should be considered for inclusion in the Tier 2 network. The criteria shown in Table 3.1 were used in evaluating candidate facilities. The Tier 2 network includes roadways that meet the criteria in Table 3.1, but are not included in the air conformity network.

Network links were added to the Tier 2 network based on the criteria and a thorough visual review was performed to remove network elements that were not necessary the network and to fill gaps in the network in order to maintain continuity within the corridors being added. Links that serve as connectors for the roadway network such as various types of on/off ramps, frontage roads (coded as arterials or collectors) adjacent to freeways, HOV / transit connectors, etc. were not included in the Tier 2 network. The network elements presented in the Tier 2 network provide a framework for future expansion.

Table 3.1 Criteria for H-GAC Tier 2 Network

Category	Description	Comment
Freeways / Highways	• All Access-Controlled Facilities including (but not limited to) Interstates and US Highways	• Toll Facilities within these corridors will be captured as an attribute in the facility description
Tollways	• All Toll Facilities	• Toll Facilities within the corridor of a Non-Toll Facility will be referenced with the category above
Principal Arterials	• Principal Arterials as classified by the H-GAC Travel Demand Model Summary Road Type Equivalency	Include H-GAC Facility Types: • 09 – Principal Arterial with some Grade Separations; • 10 – Principal Arterial – Divided; • 11 – Principal Arterial – Undivided; • 19 – Saturated Arterial
AADT Threshold Criteria for lower than Principal Arterials	• Facilities below Principal Arterial Classification based on Area Type and AADT volume.	• Urban Minor Arterials > 20,000 vehicles per day • Rural Minor Arterials > 25,000 vehicles per day
Strategic Connections	• All State System Facilities not included in the above Categories. • Corridors which provide regional (>10 miles) mobility which are not encompassed within the other criteria provided above.	Includes: • Farm to Market; • State Highways; • US Highways; • Interstate Highways

3.2 CMP Network

Table 3.2 summarizes the number of directional miles by functional classification included in the combined CMP and Tier 2 network. Maps showing the network coverage are provided in Figures 3.1 through 3.4. A listing of the facilities included in the networks is provided in Appendices A and B.

Table 3.2 Combined CMP and Tier 2 Network Coverage

	Directional Miles		
Functional Classification	CMP Network	Tier 2 Network	Total
Freeways / Highways	1,129.1	-	1,129.1
Tollways	143.4	-	143.4
Principal Arterial	1,729.7	18.8	1,748.5
Lower than Principal Arterial	1.5	434.4	435.8
Total	3,003.7	453.1	3,456.8

Figure 3.1 Combined CMP and Tier 2 Network (Extents)

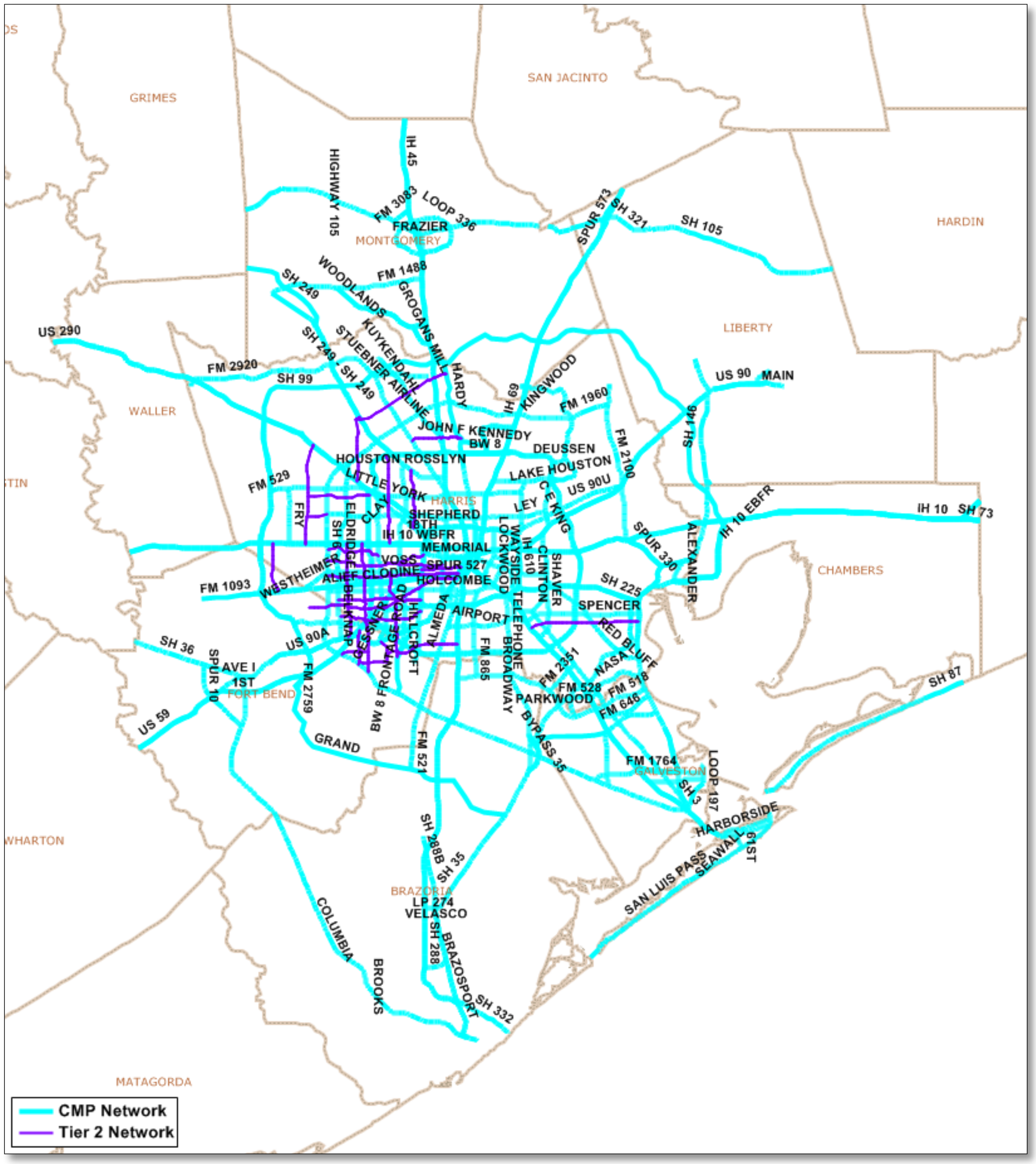


Figure 3.2 Combined CMP and Tier 2 Network (Inside Grand Parkway)

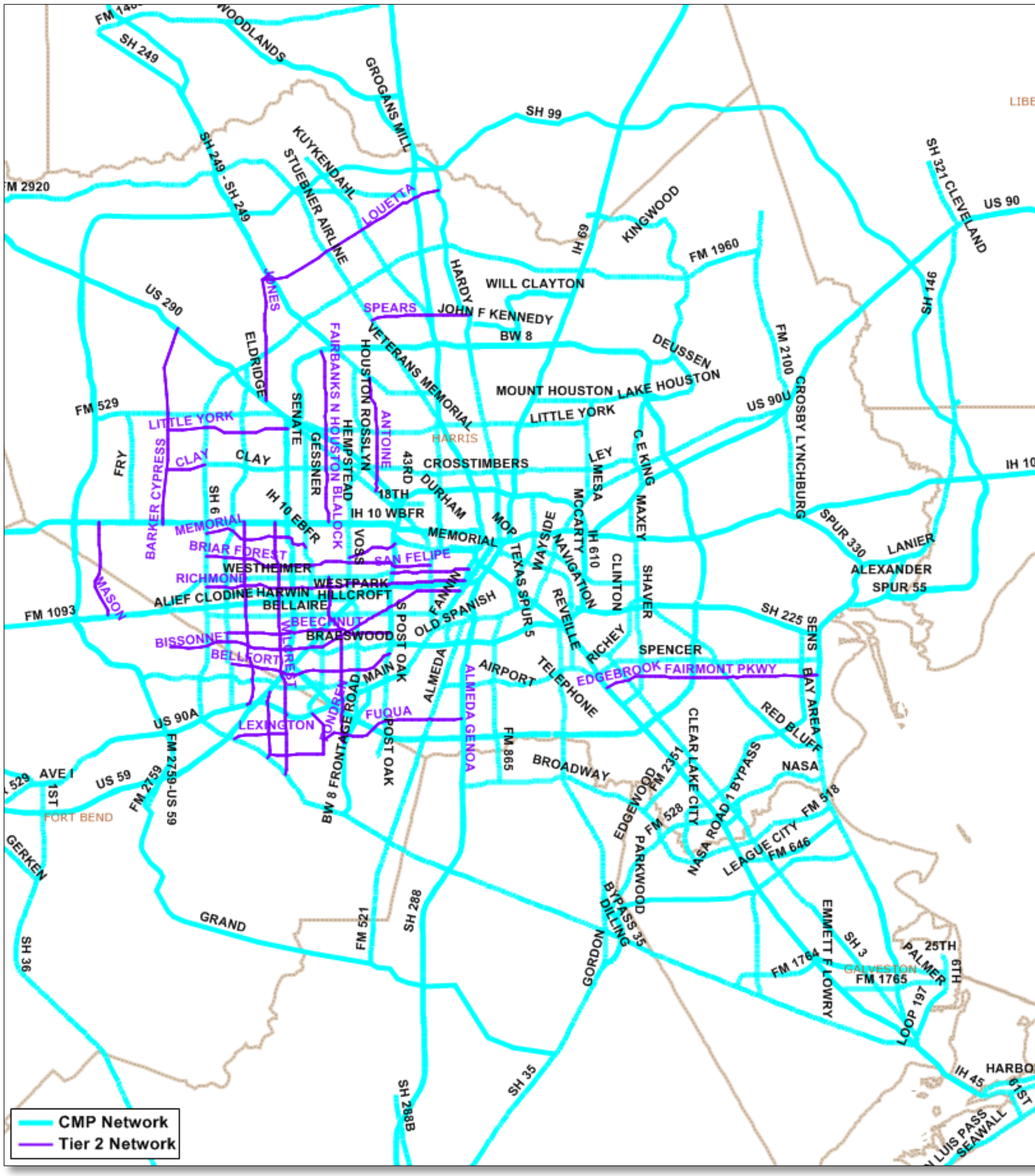


Figure 3.3 Combined CMP and Tier 2 Network (Inside Beltway 8)

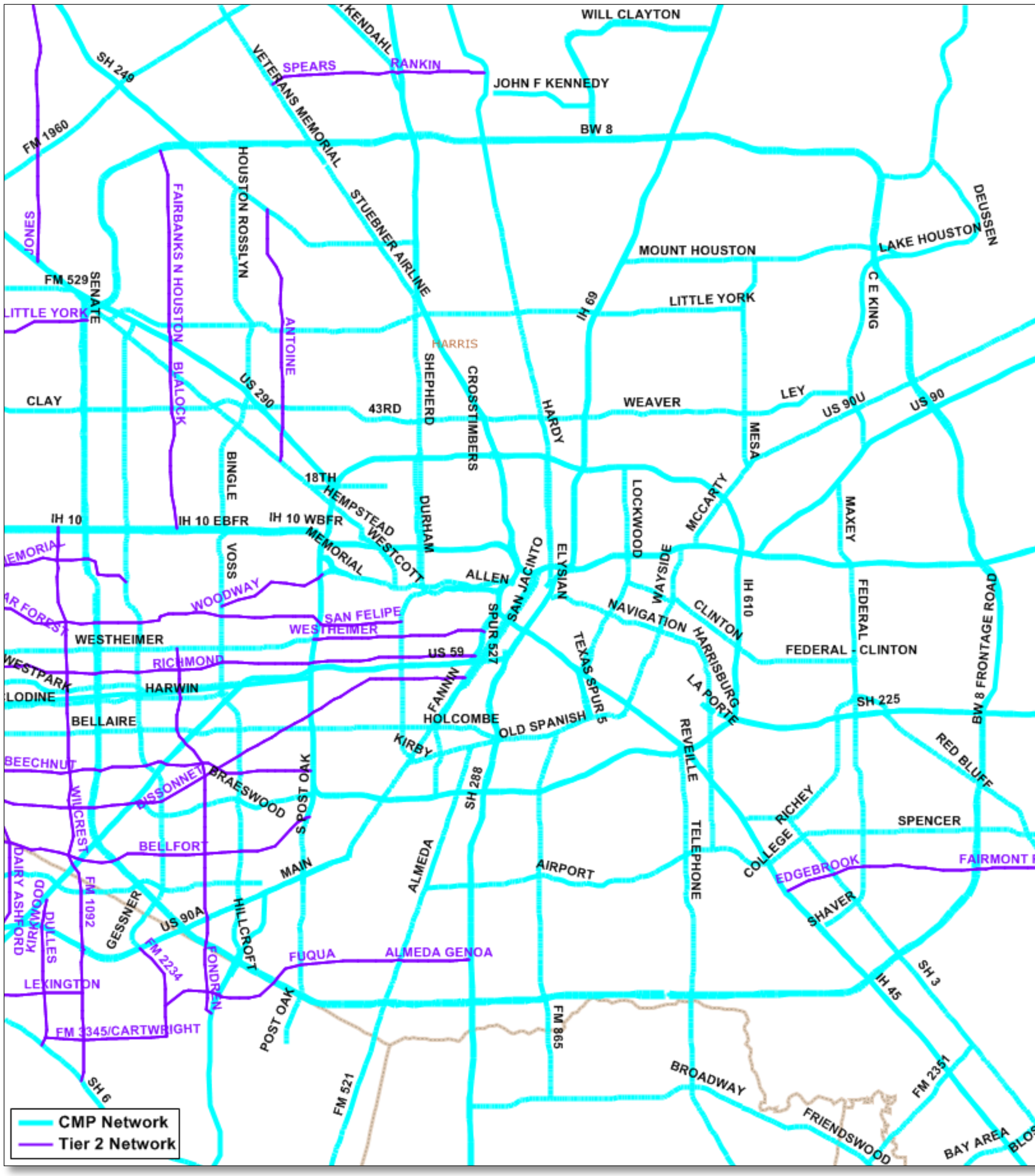


Figure 3.4 Combined CMP and Tier 2 Network (West Region)

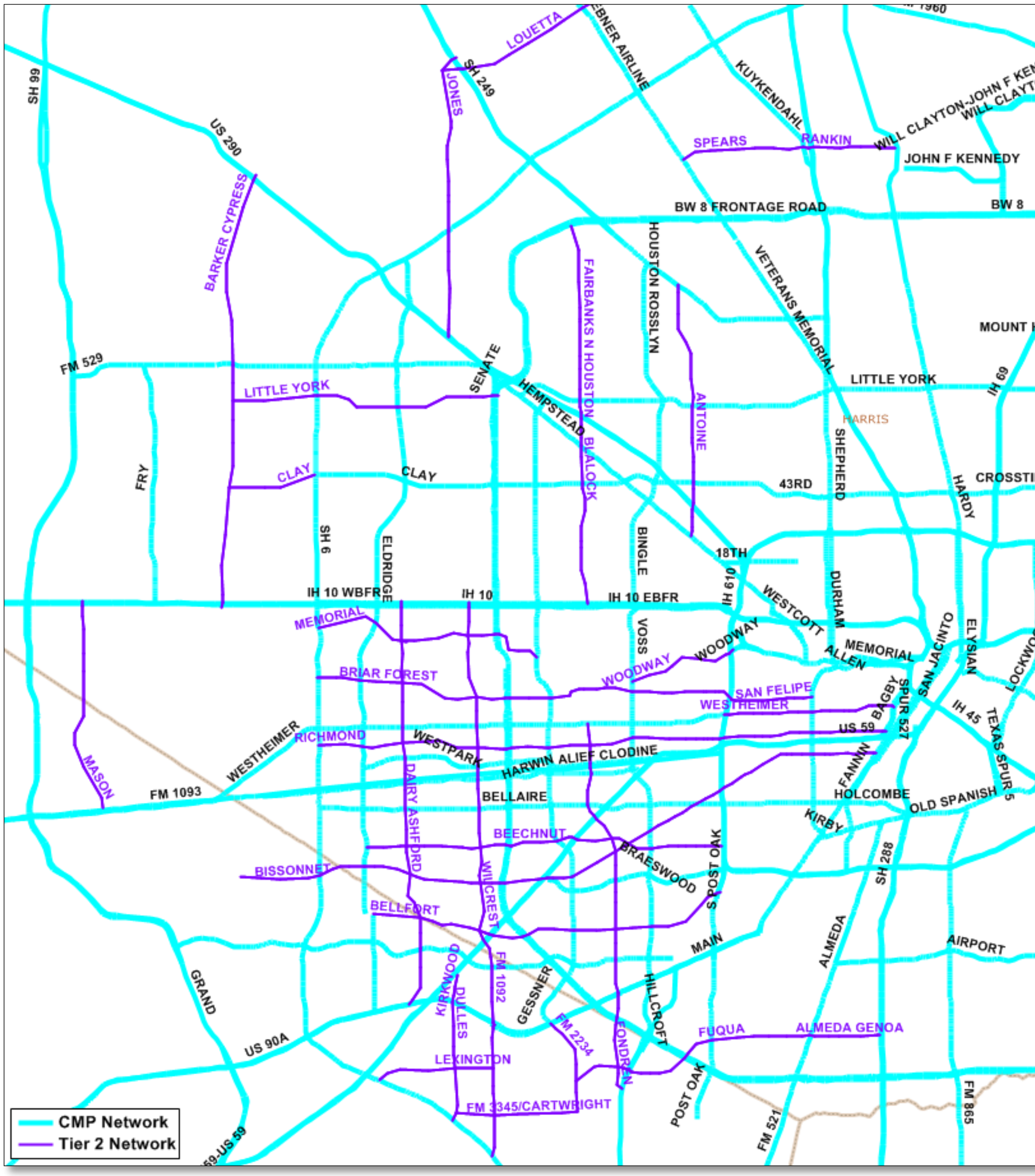


Figure 3.5 CMP Fixed Guideway Network (Extents)

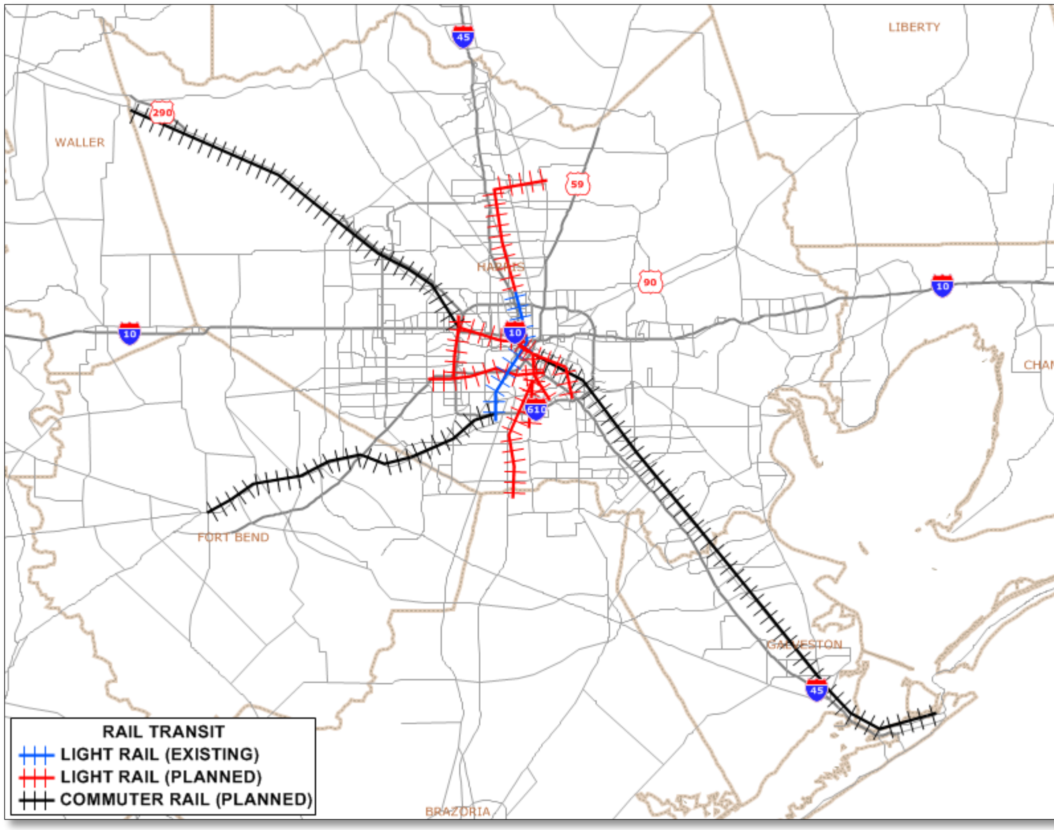
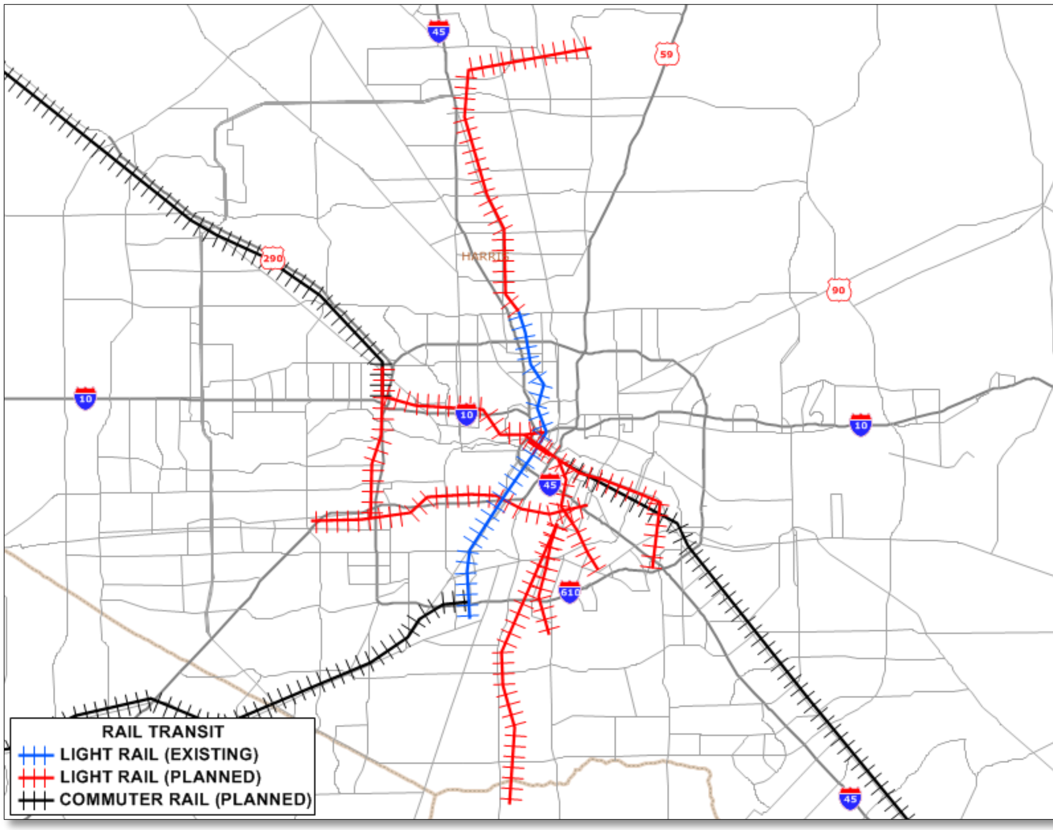


Figure 3.6 CMP Fixed Guideway Network (Inside Grand Parkway)



4.0 Performance Measures

The section presents the multimodal performance measures that will be applied to understand congestion problems, assess potential solutions, and monitor the effectiveness of implemented congestion management strategies. Performance measures were identified using the following approach:

- A comprehensive review of best practices was conducted, including a review of other state agency CMP performance measures, as well as currently adopted measures used in several H-GAC planning documents. Documents reviewed included the Houston State of Congestion Report, 2012 Mobility Report, Congestion Management Process (adopted September 2009), and proposed 2040 Regional Transportation Plan (RTP) performance measures.
- A short list of potential measures was developed by building on the proposed draft 2040 RTP performance measures (drafted in February 2014). Additional measures were identified for consideration based on applications by other agencies (as identified in the best practices review), as well as the potential to provide multimodal assessments of the congestion benefits of potential CMP strategies.
- The short list of potential measures were assessed for their applicability using the following criteria: easily understood, support with available data and models, provide consistency with other planning processes, and provide an adequate comparison of congestion.
- A recommended list of measures was developed for the CMP Update based on the assessment results, while striving to keep the total number of measures to a small, yet meaningful set of indicators.

4.1 CMP Performance Measures

Tables 4.1 and 4.2 present optional (#1 and #2) performance measures for the H-GAC CMP Update. Option #1 (Table 4.1) includes a relatively large number of measures that H-GAC can work toward implementing, while Option #2 (Table 4.2) represents a smaller set of initially recommended measures.

It should be noted that an Accessibility goal area was defined and added to these tables as a proxy for the economic competitiveness goal area in H-GAC's 2040 RTP. Accessibility, through our best practices research and review of H-GAC documents and plans, was added to identify measures applicable for CMP evaluations.

The measures are organized by H-GAC's 2040 RTP goals, as well as tiers that categorize the priority for implementation. The following tiers are included:

- **Tier 1 Performance Measures.** Measures that maintain consistency with the proposed 2040 RTP performance measures. It is envisioned that these measures will be used to assess the congestion impacts of RTP projects and strategies. These measures will also be used to assess CMP projects and strategies to maintain consistency with the RTP performance evaluations, but detailed CMP Update impacts will be focused on the Tier 2 measures (below).
- **Tier 2 Performance Measures.** Specific measures to provide detailed analysis of congestion management strategies/projects and that are supported by current data/models maintained and used by H GAC. It is envisioned that these measures will be the basis for CMP performance evaluations, which provide H-GAC with more detailed analysis (e.g., at the system, corridor, subregion, and project levels) than provided with the Tier 1 RTP congestion-oriented measures.
- **Tier 3 Performance Measures.** Additional measures for potential future use by H-GAC that provide detailed analysis of congestion management strategies/projects, but that are not currently supported by H-GAC data/models. The additional benefits provided by these measures are noted above in the Comments Field of Table 2.3. These measures are envisioned to provide H-GAC with a potential future set of measures for more detailed congestion management analysis upon the collection of new data in the region and the development of new planning tools.

For both options presented below, it is recommended that H-GAC use the Tier 2 measures as the minimum set of measures for this CMP Update, and phase in Tier 3 measures for future CMP updates as data collection/modeling capabilities expand within the agency. The Tier 1 measures will be used to support the 2040 RTP.

Table 4.1 Option #1 – CMP Performance Measures

Goal Area	Tier Categories of Performance Measures		
	Tier 1	Tier 2	Tier 3
Safety	• Traffic, bus, rail crash rate per VMT	• Same as RTP Measure	• Traffic, bus, rail crash severity
Congestion	• Planning time index (80th, 95th percentile)	• Person miles of travel • Lane-miles severely congested on highways • Traveler hours of delay on highways • Transit vehicle peak-hour load factor	• Percent lane-miles severely congested on arterials • Traveler hours of delay on arterials
Asset Management & Operations	• Incident clearance time on highways	• Same as RTP Measure	• Incident clearance time on arterials
Accessibility	• N/A	• Percent of population and jobs with access to transit (within one-quarter mile) • Percent of freight terminals/intermodal facilities (air, rail, truck cargo) located within 5 miles of a freeway • Connectivity index for pedestrian and bikeway system	• N/A
Economic Competitiveness	• Total truck congestion costs relative to commodity value • Commute split	• See measures above for Accessibility	• Benefit/cost analysis
Natural/Cultural Resources	• Ground level ozone levels	• PM 2.5 Emissions	• GHG Emissions

Table 4.2 Option #2 – Initially Recommended CMP Performance Measures

Goal Area	Tier Categories of Performance Measures: Tier 1	Tier 2	Tier 3
Safety	• Traffic, bus, rail crash rate per VMT	• Same as RTP Measure	• Traffic, bus, rail crash severity
Congestion	• Planning time index (80th, 95th percentile)	• Lane-miles severely congested on highways • Traveler hours of delay on highways	• Percent lane-miles severely congested on arterials • Traveler hours of delay on arterials
Asset Management & Operations	• Incident clearance time on highways	• Same as RTP Measure	• Incident clearance time on arterials
Accessibility	• N/A	• Percent of population and jobs with access to transit (within one-quarter mile) • Percent of freight terminals/intermodal facilities (air, rail, truck cargo) located within 5 miles of a freeway	• N/A
Economic Competitiveness	• Total truck congestion costs relative to commodity value • Commute split	• See measures above for Accessibility	• Benefit/cost analysis
Natural/Cultural Resources	• Ground level ozone levels	• PM 2.5 Emissions	• GHG Emissions

The initial set of recommended performance measures shown in Option #2 (Table 4.2) represent a manageable number of measures designed to specifically address the impacts of congestion-oriented projects and strategies within the CMP. Specific Tier 2 recommended CMP measures provide additional detail to the congestion-oriented measures in the 2040 RTP. These measures include:

- Congestion goal area:
  - Lane-miles severely congested on highways; and
  - Traveler hours of delay on highways (for all vehicles including transit, truck, auto).
- Accessibility/Economic Competitiveness goal area:
  - Percent of population and jobs with access to transit (within one-quarter mile); and
  - Percent of freight terminals/intermodal facilities (air, rail, truck cargo) located within 5 miles of a freeway).

- Natural/Cultural Resources goal area:
  - PM 2.5 emissions.

5.0 Performance Monitoring Plan

The section presents a performance monitoring plan for acquiring, analyzing, and monitoring the data needed to implement the multimodal performance measures identified in the previous section.

5.1 Data Collection and Analysis

Data to support the CMP can come from multiple potential sources. Understanding the type and availability of data that is collected is essential in analyzing the CMP network, as the data will be used to calculate performance measures with accuracy and efficiency. For the proposed CMP, some sources provide data that could be used more often in analysis than other sources. Based on an analysis of available data sources and coverage, the following data sources are recommended to support data collection for the proposed CMP network.

- TranStar and FHWA current data can be used for travel time data and average speed. TranStar has had a partnership with H-GAC going back to the 2009 CMP. The TranStar network is slightly limited, while the NPMRDS provides more coverage with the National Highway System (NHS). Both do not include every arterial included in the CMP network. TranStar's data set includes a broader set of historical data, since the FHWA did not track travel times on the NHS until July 2013. In addition, TranStar can be used for incident clearance time on highways, but does not include clearance time for many arterials. If it is imperative to include the travel time and average speed on every arterial in the CMP network, INRIX should be considered. INRIX is a private company that has done work with the Texas Transportation Institute (TTI) on numerous mobility and congestion reports. There network provides more coverage, but they would have to be subcontracted for the data.
- TxDOT should be used for crash data and traffic counts. Crash data for crash rate and severity can be determined using the Crash Records Information System (CRIS) database. The database is up to date and goes back to 2009. Traffic counts for highways and major arterials are updated yearly by TxDOT.
- The Federal Transit Administration's National Transit Database should be used for transit crash rates. The Federal Railroad Administration's crash statistics should also be considered since they examine freight crashes. The FTA receives crash data from multiple transit agencies in the Houston-Galveston Area including METRO, Fort Bend Transit, Brazos Transit, and Galveston Island Transit. Houston METRO does provide the same monthly crash data, but it is limited to Harris County. If there is a particular area of large congestion in Harris County, METRO may be able to provide more in-

depth data on their buses. METRO does provide monthly ridership reports that can be used to determine transit vehicle peak-hour load factor.

- GIS transit and demographic data is provided at several websites. H-GAC's GIS Datasets are recommended because of continuity in agency datasets and their use of the most recently available datasets. GIS data for intermodal facilities and freight locations is more difficult to locate. There are several maps provided by various public and private railroad agencies. The eight data sources in the performance measure should be used to develop a current map of freight/intermodal facilities to lay over the CMP network map. The performance measure for intermodal facilities may require more time to process the data and integrate different sources.
- The Texas Commission on Environmental Quality (TCEQ) should be used as the data source for ozone levels and emissions. Emissions for each roadway link in the Houston-Galveston area are only updated every three years, but TCEQ provides an extensive database for ozone levels that dates back to 1997. TCEQ combines EPA standard procedure with TxDOT vehicle registration county database information to come up with accurate emissions estimates.
- FHWA's FAF Data Tabulation Tool should be used to analyze total truck congestion cost relative to total truck commodity value. The tool provides truck commodity values for regional areas. Truck congestion cost can be estimated based on previous reports or based on travel time and average speed data provided by TranStar/INRIX.
- Another important factor to consider for the performance measures are upcoming projects programmed for implementation through various local agencies. Upcoming projects could have a significant impact on congestion. Table 5.1 summarizes some of the data sources available for identifying upcoming projects.

Table 5.2 summarizes the recommended CMP performance measures, associated monitoring calculations, and data requirements/sources based on the recommendations above.

Table 5.1 Upcoming Project Data Sources

Mode Type	Data	Source Agency	Department	Division/Report
Roadway	Locations and Dates	H-GAC	Transportation Planning	2035 RTP Update, Project Viewer
		Harris County Toll Rd Auth.	Construction and Engineering	HCTRA Major Projects
		TxDOT	Houston District	Construction Projects
Bus	Locations and Dates	H-GAC	Transportation Planning	2035 RTP Update, Project Viewer
		METRO	Current Projects	METRO Bus Shelter Program, expansions
Rail	Locations and Dates	H-GAC	Transportation Planning	2035 RTP Update, Project Viewer
		METRO	Current Projects	Go METRORail (System Plan)
Freight/ Intermodal	Locations and Dates	PHA	Strategic Planning	2013 Strategic Initiatives
		H-GAC	Transportation Planning	2035 RTP Update, Project Viewer
		CenterPoint/KCS	Projects	CenterPoint Intermodal Center
Bike/ Pedestrian	Locations and Dates	H-GAC	Transportation Planning	2035 RTP Update, Project Viewer
		City of Houston	Public Works	Various Projects
Airport	Locations and Dates	Houston Airport System	Capital Projects Program	IAH, HOU, EFD

Table 5.2 Data Sources for CMP Performance Measures

Goal Area/ Performance Measure	Definition	Calculation Method	Data Required	Source Agency	Source Data System
Safety					
Vehicle crash rate per VMT	Number of traffic crashes per 100M VMT annually	(Crashes x 100,000,000) / (AADT x 365 x Length (miles))	Crash count and locations, VMT	TxDOT	Crash Records Information System (CRIS)
Bus crash rate per VMT	Number of bus crashes per 100,000 vehicle miles	(Crashes x 100,000,000) / (AADT x 365 x Length (miles))	Crash count and locations, VMT	Federal Transit Administration	National Transit Database
Rail crash rate per VMT	Number of rail crashes per 100,000 vehicle miles	((Crashes x 100,000,000) / (AADT x 365 x Length (miles))	Crash count and locations, VMT	Federal Transit Administration Federal Railroad Administration	National Transit Database FRA Crash Statistics
Vehicle crash severity	Number of fatality and serious injury crashes	Associate weighted value to crash severity to obtain a weighted count, then rank segments by weighted count	Crash severity	TxDOT	Crash Records Information System (CRIS)
Congestion					
Planning time index (80th, 95th percentile)	Total travel time that should be planned for a trip in order to ensure that one reaches their destination on time 80/95 percent of the time.	80th and 95th percentile travel time divided by the free-flow travel time	Travel time distribution, free-flow travel time	TranStar FHWA Inrix	Travel time and speed data FHWA National Performance Management Research Data Set (NPMRDS) Inrix travel time data
Person miles of travel	Person miles of travel (based on segment length, vehicle volume and average vehicle occupancy, transit ridership per route).	AADT x weekday adjustment x hourly factor x persons/vehicle	Segment length, traffic volume, vehicle occupancy, transit ridership per route	TxDOT	Statewide Planning Map and Traffic Maps
Percent of highway lane-miles	Percent of highway lane-miles	% of CMP network highway	Speed or travel time,	TranStar	Travel time and speed

Goal Area/ Performance Measure	Definition	Calculation Method	Data Required	Source Agency	Source Data System
severely congested	operating below established congestion threshold (e.g., level of service (LOS) F, volume-to-capacity (V/C) >1.0, etc.)	segments > congestion threshold	volume, capacity, determination of congestion threshold (e.g., LOS F, V/C > 1,0, speed < 45 mph)	FHWA Inrix	data FHWA National Performance Management Research Data Set (NPMRDS) Inrix travel time data
Percent of arterial lane-miles severely congested	Percent of arterial lane-miles operating below established congestion threshold (e.g., level of service (LOS) F, volume-to-capacity (V/C) >1.0, etc.)	% of CMP network arterial segments > congestion threshold	Speed or travel time, volume, capacity, determination of congestion threshold (e.g., LOS F, V/C > 1,0, speed < 45 mph)	TranStar FHWA Inrix	Travel time and speed data FHWA National Performance Management Research Data Set (NPMRDS) Inrix travel time data
Traveler-hours of delay	Annual number of traveler-hours of delay. Delay is based on travel speeds operating below established congestion threshold speed. Provides a measure of congestion intensity.	((VMT/Speed) – (VMT/free-flow speed)) x persons/veh	Speed or travel time, VMT on corridor segments, free flow speed, determination of congestion threshold (e.g., LOS F, V/C > 1,0, speed < 45 mph), vehicle occupancy	TranStar FHWA Inrix	Travel time and speed data FHWA National Performance Management Research Data Set (NPMRDS) Inrix travel time data
Transit vehicle peak-hour load factor	Average load factor on express bus/freeway bus rapid transit (BRT) routes during the peak hour	(Passengers)/(Seating Capacity)	Transit ridership during peak hour, bus capacity	METRO	Monthly ridership reports
Operations					
Incident clearance time on highways	Time between initial notification time and the time the last responder leaves the scene for incidents occurring on highways	Average	Time of initial incident notification, time that the last responder has left the scene, incident location	TranStar	Regional Incident Management System (RIMS) database
Incident clearance time on	Time between initial	Average	Time of initial incident	TranStar	RIMS database

Goal Area/ Performance Measure	Definition	Calculation Method	Data Required	Source Agency	Source Data System
arterials	notification time and the time the last responder leaves the scene for incidents occurring on arterials		notification, time that the last responder has left the scene, incident location		
Accessibility					
Percent of population and jobs with access to transit	Percent of population and jobs located within one-quarter mile of local bus, service or one-half mile of commuter bus service	Use census data overlaid into GIS on the CMP transit network with a buffer zone of walking	GIS transit stop locations and spatial demographic data	H-GAC	GIS datasets for census blocks, bus routes, and bus stops
Percent of freight terminals/intermodal facilities located within 5 miles of a freeway	Percent of freight terminals/intermodal facilities (air, rail, and truck cargo) located within 5 miles of a freeway	(Freight terminals within 5 miles of freeway) / (Total number of freight terminals)	Location of freight terminals/intermodal facilities	TxDOT	Statewide Planning Map / Railroad
Connectivity index for pedestrian and bikeway system	Measurement of the density of pedestrian and bikeway connections in the road network and directness of links	(Actual travel distance) / (Direct travel distance)	Location of pedestrian/ bicycle facilities, bicycle and pedestrian trip origin/ destination, number of street links, number of nodes	H-GAC	GIS datasets for bikeways and pedestrian facilities
Total truck congestion cost relative to total truck commodity value (percent)	Total truck congestion cost relative to total truck commodity value (percent).	(Delay on segment x cost of delay) / (Commodity value traveling on segment)	Truck-hours of delay, commercial vehicle operator value of time, wasted fuel, fuel costs, total truck commodity value	FHWA	Freight Analysis Framework (FAF) Data Tabulation Tool
Commute split	Percentage or number of commuter trips (or all trips) by mode	(Number of commuters on Mode A) / (Total number of commuters)	Mode choice by trip	Central Houston, Inc. Transportation Committee	Downtown Commute Survey 2013
Delay savings per dollar invested (benefit/cost ratio)	Benefit-cost calculation indicating the value of transportation investments in terms of delay savings	(Time saved x VOT) / (Cost of implementation and operation)	Traveler hours of delay, traveler value of time, improvement costs	TranStar	Houston TranStar 2012 Annual Report

Goal Area/ Performance Measure	Definition	Calculation Method	Data Required	Source Agency	Source Data System
	relative to the costs of those investments.				
Natural/Cultural Resources					
Ground level ozone levels	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years.	Rank by segment	8-hour ground level ozone concentrations for 3-year period	Texas Commission on Environmental Quality (TCEQ)	Current Texas Ozone Levels
Particulate Matter (PM) 2.5 emissions	PM2.5 emissions (tons per day)	Rank by segment	PM 2.5 levels from ground level monitoring	H-GAC/TCEQ	PM 2.5 monitoring sites
GHG emissions	GHG emissions (tons per day)	Rank by segment	GHG Emissions from ground level monitoring	TCEQ	TexAER, Area Source Emissions

5.2 REGIONAL MONITORING PLAN

Current Monitoring Activities

Information about the state of the transportation system in the Houston-Galveston area is currently published as part of the Annual Mobility Report and the Houston State of Congestion report.

Annual Mobility Report

H-GAC's Annual Mobility Report, produced annually beginning in 2012, summarizes key performance measure results for each of the stated goals in the 2035 Regional Transportation Plan. The report is published in scorecard format and identifies current/previous year performance measure results for each goal area, general trend direction of performance results (e.g., increase, decrease, or no change), source of the performance measure, and a list of the top 20 projects in the Houston-Galveston region completed that year. Table 5.3 summarizes the performance measures included in the 2012 report.

Table 5.3 Annual Mobility Report Measures

2035 RTP Goal	Mode	Performance Measure
1. Improve Mobility and Reduce Congestion	Traffic Congestion	Cost per Peak Auto Commuter
	Freeway Usage	Daily Vehicle Miles of Travel (VMT)
	Transit Usage	Annual Passenger Miles of Travel (PMT)
2. Improve Access to Jobs, Homes and Services	Roadways	Lane Miles Added
	Toll	Lane Miles Added
	Bicycle	Lane Miles Added
3. Preserve the Transportation System	Roadway Pavement Conditions	Percent of Lane Miles in Good or Better Condition
	Bridge Conditions	Percent of On-system Bridges in Good or Better Condition
	Maintenance Expenditures	Non-contracted and Contracted Maintenance
4. Support Economic Growth	Sea Ports	Annual Total Tonnage
	Commercial Airports	Annual Enplaned Passengers
5. Create a Healthier Environment	Air Quality	8-Hour Ozone Standard
		NOx Emissions Reductions
6. Safety – Minimize Crashes and	Traffic Crashes	Number of Crashes

2035 RTP Goal	Mode	Performance Measure
Deaths		
	Traffic Fatalities	Number of Fatalities
7. Increase Transit Options	Light Rail	Miles Added
	Park-and-Ride Lots	Number of Lots

Houston State of Congestion Report

The Houston State of Congestion Report, produced in 2012, provides a more in-depth examination of congestion issues in the eight-county Houston region. Analysis for the 2012 report was based on archived average speed data from INRIX for over 400 miles of freeway and 3,700 miles of major streets in the region. Speed data was obtained for the time period September 2009 through May 2010. The report identifies the top 50 congested corridors and "hotspot" locations throughout the region, as well as the top 10 hotspots within each individual county.

The following performance measures are included in the 2012 report:

- Annual Person-Hours of Delay
- Annual Congestion Cost
- Travel Time Index
- Planning Time Index (90th percentile)
- Delay per Mile

In addition, the study database included the following measures for each roadway segment:

- Delay
- Congestion Cost
- Wasted Fuel
- Travel Time Index, Planning Time Index, Buffer Index
- Commuter Stress Index
- Average Speed

Recommended Monitoring Plan

In order for the Congestion Management Process to maintain quality, up to date data for the performance measures, monitoring standards and protocols must be established. The following standards and procedures for data collection/monitoring are recommended:

- The CMP should be updated at a minimum on a five year cycle in conjunction with the Regional Transportation Plan (RTP) update. However, updates to the CMP should be made in accordance with significant changes in the CMP network. System performance and strategy effectiveness should be monitored more frequently.
- An evaluation of system performance and strategy effectiveness should be done annually or biennially. It is unfeasible to expect the data for the CMP to be updated more often than every year. In addition, many data types do not update daily or monthly. On the other hand, monitoring system performance at an interval larger than one year could result in outdated numbers and lead to a delay in future CMP updates. For instance, if system performance is evaluated after one year and six months, the next evaluation is unlikely to return to the scheduled update six months later.
- The CMP performance measures should be incorporated into current monitoring activities being done through H-GAC's Annual Mobility Report and Houston State of Congestion Report. Tier 1 measures that are consistent with the RTP should be incorporated into the Annual Mobility Report; this report should continue to be produced annually. Tier 2 measures related to congestion and asset management/operations should be incorporated into the Houston State of Congestion Report; this report should be produced biennially. These actions will provide a consistent reporting mechanism for the CMP, as well as leverage existing resources for monitoring congestion patterns in the region.
- The evaluation of system performance should be done in the second half of the year to allow for reports and databases with the most recent year to be used in the CMP. This keeps the data current and consistent between years.
- If possible, it would be beneficial to integrate data from multiple sources into a single database. Integration of data types into a single location would allow ease in access and data analysis. It would also speed up data collection when it is time to update the CMP.
- Data used should be inspected for outliers and flawed data. If data is incomplete or missing, it should be corrected or thrown out. For example, data from TxDOT's CRIS can occasionally have incomplete data where a crash report was not filled out or filed correctly. This data should be discarded as it can alter performance measure results.
- Data analysis should be consistent among separate datasets. If a performance measure is being calculated for historical data, the timeline of analysis should be consistent between data types. For example, if historical bus crash rate runs from 2010 to 2013, the historical rail crash rate time interval should be the same. Consistency in time intervals allows easier comparisons among performance measures and congestion thresholds.

6.0 Congestion Problems and Needs

This section presents an analysis of congestion problems and needs in the Houston-Galveston region. The analysis focuses on identifying congested freeway segments using the following existing congestion and operations related performance measures: change in travel times; average incident clearance time; travel time index; and percent of time with average speeds below 30 mph, 40 mph and 50 mph. In the future, it is recommended that H-GAC adopt the performance measures recommended for CMP analysis and incorporate them into current monitoring activities being done through H-GAC's Annual Mobility Report and Houston State of Congestion Report.

6.1 Travel Times

The change in travel times from 2011 to 2013 was analyzed for major freeway corridors in the Houston-Galveston Area. For historical analysis, TranStar data was used since historical travel time data was unavailable from other sources. The analysis was for AM and PM peak periods which were 6-10 am and 3-7 pm, respectively. Tables 6.1 and 6.2 show the freeway corridor segments with the greatest increase in AM and PM peak period travel times from 2011 to 2013.

Table 6.1 Top 10 Increases in Travel Time for AM Peak Period (6-10 a.m.)

Freeway Corridor	From	To	Length (miles)	Direction	Percent Increase
I-610 West Loop	Ella	Stella Link	10.9	SB	37.1%
I-610 West Loop	Evergreen	Ella	9.9	NB	32.2%
I-10 Katy	Pin Oak	BW-8 W	15.3	EB	31.1%
I-610 North Loop	Wayside	Shepherd	7.2	WB	27.4%
I-10 Katy	Downtown	BW-8 W	13.8	WB	23.9%
I-610 South Loop	Broadway	Stella Link	8.9	WB	21.7%
SH-288	SH-6	Downtown	15.6	NB	21.1%
US-59 Eastex	Townsen	Downtown	19.5	SB	19.5%
SH-249	Jones	BW-8 N	6.2	SB	18.4%
US-59 Southwest	SH-99	IH-610 West	16.7	NE	17.4%

Table 6.2 Top 10 Increases in Travel Time for PM Peak Period (3-7 p.m.)

Freeway Corridor	From	To	Length (miles)	Direction	Percent Increase
I-610 West Loop	Evergreen	Ella	9.9	NB	31.2%
I-610 West Loop	Ella	Stella Link	10.9	SB	28.7%
US-59 Southwest	IH-610 West	Downtown	7.45	NE	27.1%
I-10 Katy	BW-8 W	Downtown	13.7	EB	25.7%
I-10 Katy	Downtown	BW-8 W	13.8	WB	24.2%
I-10 Katy	BW-8 W	Pin Oak	15.4	WB	20.9%
SH-249	BW-8 N	Northpointe	7.7	NB	20.3%
Westpark Tollway	Hillcroft	SH-6	8.6	WB	19.3%
US-59 Southwest	Downtown	IH-610 West	7.45	SW	19.0%
I-10 Katy	Pin Oak	BW-8 W	15.3	EB	16.0%

The freeways with observed large increases in travel time for both AM and PM peak periods are:

- I-610 West Loop NB and SB
- I-10 Katy EB from Pin Oak to BW-8 W
- I-10 Katy WB from Downtown to BW-8 W

6.2 Incident Clearance Time

Another indicator of congestion is the average clearance time for incidents. TranStar provides incident clearance time data in its Regional Incident Management System (RIMS). The data includes freeways and major arterials in the Houston area. Table 6.3 lists the statistical characteristics of the incident clearance times.

Table 6.3 Incident Clearance Time Characteristics for TranStar Network

Average (min)	31.1
Standard Deviation (min)	14.4
Average + One Standard Deviation (min)	45.5

The average + one standard deviation provides the congestion threshold for incident clearance times. Table 6.4 lists the roadways that exceed the congestion threshold and provides the number of incidents in 2013. Roadways with a single incident in 2013 that were above the congestion threshold were excluded because of the small sample size.

Table 6.4 Roadways Above Incident Clearance Time Threshold

Roadway	Incident Clearance Time (min)	Incident Count
FM 528	230	2
FM 521 Almeda	203	2
Spur 330	198	6
US-90 Alternate	184	17
SH-146	168	33
BS-90/Old Beaumont Hwy	138	6
FM 1960	121	3
SH-6	107	10
IH-10 Katy HOV	69	11
US-90	64	5
Hardy Airport Connector	63	5
SH-225	56	105
Nasa Rd 1	55	4
IH-10 East	49	457

Although IH-10 East is only slightly over the congestion threshold, it is concerning considering the high number of vehicle incidents. The high incident clearance rates at US-90 Alternate, SH-146, SH-6, IH-10 Katy HOV, and SH-225 are also reflections of potential incident management problems.

6.3 Travel Time Index

TranStar data for 2013 and 2014 was analyzed to determine the travel time indices in the corridors. The analysis was for AM and PM peak periods which were 6-10 a.m. and 3-7 p.m., respectively. Tables 6.5 and 6.6 show the freeway corridor segments with the highest travel time indices.

Table 6.5 Top 20 Highest TTI During the AM Peak (6-10 a.m.)

Roadway	Direction	From	To	AM Peak TTI
US-59 Eastex	Southbound	Quitman	IH-45 Gulf	3.52
IH-10 Katy	Eastbound	Greenhouse	SH-6	2.62
IH-45 Gulf	Northbound	Monroe	Broadway	2.58
IH-10 Katy	Eastbound	SH-6	Eldridge	2.55

US-290 Northwest	Eastbound	Beltway 8-West	Fairbanks-North Houston	2.53
US-59 Southwest	Southbound	IH-45 Gulf	Fannin	2.52
SH-289	Northbound	Beltway 8-South	Airport	2.46
IH-10 Katy	Eastbound	Westgreen	Greenhouse	2.45
IH-45 Gulf	Northbound	Edgebrook	Monroe	2.38
SH-288	Northbound	McHard	Beltway 8-South	2.36
US-290 Northwest	Eastbound	Barker-Cypress	SH-6/FM-1960	2.33
US-290 Northwest	Eastbound	SH-6/FM-1960	Beltway 8-West	2.32
IH-610 West Loop	Southbound	Shepherd	IH-10 Katy	2.27
IH-45 North	Southbound	IH-10 Katy	Allen Parkway	2.26
IH-45 North	Southbound	North Shepherd	Crosstimbers	2.24
Beltway 8-North	Eastbound	Ella	Hardy Toll Road	2.19
IH-10 East	Westbound	Lockwood	US-59 Eastex	2.19
US-59 Southwest	Northbound	Williams Trace	Wilcrest	2.17
US-59 Southwest	Northbound	Hillcroft	IH-610 West Loop	2.08
IH-45 North	Southbound	Aldine-Bender (FM-525)	North Shepherd	2.08

Table 6.6 Top 20 Highest TTI During the PM Peak (3-7 p.m.)

Roadway	Direction	From	To	PM Peak TTI
US-59 Southwest	Northbound	Hazard	Fannin	4.66
IH-610 West Loop	Northbound	US-59 Southwest	Westheimer	4.08
US-59 Southwest	Northbound	Fannin	IH-45 Gulf	3.29
IH-610 West Loop	Southbound	IH-10 Katy	Westheimer	3.12
US-59 Southwest	Southbound	IH-45 Gulf	Fannin	2.91
IH-45 Gulf	Southbound	Woodridge	Broadway	2.88
US-59 Southwest	Northbound	Newcastle	Hazard	2.76
IH-45 North	Southbound	IH-10 Katy	Allen Parkway	2.74
Beltway 8-North	Eastbound	Ella	Hardy Toll Road	2.46
US-290 Northwest	Westbound	West 34th	Pinemont	2.42
IH-45 Gulf	Southbound	Wayside	Woodridge	2.41
US-290 Northwest	Westbound	Beltway 8-West	SH-6/FM-1960	2.39
Westpark Tollway	Westbound	Gessner	Wilcrest	2.38
IH-45 North	Northbound	Crosstimbers	North Shepherd	2.33

IH-10 Katy	Westbound	Blalock	Beltway 8-West	2.29
SH-289	Southbound	IH-610 South Loop	Airport	2.28
IH-10 Katy	Eastbound	T.C. Jester	Taylor	2.28
IH-45 Gulf	Southbound	Fuqua	Dixie Farm Road (FM-1959)	2.27
US-59 Eastex	Southbound	Quitman	IH-45 Gulf	2.24
IH-610 West Loop	Southbound	US-59 Southwest	Evergreen	2.24

6.4 Reduced Speed

TranStar data for 2013 and 2014 was analyzed to determine the 15-minute speed profiles in the corridors. The analysis was for the entire daily speed distribution. Tables 6.7, 6.8 and 6.9 show the freeway corridor segments with the highest percentages of the day below 30 mph, 40 mph and 50 mph, respectively. Tables 6.10 and 6.11 show the freeway corridor segments with the lowest average speeds during the AM and PM peak periods, respectively.

Table 6.7 Top 20 Freeway Segments with the Longest Duration Below 30 mph

Roadway	Direction	From	To	Free Flow Speed (mph)	% of Day Below 30 mph
US-290 Northwest	Eastbound	Pinemont	West 34th	35.5	33.3%
IH-610 West Loop	Southbound	Shepherd	IH-10 Katy	49.3	28.1%
IH-45 North	Southbound	IH-10 Katy	Allen Parkway	66.6	26.0%
IH-610 West Loop	Northbound	US-59 Southwest	Westheimer	63.7	26.0%
US-59 Eastex	Southbound	Quitman	IH-45 Gulf	63.7	26.0%
US-59 Southwest	Southbound	IH-45 Gulf	Fannin	66.0	26.0%
IH-610 West Loop	Southbound	IH-10 Katy	Westheimer	66.2	22.9%
US-59 Southwest	Northbound	Hazard	Fannin	64.8	20.8%
Beltway 8-North	Eastbound	Ella	Hardy Toll Road	68.4	19.8%
US-290 Northwest	Eastbound	West 34th	IH-610 West Loop	58.8	18.8%
SH-289	Northbound	MacGregor	US-59 Southwest	52.0	17.7%
IH-45 Gulf	Southbound	Woodridge	Broadway	65.4	15.6%
US-59 Southwest	Northbound	Fannin	IH-45 Gulf	64.0	15.6%
SH-288	Northbound	IH-610 South Loop	MacGregor	48.3	14.6%
IH-10 Katy	Westbound	US-59 Eastex	Taylor	63.8	13.5%

IH-10 Katy	Westbound	Taylor	T.C. Jester	65.0	13.5%
US-290 Northwest	Westbound	West 34th	Pinemont	56.1	13.5%
IH-45 Gulf	Northbound	Monroe	Broadway	66.3	12.5%
IH-45 North	Northbound	Crosstimbers	North Shepherd	64.5	12.5%
US-59 Southwest	Northbound	Newcastle	Hazard	64.5	12.5%

Table 6.8 Top 20 Freeway Segments with the Longest Duration Below 40 mph

Roadway	Direction	From	To	Free Flow Speed (mph)	% of Day Below 40 mph
US-290 Northwest	Eastbound	Pinemont	West 34th	35.5	100.0%
IH-610 West Loop	Southbound	Shepherd	IH-10 Katy	49.3	51.0%
IH-45 North	Southbound	IH-10 Katy	Allen Parkway	66.6	41.7%
IH-610 West Loop	Southbound	IH-10 Katy	Westheimer	66.2	34.4%
IH-610 West Loop	Northbound	US-59 Southwest	Westheimer	63.7	33.3%
US-59 Southwest	Southbound	IH-45 Gulf	Fannin	66.0	32.3%
US-59 Eastex	Southbound	Quitman	IH-45 Gulf	63.7	31.3%
US-290 Northwest	Eastbound	West 34th	IH-610 West Loop	58.8	29.2%
US-59 Southwest	Northbound	Hazard	Fannin	64.8	28.1%
IH-10 Katy	Eastbound	SH-6	Eldridge	67.9	26.0%
SH-289	Northbound	MacGregor	US-59 Southwest	52.0	26.0%
IH-45 Gulf	Northbound	Wayside	Scott	66.0	25.0%
IH-45 Gulf	Northbound	Scott	Allen Parkway	62.9	25.0%
Beltway 8-North	Eastbound	Ella	Hardy Toll Road	68.4	24.0%
US-290 Northwest	Westbound	West 34th	Pinemont	56.1	24.0%
IH-10 Katy	Eastbound	Eldridge	Kirkwood	64.3	22.9%
IH-10 Katy	Eastbound	T.C. Jester	Taylor	66.6	22.9%
IH-10 Katy	Westbound	US-59 Eastex	Taylor	63.8	21.9%
IH-45 North	Southbound	Aldine-Bender (FM-525)	North Shepherd	67.0	21.9%
IH-610 West Loop	Northbound	Evergreen	US-59 Southwest	63.6	20.8%

Table 6.9 Top 20 Freeway Segments with the Longest Duration Below 50 mph

Roadway	Direction	From	To	Free Flow Speed (mph)	% of Day Below 50 mph
US-290 Northwest	Eastbound	Pinemont	West 34th	35.5	100.0%
IH-610 West Loop	Southbound	Shepherd	IH-10 Katy	49.3	82.3%
IH-45 North	Southbound	IH-10 Katy	Allen Parkway	66.6	56.3%
IH-45 Gulf	Northbound	Scott	Allen Parkway	62.9	53.1%
US-290 Northwest	Westbound	West 34th	Pinemont	56.1	49.0%
US-59 Southwest	Southbound	IH-45 Gulf	Fannin	66.0	49.0%
US-290 Northwest	Eastbound	West 34th	IH-610 West Loop	58.8	46.9%
IH-610 West Loop	Southbound	IH-10 Katy	Westheimer	66.2	45.8%
IH-45 Gulf	Northbound	Wayside	Scott	66.0	44.8%
US-59 Southwest	Northbound	Hazard	Fannin	64.8	42.7%
IH-610 West Loop	Northbound	US-59 Southwest	Westheimer	63.7	41.7%
IH-610 North Loop	Westbound	Irvington	Shepherd/Durham	55.3	40.6%
IH-45 North	Northbound	Crosstimbers	North Shepherd	64.5	39.6%
US-59 Eastex	Southbound	Quitman	IH-45 Gulf	63.7	39.6%
IH-45 Gulf	Southbound	Allen Parkway	Scott	64.4	35.4%
IH-10 East	Eastbound	Taylor	US-59 Eastex	65.4	34.4%
IH-45 Gulf	Northbound	Monroe	Broadway	66.3	33.3%
IH-10 Katy	Eastbound	Eldridge	Kirkwood	64.3	32.3%
IH-10 Katy	Eastbound	T.C. Jester	Taylor	66.6	32.3%
IH-45 North	Southbound	Aldine-Bender (FM-525)	North Shepherd	67.0	32.3%

Table 6.10 Top 20 Lowest Average Speeds During AM Peak (6-10 a.m.)

Roadway	Direction	From	To	Lowest AM Peak Speed (mph)
US-59 Eastex	Southbound	Quitman	IH-45 Gulf	18.1
IH-610 West Loop	Southbound	Shepherd	IH-10 Katy	21.7
US-290 Northwest	Eastbound	Pinemont	West 34th	22.1
SH-288	Northbound	McHard	Beltway 8-South	23.9
IH-45 Gulf	Northbound	Monroe	Broadway	25.7

US-290 Northwest	Eastbound	Beltway 8-West	Fairbanks-North Houston	26.0
US-59 Southwest	Southbound	IH-45 Gulf	Fannin	26.2
SH-289	Northbound	Beltway 8-South	Airport	26.2
IH-10 Katy	Eastbound	SH-6	Eldridge	26.6
IH-10 Katy	Eastbound	Greenhouse	SH-6	26.7
IH-10 Katy	Eastbound	Westgreen	Greenhouse	26.7
IH-45 North	Southbound	North Shepherd	Crosstimbers	28.3
IH-45 Gulf	Northbound	Edgebrook	Monroe	28.6
IH-10 East	Westbound	Lockwood	US-59 Eastex	29.1
IH-45 North	Southbound	IH-10 Katy	Allen Parkway	29.5
US-290 Northwest	Eastbound	Barker-Cypress	SH-6/FM-1960	29.5
IH-610 North Loop	Westbound	Irvington	Shepherd/Durham	29.6
US-290 Northwest	Eastbound	West 34th	IH-610 West Loop	29.8
US-290 Northwest	Eastbound	SH-6/FM-1960	Beltway 8-West	29.9
US-59 Southwest	Northbound	Williams Trace	Wilcrest	30.9

Table 6.11 Top 20 Lowest Average Speeds During PM Peak (3-7 p.m.)

Roadway	Direction	From	To	Lowest PM Peak Speed (mph)
US-59 Southwest	Northbound	Hazard	Fannin	13.9
IH-610 West Loop	Northbound	US-59 Southwest	Westheimer	15.6
US-59 Southwest	Northbound	Fannin	IH-45 Gulf	19.5
IH-610 West Loop	Southbound	IH-10 Katy	Westheimer	21.2
US-59 Southwest	Southbound	IH-45 Gulf	Fannin	22.7
IH-45 Gulf	Southbound	Woodridge	Broadway	22.7
US-290 Northwest	Westbound	West 34th	Pinemont	23.2
US-59 Southwest	Northbound	Newcastle	Hazard	23.4
IH-45 North	Southbound	IH-10 Katy	Allen Parkway	24.3
IH-45 Gulf	Southbound	Fuqua	Dixie Farm Road (FM-1959)	25.3
US-290 Northwest	Eastbound	Pinemont	West 34th	25.7
SH-290	Northbound	MacGregor	US-59 Southwest	25.9
IH-610 West Loop	Southbound	Shepherd	IH-10 Katy	26.8
Westpark Tollway	Westbound	Gessner	Wilcrest	27.0
IH-45 Gulf	Southbound	Wayside	Woodridge	27.0

SH-289	Southbound	IH-610 South Loop	Airport	27.2
IH-10 Katy	Westbound	Blalock	Beltway 8-West	27.6
IH-45 North	Northbound	Crosstimbers	North Shepherd	27.7
IH-610 West Loop	Southbound	US-59 Southwest	Evergreen	27.8
Beltway 8-North	Eastbound	Ella	Hardy Toll Road	27.9

7.0 Congestion Management Strategies

Congestion management strategies include a variety of projects, actions and programs, and strategies that will best mitigate congestion in the Houston region. The strategies were identified based on existing H-GAC and partner agency reports (e.g., CMP, MTP, TIP, METRO Re-imagining Plan, etc.), strategies included in H-GAC's Commute Solutions program, and other agency best practices. The recommended strategies are consistent with the proposed CMP objectives defined in Section 2.0. Only strategies that best meet the unique characteristics and needs of the Houston region's transportation land use and system, and that can be achieved and implemented, are included.

This section provides a framework for identifying and evaluating congestion management strategies, presents a general toolbox of potential CMP strategies for application, and describes potential evaluation methods and the expected effectiveness and impact of the strategies.

7.1 Identifying Strategies

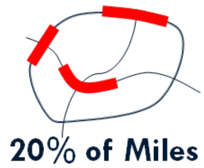
One of the key components of the CMP is to identify a set of recommended solutions to effectively manage congestion and achieve regional congestion management goals and objectives. Federal guidance recommends that identification of strategies be based on their ability to support regional congestion management objectives, meet local context and relevance, contribute to other regional goals and objectives, and consider the coordination and collaboration that will be needed to assign jurisdictional responsibility for implementing the strategies.

An agency must also have an understanding of the nature of the need and current operating characteristics of the system/corridor/project location. Congestion management strategies may vary depending on: (1) the specific issue or dimension of congestion that needs to be addressed (see Figure 7.1), (2) the objectives to be accomplished through the strategy, (3) whether the strategy is to be implemented on new capacity or an existing facility, (4) the availability of right-of-way, (5) current operational characteristics of the system/corridor/ project location, and (6) environmental and societal concerns.

Figure 7.1 Different Dimensions of Congestion

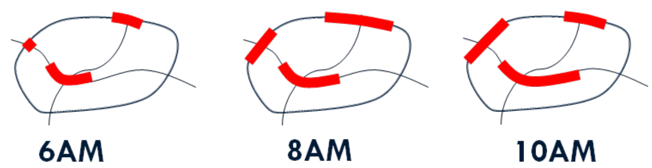
Spatial

How much of the system is congested? The image presents an example of a metropolitan highway network with 20 percent of all miles congested.



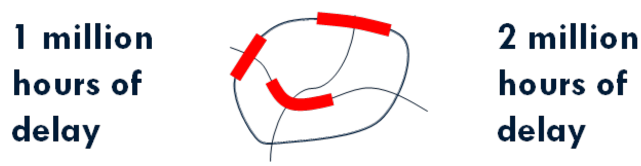
Temporal

How long does congestion last? The image presents an example of a metropolitan highway network with congestion from 6:00 a.m. through 10:00 a.m.



Severity

How much delay is there or how low are travel speeds? The image shows that for the same percentage of miles congested, the number of vehicles and total hours of vehicular delay can be different.



Variability

How does congestion change from day to day? The image shows how the severity and location of congestion can change from day to day. More variation in travel time indicates less reliable travel. A reliable system would have consistent levels of congestion from hour to hour and day to day.

The CMP goals, objectives, and actions identified in Section 2.0 provide additional context for identifying appropriate strategies to resolve specific congestion issues. For example, if incidents prove to cause unreliable travel on a project corridor, the analyst might consider operations/intelligent transportation system (ITS) strategies such as incident detection and management. Table 7.1 identifies potential actions and strategies based on CMP objectives.

The table also identifies performance measures that can be used to evaluate potential congestion management strategies. Important criteria for selecting these measures include: 1) ability to support CMP goals and objectives; 2) ability to evaluate progress in meeting these goals and objectives; and 3) ability to be calculated with existing data. As a result, only Tier 1 (2040 RTP measures) and Tier 2 (supported by current data/models) performance measures are included.

Table 7.1 Strategy Identification

2040 RTP Goals & Objectives	CMP Goals & Objectives	CMP Actions & Strategies	CMP Performance Measures
Improve Safety: Reduce the rate and severity of crashes for all system users	Reduce the rate and severity of crashes for all system users	Assess the safety benefits of TDM, TSM, operations/ITS, transit, and roadway strategies, projects, and programs	Traffic, bus, rail crash rate per VMT
Manage and Mitigate Congestion: Increase reliability across all modes and systems of travel in the region	Improve transportation system reliability across all modes and systems of travel in the region Emphasize TDM, TSM, Operations, and ITS Solutions Increase opportunities for travelers to use regional and local transit services Maintain or reduce percent of lane-miles severely congested during the peak period Maintain or reduce traveler hours of delay on all modes Reduce transit vehicle crowding during peak hours	Develop tools and processes to better manage transportation system congestion into the future by implementing a comprehensive set of TDM, TSM, operations/ITS, transit, and pedestrian/bicycle strategies Link transit strategies, programs, and projects directly with Houston Metro's ongoing Reimagining Study for evaluation within the CMP	Planning time index (80th 95th percentile) Person miles of travel Lane-miles severely congested on highways Traveler hours of delay on highways (for all vehicles including transit, truck, auto) Transit vehicle peak-hour load factor
Ensure Strong Asset Management and Operations: Preserve and enhance system functionality to maintain capacity and efficiency; Promote a state of good repair to facilitate the movement of people and goods	Reduce the impacts of incidents on traffic flow Reduce incident clearance time for incidents on highways and arterials	Implement operations/ITS strategies that enhance the region's traffic incident management program	Incident clearance time on highways
Bolster Regional Economic Competitiveness: Improve cost competitiveness of goods movement; attract a highly skilled workforce	Accessibility – Increase opportunities for travelers to use regional and local transit services and participate in TDM programs to provide more travel choices Goods Movement – Improve system operational efficiency and accessibility to accommodate freight movement within the region Increase alternative (non-SOV)	Accessibility - Emphasize TDM strategies to better manage congestion across the transportation system Accessibility – Identify/link transit strategies, programs, and projects from Metro's Re-Imagining Study in the CMP Goods Movement – Emphasize reliability/ operational efficiency on	Commute Split Total truck congestion costs relative to commodity value Percent of population and jobs with access to transit (within ¼ mile) Percent of freight terminals/intermodal facilities within 5 miles of a freeway/ tollway Connectivity index for

	mode share for commuter trips Increase access to transit (within ¼ mile) to specified percentage of the population and jobs Increase accessibility to freight terminals/intermodal facilities from freeways/tollways	major freight corridors in the region	pedestrian and bikeway system
Conserve and Protect Natural and Cultural Resources: Minimize loss of wetlands, natural and historic resources due to transportation project development; Reduce emissions to improve air quality and meet air quality standards	Reduce emissions through congestion management	Assess the air quality benefits of TDM, TSM, and operations/ITS strategies, projects, and programs	Ground-level ozone levels PM 2.5 Emissions

Source: Memorandum – HGAC-CMP Update – Subtask 3.1 – Draft Technical Memorandum Summary of the CMP Regional Objectives, April 24, 2014

7.2 Congestion Management Toolbox

Guiding principles for H-GAC's CMP suggest that preference be given to demand management strategies that eliminate or reduce travel, while leaving high-cost capacity increases that primarily serve single occupant vehicle travel as a last resort. The following is a list of congestion management strategy types in hierarchical order:

9. Transportation demand management (TDM) strategies that eliminate or reduce the need to make trips by motor vehicle
10. Land use strategies that promote mixed-use and transit-oriented development and allow for reduced use of motor vehicles for some discretionary trips
11. Strategies that expand public transportation and promote the use of higher occupancy modes
12. Operational improvements and Intelligent Transportation Systems (ITS) that make the best use of existing capacity
13. Pricing strategies that reduce vehicle demand
14. Bicycle and pedestrian strategies that shift trips to bicycling and walking modes
15. Roadway/mobility (non-ITS) strategies that are designed to help improve operations and relieve bottlenecks on existing facilities through non-capacity adding improvements

16. Roadway capacity expansion strategies such as adding additional capacity to existing roadway facilities or constructing new roadway facilities that serve newer developed or rapidly developing areas, or where gaps exist in the existing freeway or arterial network

Each strategy type is described in greater detail below. Table 7.2 provides a congestion management toolbox that identifies strategies within each of the hierarchical categories. Some of the strategies are more regional or systemwide in applications, while others are corridor or project specific. For each of the projects and strategies, the potential for congestion reduction benefits is indicated, along with a recommended analysis method to help with location-specific assessment and prioritization. Order-of-magnitude cost estimates are also provided based on national cost data built into IDAS and the TOPS-BC software. Finally, the toolbox indicates strategies that are complementary, and in what situations they are best used together.

Transportation Demand Management

Ten different TDM categories are identified including alternative work hours, telecommuting, road pricing, and toll roads. The costs of these strategies tend to be low to moderate and have benefits such as reducing peak period travel and reducing single-occupant VMT. These, in turn can provide a number of environmental benefits including improved air quality and reduce greenhouse gas emissions. TDM strategies can be grouped well with various public transportation services as well as land use and bicycle and pedestrian strategies.

Land Use and the Built Environment

Five strategies related to land use and the built environment are identified including infill development, transit oriented development (TOD), and densification efforts. Effective land use strategies decrease SOV trips, increase walk trips as well as transit mode share, and provide air quality benefits to the region. Most practices in this category are important components to transit friendly and transit oriented developments.

In addition to the strategies outlined above, Transportation Management Associations may be established. These are nonprofit, member-controlled organizations that provide transportation services in a particular area, such as a commercial district, mall, medical center, or industrial park. They are generally public-private partnerships consisting primarily of area businesses with local government support.

Generally, land use strategies have low to moderate costs and tend to involve the establishment of ordinances and the potential need for economic incentives that will encourage developer buy-in.

Table 7.2 Congestion Management Toolbox

Project/Mode Type	Congestion Impacts	Application Scale	Implementation Costs	Implementation Timeframe	Analysis Tools	Grouping
1. Transportation Demand Management Strategies						
Alternative Work Hours – This allows workers to arrive and leave work outside of the traditional commute period. It can be on a scheduled basis or a true flex-time arrangement. Can also include a compressed work week.	• Reduce peak-period VMT • Improve travel time among participants • Reduction in peak period SOV trips	• Region	• No capital costs • Agency costs for outreach and publicity • Employer costs associated with accommodating alternative work schedules	• Employer-based • Short-term: 1 to 5 years	• TDM Evaluation Models • Vehicle Emissions Model • Regional Travel Model	
Telecommuting – This involves employees to work at home or regional telecommute center instead of going into the office. They might do this all the time, or only one or more days per week. Also include teleconferencing and videoconferencing - The live exchange of information among several persons and machines linked by telecommunications.	• Reduce peak period VMT • Reduce peak period SOV trips • Fewer drivers during morning and afternoon rush hours • Increased employee productivity, improved employee retention and recruitment, reduced overhead costs and lower demand for physical office and parking space • Decreased commuting time (VHT) and expenses for employees	• Region	• First-year implementation costs for private-sector (per employee for equipment) • Second-year costs tend to decline	• Employer-based • Short-term: 1 to 5 years	• TDM Evaluation Models • Vehicle Emissions Model • Regional Travel Model	• Telework participants may also be interested in alternative travel mode services on days
Ridesharing – This is typically arranged/encouraged through employers or transportation management agencies (TMA) that provide ride-matching services. Programs to promote carpooling and vanpooling, including ridematching services and policies that give ridesharing vehicles priority in traffic and parking.	• Reduce commuter-based VMT • Reduce peak period SOV trips • Lower commuting costs • Reduce parking congestion • Promote transit, biking and walking	• Region	• Low to Moderate • Savings per carpool and vanpool riders • Costs per year per free parking space provided • Administrative costs	• Employer-based • Short-term: 1 to 5 years	• TDM Evaluation Models • Vehicle Emissions Model • Regional Travel Model	• Cross-promotion of complementary transit services can result in greater overall benefits • Programs to encourage carpooling to transit stations may have merit • Services that provide an emergency ride home to car/vanpoolers (e.g. Guaranteed Ride Home) should be provided • Employer-based "trip reduction managers" can operate programs geared toward their employees
Guaranteed Ride Home Policies – Provides a guaranteed ride home at no cost to the employee in the event an employee or a member of their immediate family becomes ill or injured, requiring the employee to leave work	• Decrease work VMT • Decrease SOV trips	• Region • Project	• Requires administrative support from employers • Potential to be costly	• Employer-based • Short-term: 1 to 5 years	• TDM Evaluation Models • Vehicle Emissions Model	• Employee incentives • Carpool and vanpool programs • Telecommuting
Trip Reduction Strategies – Plans, policies, and regulations instituted to reduce the use of SOVs for commuting; often linked to air quality planning.	• Reduce VMT • Reduce SOV trips • Increase alternative modes share • Increase transit mode share	• Region	• First-year implementation costs for private-sector (per employee equipment) • Second-year costs tend to decline • Requires interagency and private sector coordination	• Employer-based • Short-term: 1 to 5 years	• Vehicle Emissions Model • TDM Evaluation Models	• Travel demand management strategies
Alternative travel mode events and assistance – Variety of events that promote, encourage and educate	• Fewer single-occupant vehicles on the road and less overall traffic congestion	• Region	• Low • Cost can be relatively low,	• Short-term		• Cross-promotion of complementary transit services can result in greater

Project/Mode Type	Congestion Impacts	Application Scale	Implementation Costs	Implementation Timeframe	Analysis Tools	Grouping
people about alternative travel modes (e.g. Bike to Work Day, RideSmart Thursdays and employer transportation fairs). Programs that provide free or low-cost transit services (e.g. EcoPass) or other incentives	• Lower commuting costs		depending on the level of participation from employers and sponsors			overall benefits • Provision of additional transit or vanpool service and construction of bicycling facilities offers further encouragement • Complementary facilities such as high-occupancy vehicle (HOV) lanes that offer carpools a less-congested roadway
Public Education Campaigns – E.g. driving habits, trip chaining, idle reduction, hard acceleration (i.e., jackrabbit starts)	• Air Quality Benefit Medium • Positive user impacts	• Region		• Immediate		• Improved safety (auto, transit, bicycle and pedestrians)
Traditional Toll Roads – Payment charged for passage on roads, bridges or ferries that carry cars. Primary use as a revenue generator to help pay for building new facilities and maintaining infrastructure. Often associated with bonding for infrastructure.	• Improve mobility/reduce congestion on freeways • Provide additional roadway capacity • GHG Reduction	• Region • Corridor		• Mid term (3 to 10 years) for implementation • Long term (11+ years) before strategy becomes effective	• Regional Travel Model	• Land Use and Built Environment (e.g., Combined land use and transportation strategies) • Transportation Demand Management Operations and ITS (e.g., traveler information) • Public Transportation (e.g., transit use of toll lanes) • Capacity Expansion/Bottleneck Relief • Electronic toll collection methods
Non-traditional toll roads – Travelers choose to pay for passage on roads that carry cars. Implemented similarly to traditional toll roads, but with non-traditional implementation: Managed Lanes – A toll lane or lanes designed to increase freeway efficiency through a combination of operational and design actions; and HOT Lanes – High Occupancy Vehicle (HOV) toll lanes that allow a limited number of low-occupancy vehicles to use the lane if a fee is paid. Typically free for HOVs	• Improve mobility • Decrease peak period VMT • Decrease SOV trips • Utilize unused roadway capacity	• Region • Corridor		• Short-term: 1 to 5 years	• TDM Evaluation Models • Vehicle Emissions Model • Regional Travel Model • IDAS • TOPS-BC	• Telework • Flexible work hours • HOV Lanes • Electronic toll collection • Electronic sign messaging
Car sharing – Program in which automobile rental services are used to substitute private vehicle use and ownership. Programs are designed to be accessible to residences, affordable, follow easy check-in/out processes, and reliable. Includes both peer to peer and commercial (such as zip car). Peer to peer car sharing, also known as Personal Vehicle Car-Sharing (PVCS) enables private car owners to make their vehicle available on a temporary basis to a private carsharing company for rental. In return, the vehicle owner gets a substantial portion of the rental revenue from the carsharing company. When not rented, the vehicle owner can continue to use their car as before. Commercial Car Sharing, run by private firms such as Zip Car, maintain a fleet of vehicles that are deployed regionally (neighborhoods) for rental and use.	• Provide cost savings to users • Reduce parking congestion • Promote transit, biking, and walking • Increase public health through physical activity and walkability	• Region		• Near-Term to Mid-Term • Implemented within 1 to 2 years or between 3 to 10 years depending on the level of service changes and magnitude of project		• Other Transportation Demand Management • Public Transportation • Land Use and Built Environment • Bicycle and Pedestrian
2. Land Use Strategies						

Project/Mode Type	Congestion Impacts	Application Scale	Implementation Costs	Implementation Timeframe	Analysis Tools	Grouping
Mixed-Use Development – This allows many trips to be made without automobiles. People can walk to restaurants and services rather than use their vehicles	• Increase walk trips • Decrease SOV trips • Decrease in VMT • Decrease vehicle hours of travel	• Region	• Public costs to set up and monitor appropriate ordinances • Economic incentives used to encourage developer buy-in	• Long-term: 10 or more years	• Regional Travel Model • TDM Evaluation Models	
Infill and Densification – This takes advantage of infrastructure that already exists, rather than building new infrastructure on the fringes of the urban area.	• Decrease SOV • Increase transit, walk, and bicycle • Doubling density decreases VMT per household • Medium/high vehicle trip reductions • Air quality benefit to densification	• Region	• Public costs to set up and monitor appropriate ordinances • Economic incentives used to encourage developer buy-in	• Long-term: 10 or more years	• Regional Travel Model • TDM Evaluation Models	
Transit-Oriented Development – This clusters housing units and/or businesses near transit stations in walkable communities.	• Decrease SOV share • Shift carpool to transit • Increase transit trips • Decrease VMT • Decrease in vehicle trips • Increase transit mode share	• Region	• Public costs to set up and monitor appropriate ordinances • Economic incentives used to encourage developer buy-in	• Long-term: 10 or more years	• Regional Travel Model • TDM Evaluation Models	
Efficient land use and development practices – Areawide policies and strategies that result in a more transportation-efficient regional development pattern (e.g. urban growth boundary). Localized planning, zoning, ordinances and site approval strategies that result in more transportation-efficient developments (e.g. mixed-land-uses, higher density, urban centers, well connected transit, pedestrian and bicycling facilities)	• Less motor vehicle use through greater bicycling, walking and transit use • Related health benefits and economic savings via less infrastructure needs • Reduce VMT • Reduce SOV trips • Increase alternative modes share	• Region	• Low to moderate • Costs can vary widely and are difficult to calculate, as they will be shared by local governments, developers, home buyers, businesses and customers	• Short- to long-term • Small-scale retrofit practices, re-zonings or comprehensive plan amendments can be done in a short to moderate timeframe. • Regional-scale policy changes may take a long time to adopt and result in development changes on the ground and integration with transportation systems.	• Regional Travel Model	• Transit-oriented development (TOD)
Transportation Management Associations – Nonprofit, member-controlled organizations that provide transportation services in a particular area, such as a commercial district, mall, medical center, or industrial park. They are generally public-private partnerships consisting primarily of area businesses with local government support.	• Reduce VMT • Reduce SOV trips • Increase alternative modes share • Increase transit mode share	• Region	• First-year implementation costs for private-sector (per employee equipment) • Second-year costs tend to decline • Requires interagency and private sector coordination	• Employer-based • Short-term: 1 to 5 years	• Vehicle Emissions Model	• Travel demand management strategies
3. Public Transportation Strategies						
Reducing Transit Fares – This encourages additional transit use, to the extent that high fares are a real barrier to transit.	• Reduce daily VMT • Reduce congestion • Increase ridership	• Region	• Lost in revenue per rider • Capital costs per passenger trip • Operating costs per passenger trip • Operating subsidies needed to replace lost fare revenue • Alternative financial arrangements need to be	• Short-term: Less than one year	• Regional Travel Model • TDM Evaluation Models • Vehicle Emissions Model	

Project/Mode Type	Congestion Impacts	Application Scale	Implementation Costs	Implementation Timeframe	Analysis Tools	Grouping
			negotiated with donor agencies			
Increasing Bus Route Coverage or Frequencies – This provides better accessibility to transit to a greater share of the population. Increasing frequency makes transit more attractive to use. May require investment in new buses which would create a capital cost per passenger trip. May also include new routes or extensions to existing routes.	• Increase transit ridership • Decrease travel time • Reduce daily VMT • Improved convenience and travel reliability • Reduced traffic congestion due to trips switched from driving alone to transit	• Region	• Capital costs per passenger trip • Operating costs per trip • New bus purchases likely	• Short-term: 1 to 5 years (includes planning, engineering, and construction)	• Regional Travel Model • TDM Evaluation Models • Vehicle Emissions Model	• Transit queue jump lanes • Use of automated vehicle location (AVL) technology enables provision of real-time traveler information • Developments designed with transit friendly features and connections to and from transit stops make bus travel more convenient
Implementing Park-and- Ride Lots – These can be used in conjunction with HOV lanes and/or express bus services. They are particularly helpful for encouraging HOV use for longer distance commute trips.	• Reduce regional VMT (up to 0.1 percent) • Increase mobility and transit efficiency • Reduce SOV trips • Increased transit boardings and mode share • Decrease congestion by increasing vehicle occupancy rate	• Corridor • Project	• Structure costs for transit stations • Land acquisition costs	• Medium-term: 5 to 10 years (includes planning, engineering, and construction)	• TDM Evaluation Models • Regional Travel Model	• Increased transit service and coverage and other transit related congestion strategies • Enhanced bicycle and pedestrian facilities
HOV Lanes – This increases corridor capacity while at the same time provides an incentive for single-occupant drivers to shift to ridesharing. These lanes are most effective as part of a comprehensive effort to encourage HOVs, including publicity, outreach, park-and-ride lots, and rideshare matching services.	• Reduce regional VMT • Reduce regional trips • Increase vehicle occupancy • Improve travel times • Increase transit use and improve bus travel times	• Corridor	• HOV, separate ROW costs • HOV, barrier separated costs • HOV, contraflow costs • Annual operations and enforcement • Can create environmental and community impacts	• Medium-term: 5 to 10 years (includes planning, engineering, and construction)	• Regional Travel Model • TDM Evaluation Models • IDAS	• Non-traditional toll roads • Enhanced bus service, bus rapid transit, and TDM programs will increase the number of persons using the facility • Electronic toll collection methods are commonly used with non-traditional toll roads
Implementing Rail Transit – This best serves dense urban centers where travelers can walk to their destinations. Rail transit from suburban areas can sometimes be enhanced by providing park- and- ride lots.	• Reduce daily VMT • More consistent and sometimes faster travel times versus driving • Reduce SOV trips	• Region • Corridor	• Capital costs per passenger • New systems require large upfront capital outlays and ongoing sources of operating subsidies, in addition to funds that may be obtained from federal sources, under increasingly tight competition.	• Long-term: 10 or more years (includes planning, engineering, and construction)	• Regional Travel Model	
New Fixed Guideway Transit Travelways – Exclusive guideways (e.g. light rail, heavy/commuter rail) and street travelways (e.g. bus rapid transit (BRT)) devoted to increasing the person-carrying capacity within a travel corridor	• More consistent and sometimes faster travel times for transit passengers versus driving • Increased person throughput capacity within a corridor due to people switching from single occupant motor vehicles to transit • Stimulation of efficient mixed-use or higher-density development	• Corridor	• Moderate to high • Implementation cost will vary, but cost could be high due to acquisition of rights-of-way, materials and infrastructure.	• Medium- to long-term • Development and implementation of a rail project is a major undertaking that can take 10 or more years from initial planning phases through NEPA studies to an opening day • On-street conversion of travel lanes to BRT may not take quite as long	• Regional Travel Model	• Transit-oriented developments (TODs) adjacent to stations stimulate additional use of rail and bus services • Parking management, fare collection and other technological transit applications are important elements • Transportation demand management services and promotions encourage more transit use
Dedicated Rights-of-Way for Transit – Reserved travel lanes or rights-of-way for transit operations, including use of shoulders during peak periods	• Increase transit ridership • Decrease travel time	• Corridor	• Costs vary by type of design	• Medium-term: 5 to 10 years (includes planning, engineering, and construction)	• Regional Travel Model	• Transit signal priority • Paved shoulders

Project/Mode Type	Congestion Impacts	Application Scale	Implementation Costs	Implementation Timeframe	Analysis Tools	Grouping
Light-Rail Service Extension – High-capacity, fixed-guideway system operating on dedicated right-of-way or in mixed traffic.	• Reduce VMT • Reduce SOV trips • Increase transit ridership & mode share	• Region • Corridor	• Capital costs per passenger trip • New & expanded systems require large up-front capital outlays and ongoing sources of operating subsidies, in addition to funds that may be obtained from federal sources, under increasingly tight competition	• Long-term: 10 or more years (includes planning, engineering, and construction)	• Regional Travel Model • Vehicle Emissions Model	
Employer Incentive Programs – Encourages additional transit use through transit subsidies of mass transit fares provided by employers	• Increase transit ridership • Decrease travel time • Decrease daily VMT	• Region	• Cost of incentives to employers offering employee benefits for transit use	• Short-term: 1 to 5 years	• Vehicle Emissions Model	• Increasing transit/bus route coverage and frequency • Carpool, vanpool, and rideshare programs
Electronic Payment Systems and Universal Fare Cards – Interchangeable smartcard payment system (including RFID) that can be used as a fare payment method for multiple transit agencies throughout the region	• Increase transit ridership • Decrease travel time	• Region	• Considerably high, but expected to decrease • Implementation costs vary based on system design and functionality	• Short-term: 1 to 5 years		• Increasing transit/bus route coverage and frequency • Intelligent transit stops • Enhance transit amenities
Realigned Transit Service Schedules and Stop Locations – Service adjustments to better align transit service with ridership markets	• Increase transit ridership • Decrease daily VMT	• Region	• Operating costs per trip	• Short-term: 1 to 5 years		• Increasing transit/bus route coverage and frequency • Intelligent transit stops • Enhance transit amenities
Intelligent Transit Stops – Ranges from kiosks, which show static transit schedules, to real-time information on schedules, locations of transit vehicles, arrival time of the vehicle, and alternative routes and modes	• Decrease daily VMT • Decrease congestion • Increase ridership	• Region • Corridor • Project	• Capital costs per passenger	• Medium-term: 5 to 10 years (includes planning, engineering, and construction	• TOPS-BC	• Increasing transit/bus route coverage and frequency • Electronic payment systems and universal farecards • Enhance transit amenities • Integration of transit information into advanced traveler information systems
Transit intersection queue jump lanes and signal priority – Additional travel lane at a signalized intersection that allows buses to proceed via their own "green-time" before other vehicles. Done by restriping within existing road footprint or this may require construction.	• Reduced bus travel delays due to traffic signals and traffic congestion • Improved operational efficiency of transit service within a corridor • Increased ridership and reduced congestion due to time savings • Safer driving conditions for all vehicles due to fewer severe and sudden lane changes by buses	• Corridor • Project	• Low to moderate • Installation and operation cost of queue jump lane and signal equipment is low • Constructing a new designated transit lane has a higher cost Implementation costs vary based on system design and functionality and type of equipment	• Short-term: 1 to 5 years • All phases–planning, engineering and implementing–a queue-jump lane can be reasonably completed in less than one year • Longer time is needed if new lane must be constructed	• TOPS-BC • IDAS	• Newly constructed queue-jump lanes are costly if right-of-way must be obtained. Efforts should be made to incorporate the lane into the existing roadway • Enforcement at transit queue-jump locations is important to ensure safety and proper operation • If the queue-jump lane replaces on-street parking meter spots, cities may receive less parking revenue
Enhanced Transit Amenities – Includes vehicle replacement/upgrade, which furthers the benefits of increased transit use	• Decrease daily VMT • Decrease congestion • Increase ridership	• Region • Corridor • Project	• Capital costs • Addition of clean fuel bus fleets may be incorporated as part of regular vehicle replacement programs • Addition of clean fuel bus fleets	• Short-term: 1 to 5 years (includes planning, engineering, and construction)		• Increasing transit/bus route coverage and frequency • Intelligent transit stops • Enhance transit amenities • Paved shoulders

Project/Mode Type	Congestion Impacts	Application Scale	Implementation Costs	Implementation Timeframe	Analysis Tools	Grouping
			may be incorporated as part of regular vehicle replacement programs			
Improved Bicycle and Pedestrian Facilities at Transit Stations – Includes improvements to facilities that provide access to transit stops as well as provisions for bicycles on transit vehicles and at transit stops (bicycle racks and lockers)	• Increase bicycle mode share • Decrease motorized vehicle congestion on access routes	• Region • Corridor • Project	• Capital and maintenance costs for bicycle racks and lockers	• Short-term: 1 to 5 years (includes planning, engineering, and construction)		• Intelligent transit stops • Enhance bicycle and pedestrian connectivity • Complete Streets policy
Electronic fare collection – Equipment that allows riders to electronically pay a transit fare by using credit, debit and magnetic fare cards	• Improved service efficiency, passenger convenience and passenger loading time • Increased ridership • Acquisition of more accurate and comprehensive ridership and trip data • Improved analysis and forecasting of trip ridership patterns and fare structure impacts • Reduced overall operating cost of fare collection and processing • Increased revenue through less fare evasion and greater accountability	• Region	• Moderate to high • The cost to purchase and implement electronic fare collection equipment can be high depending on the technology used • An initial surge in the maintenance and repair of electronic fare equipment can be expected due to the need for highly trained personnel.	• Medium-term • It is estimated that a full deployment of an electronic fare payment system could take from three to five years		• Future technology and equipment may allow fare payment media to be used as general-purpose debit cards for other types of purchases
BRT – High-capacity, highly efficient bus service designed to compete with rail in terms of quality of service.	• Reduce VMT • Reduce SOV trips • Increase transit ridership & mode share	• Corridor	• Capital costs per passenger trip • New & expanded systems require large up-front capital outlays and ongoing sources of operating subsidies, in addition to funds that may be obtained from federal sources, under increasingly tight competition	• Long-term: 10 or more years (includes planning, engineering, and construction)	• Regional Travel Model • Vehicle Emissions Model	
Express Bus Service Expansion – Bus service with high-speed operations, usually between two commuter points.	• Reduce VMT • Reduce SOV trips • Increase transit ridership & mode share	• Region • Corridor	• Capital costs per passenger trip Operating costs per trip • New bus purchases	• Short-term: 1 to 5 years (includes planning, engineering, and construction)	• Regional Travel Model • Vehicle Emissions Model	• Use of automated vehicle location (AVL) technology enables provision of real-time traveler information • Developments designed with transit-friendly features and connections to and from transit stops make bus travel more convenient
Local circulator expansion – Fixed-route service within an activity area, such as a CBD or campus, designed to reduce short trips by car.	• Reduce VMT • Reduce SOV trips • Increase transit ridership & boardings	• Region • Corridor • Project	• Capital costs per passenger trip • Operating costs per trip • New bus purchases	• Short-term: 1 to 5 years (includes planning, engineering, and construction)	• Regional Travel Model • Vehicle Emissions Model	• Transit intersection queue-jump lanes save time • Use of automated vehicle location (AVL) technology enables provision of real-time traveler information • Developments designed with transit-friendly features and connections to and from transit stops make bus travel more convenient
4. ITS and Operations Strategies						
Traffic Signal Coordination and Modernization – This improves traffic flow and reduces emissions by minimizing stops on arterial streets. Enhancements to	• Improve travel time • Reduce the number of stops	• Region • Corridor	• Low to moderate (Costs include initial investment of equipment, software, and communication	• Short-term: 1 to 5 years (includes planning, engineering, and	• IDAS • Regional Travel Model	• In some cases existing traffic signals on lower-volume streets may not be warranted. More efficient traffic

Project/Mode Type	Congestion Impacts	Application Scale	Implementation Costs	Implementation Timeframe	Analysis Tools	Grouping
timing/coordination plans and equipment to improve traffic flow and decrease the number of vehicle stops. May include: • Modern technology that provides for real-time traffic and transit management • Equipment that may permit immediate knowledge of malfunctions • Responsive control that allows traffic signals to alter timing in response to immediate traffic flow conditions, rather than at predetermined times • Transit signal priority system that can extend "green-time" a few seconds to allow buses to progress through an intersection	• Reduce VMT by vehicle miles per day, depending on program • Reduce VHD and PHT • Reduced air pollution, fuel consumption and travel time • Increase "capacity" of an intersection to handle vehicles, reduced number of vehicle strategies	• Project	network and connections. Varies depending on required equipment) • O&M costs per signal • Signalized intersections per mile costs variable	implementation)	• TOPS-BC • Simulation Model	operations can occur if such signals are removed and stop-signs installed. • Intersections with low volume late-night traffic could change to flashing operation • New timing coordination plans should be implemented along with modernized equipment • In some cases, bus routes or transit stops may be modified to increase ridership in conjunction with the transit signal priority system • Appropriate communications infrastructure must be in place for both traffic signal and transit systems
Reversible Traffic Lanes – These are appropriate where traffic flow is highly directional.	• Increase peak direction capacity • Reduce peak travel times • Improve mobility	• Corridor	• Barrier separated costs per mile • Operation costs per mile • Maintenance costs variable	• Short-term: 1 to 5 years	• IDAS • Regional Travel Model • Simulation Model	
Targeted and Sustained Enforcement of Traffic Regulations – Improves traffic flow by reducing violations that cause delays; Includes automated enforcement (e.g., red light cameras)	• Improve travel time • Decrease the number of stops	• Region • Corridor • Project	• Increased labor costs per officer	• Short-term: 1 to 5 years		
Freeway Incident Detection and Management Systems – This is an effective way to alleviate non-recurring congestion. Systems typically include video monitoring, dispatch systems, and sometimes roving service patrol vehicles.	• Reduce travel delay due to incidents • Reduce the risks of secondary accidents to motorists • Improved emergency response time and information distribution • Reduce travel time • Decrease VHT and PHT	• Region • Corridor	• Capital costs variable and substantial • Annual operating and maintenance costs	• Medium- to Long-term: likely 10 years or more	• IDAS • TOPS-BC • Regional Travel Model	• Service patrols • Traffic signal timing and coordination plans along predetermined arterial street diversion/detour routes • Variable message signs and other traveler information devices to alert oncoming traffic • Traffic Surveillance and Control Systems
Service Patrols – Service vehicles patrol heavily traveled segments and congested sections of the freeways that are prone to incidents to provide faster and anticipatory responses to traffic incidents and disabled vehicles	• Reduce travel delay due to incidents • Reduce incident duration time • Restore full freeway capacity • Reduce the risks of secondary accidents to motorists	• Region • Corridor	• Costs vary based on the number of vehicles used by the patrol, number of routes that the patrol operates, and the population of the area in which the program operates	• Short-term: 1 to 5 years	• IDAS • TOPS-BC • Freeway Service Patrol Evaluation (FSPE) • FHWA Benefit/Cost Tool for Safety Service Patrols	• Freeway Incident Detection and Management Systems • Advanced Traveler Information Systems
Ramp Metering – This allows freeways to operate at their optimal flow rates, thereby speeding travel and reducing collisions. May include bus or high-occupancy vehicle bypass lanes. May require ramp widening to avoid extensive vehicle queuing.	• Decrease travel time • Decrease accidents • Improve traffic flow on major facilities • Improved speed on freeway • Decreased crash rate on freeway	• Corridor • Project	• O&M costs • Significant costs associated with enhancements to centralized control system • Capital costs	• Medium-term: 5 to 10 years	• IDAS • TOPS-BC • Regional Travel Model • Simulation Model	• Installation of a vehicle detector at the top of the ramp and active management will help avoid queues extending to the arterial street.
Advanced Traveler Information Systems – This provides an extensive amount of data to travelers, such as real time speed estimates on the web or over	• Reduce travel times and delay • Some peak-period travel and mode shift	• Region • Corridor	• Design and implementation costs variable • Operating and maintenance	• Medium-term: 5 to 10 years	• IDAS • TOPS-BC	

Project/Mode Type	Congestion Impacts	Application Scale	Implementation Costs	Implementation Timeframe	Analysis Tools	Grouping
wireless devices, and transit vehicle schedule progress. Provides travelers with real-time information that can be used to make trip and route choice decisions. Information accessible on the web, dynamic message signs, 511 systems, Highway Advisory Radio (HAR), or handheld wireless devices.		• Project	costs variable		• Regional Travel Model	
Special Events and Work Zone Management – Includes a suite of strategies including temporary traffic control, public awareness and motorist information, and traffic operations	• Minimize traffic delays • Improve mobility • Maintain access for businesses and residents	• Region • Corridor • Project	• Design and implementation costs variable	• Short-term: 1 to 5 years	• IDAS • TOPS-BC	
Road Weather Management – Identifying weather and road surface problems and rapidly targeting responses including advisory information, control measures, and treatment strategies	• Improve safety due to reduced crash risk • Increased mobility due to restored capacity, delay reductions, and more uniform traffic flow	• Region • Corridor • Project	• Design and implementation costs variable • Operating and maintenance costs variable	• Short-term: 1 to 5 years	• IDAS • TOPS-BC	
Traffic Surveillance and Control Systems – Often housed within a Traffic Management Center (TMC), monitors volume and flow of traffic by a system of sensors, and further analyzes traffic conditions to flag developing problems, and implement adjustments to traffic signal timing sequences, in order to optimize traffic flow estimating traffic parameters in real-time. Currently, the dominant technology traffic surveillance is that of magnetic loop detectors, which are buried underneath roadways and count automobiles passing over them. Video monitoring systems for traffic surveillance may provide vehicle classifications, travel times, lane changes, rapid accelerations or decelerations, and length queues at urban intersections, in addition to vehicle counts and speeds.	• Decrease travel times and delay • Some peak-period travel and mode shift	• Region • Corridor • Project	• Design and implementation costs variable • Installation of video surveillance cameras may be less expensive than magnetic loop detectors, which require disruption and digging of the road surface	• Medium-term: 5 to 10 years	• IDAS • TOPS-BC	
Electronic toll collection (ETC) – Equipment that electronically collects tolls from users without requiring vehicles to stop at a toll booth.	• Fewer vehicle stops and less traveler delay at toll stations • Cost savings due to no (or fewer) toll booth facilities or lanes • Significant decrease in pollutant emissions from stop-and-go traffic at toll booths/plazas	• Region • Corridor • Project	• Initial investment in electronic toll collection technology can be substantial (overhead transponder readers, surveillance and enforcement equipment) • The estimated annual maintenance and operational costs for an electronic toll lane are less than $20,000, whereas a staffed toll booth lane can cost nearly $200,000 annually (Source: ITE Toolbox)	• Short- to medium-term • Physical implementation of electronic toll collection equipment can be completed in a short time period for a roadway, unless additional right-of-way is needed.		• New or converted high-occupancy toll (HOT) lanes would also likely use ETC technology.
Communications networks and roadway surveillance coverage – Base infrastructure (fiber, cameras, etc.) required to support all operational activities. Communications networks that allow remote roadway surveillance and system control from a TMC and provision of data for immediate management of transportation operations and distribution of information.	• Increased capability for regional-level coordination of operations and traveler information.	• Region • Corridor • Project	• Moderate • Communication networks are not low-cost or high-profile items, but essential to get the most efficiency and capacity out of the existing transportation system	• Medium- to long-term • Small-scale items and opportunistic expansion can be done quickly. Larger-scale regional network components require more time for planning and	• IDAS • TOPS-BC	• Supplementing fiber optics communications with wireless technologies may prove beneficial • Most active management strategies require the support of roadway surveillance and communications infrastructure

Project/Mode Type	Congestion Impacts	Application Scale	Implementation Costs	Implementation Timeframe	Analysis Tools	Grouping
			• Cost can be reduced when done in conjunction with a larger scale construction project.	funding		
Transit vehicle travel information – Communications infrastructure, GPS technology, vehicle detection/monitoring devices and signs/media/Internet sites for providing information to the public such as the arrival times of the next vehicles.	• More satisfied customers and increased ridership due to enhanced and reliable information sources • Improved operations and management of transit service	• Region	• Moderate • Costs are dependent upon communication networks, changing technologies and the number of fleet vehicles to be equipped.	• Medium • Time is required for detailed planning, design and funding procurement	• IDAS • TOPS-BC	• Integrations of transit information with that provided to motorists (e.g. via web sites) provides a more comprehensive base of materials for travelers • New or expanded transit service can be marketed in conjunction with new information outlets
Speed Harmonization – Changes traffic speed limits on links that approach areas of congestion, bottlenecks, incidents, special events, and other conditions that affect traffic flow.	• Reduced delay • Reduced emissions • Improved safety	• Region • Corridor • Project			• IDAS • TOPS- BC • Simulation Model	
5. Pricing Strategies						
Road Pricing – Involves pricing facilities to encourage off-peak or HOV travel, and includes time-variable congestions pricing and cordon (area) tolls, high occupancy/ toll (HOT) lanes, and vehicle-use fees	• Decrease peak period VMT • Decrease SOV trips	• Region • Corridor	• First-year implementation costs for public -sector	• Short-term: 1 to 5 years	• TDM Evaluation Models • Vehicle Emissions Model • Regional Travel Model	• Telework • Flexible work hours • Cordon area congestion fees • Electronic toll collections • Electronic sign messaging
Cordon area congestion fees – An established cordon area or zone in which vehicles are charged a fee to enter. Such a fee can be variable (by time of day) or dynamic (based on real-time congestion conditions). Should include electronic payment/collection methods using cameras or transponders.	• Reduced pollution and congestion within the cordon area • Revenues for roadway maintenance and new transit, bicycle and pedestrian facilities • Overall reduced congestion due to less VMT • Provide incentive to use transit, bike, or walk	• Region	• High • The cost to implement infrastructure and devices for a large-scale electronic fee collection system can be high (e.g. in Stockholm, Sweden and London, England).	• Medium- to long-term • Extensive time is required for the entire process including political and public discussions, possible ballot measures, construction and implementation		• Electronic and variable pricing of toll roads, bridges, or tunnels should be used. • Expanded transit service and convenient bicycle and pedestrian facilities should be provided to serve people no longer driving into the cordon area.
Congestion Pricing – Controls peak-period use of transportation facilities by charging more for peak-period use than for off-peak. Congestion pricing fees are charged to drivers using congested roadways during specific times of the day. This strategy is evaluated in order to maintain a specific level of service on a given road or all roads (areawide systems) in a region. For example, an average fee of $0.65 cents/mile could be applied to 29 percent of urban and 7 percent of rural vehicle miles traveled (VMT) to better manage travel demand and the resulting congestion for a roadway.	• Decrease peak period VMT • Decrease SOV trips • Increase transit and nonmotorized mode shares	• Region • Corridor	• Implementation and maintenance costs vary	• Medium-term: 5 to 10 years	• TDM Evaluation Models • Vehicle Emissions Mode • Regional Travel Model	• Land Use and Built Environment (e.g., Mixed use developments) • Operations and ITS (e.g., traveler information) • Public Transportation • Transportation Demand Management
Carbon Pricing /Motor Fuel Tax – Carbon pricing considers an economy wide or system strategy set either as a fuel tax or as a result of a cap-and-trade system. Motor fuel taxes, currently the primary source of revenue for highways, would increase to higher levels to generate more revenue to highways. Very high levels of either carbon prices or motor fuel taxes may affect	• Generate revenue to maintain its system and to address transportation improvements regionwide • Reduce congestion in corridors and systems • Provide incentive to use transit, bike, or walk	• Region		• Long-Term • Travel demand shifts and associated GHG benefits will be realized sometime after implementation (11+ years).	• TDM Evaluation Models • Vehicle Emissions Model • Regional Travel Demand Model	• Land Use and Built Environment (e.g., Mixed use developments) • Transportation Demand Management Operations and ITS (e.g., traveler information) • Public Transportation

Project/Mode Type	Congestion Impacts	Application Scale	Implementation Costs	Implementation Timeframe	Analysis Tools	Grouping
fuel efficiency or fuel types, as well as travel demand. Carbon pricing strategies, while not implemented, consider: • Environmental levy on the carbon content of fuels; and • Dedicated fuel consumption tax to support development and maintenance of new and existing transportation systems. State DOTs with federal (U.S. DOT, FHWA) agency support have been assessing the potential for implementing carbon pricing strategies. An example pricing strategy could include an allowance price of $30-50 per ton in 2030, or similar carbon tax.						• Bicycle and Pedestrian (e.g., pedestrian and bicycle improvements)
Emissions-based vehicle registration fees – Fees are levied based on the carbon dioxide emission levels of a car while it is operating.	• Generate revenue to maintain its system and to address transportation improvements regionwide • Reduce congestion in corridors and systems • Provide incentive to use transit, bike, or walk • Provide incentive to purchase and use efficient vehicles	• Region		• Mid-Term • Implementation should take between 3 to 10 years.		• Land Use and Built Environment (e.g., Mixed use developments) • Transportation Demand Management Operations and ITS (e.g., traveler information) • Public Transportation
VMT fee – A VMT Fee is charged based on how many miles a car is driven. Odometer readings determine the exact fee charged. A city or county could modify the structure of the fee to include a carbon fee (see Carbon Pricing/Motor Fuel Tax). VMT fees can be layered to be higher or lower based on the fuel economy of cars and also layered based on urban and rural usage . Specific VMT fees of 2 to 5 cents per mile have been tested. VMT Fees consider distance-traveled charges levied to users based on the amount a vehicle uses a road system, while Congestion Pricing/Road User fees are levied to system users during congested periods of the day.	• Generate revenue to maintain its system and to address transportation improvements regionwide • Reduce congestion in corridors and systems • Incentive to use transit, biking, and walking • Provide incentive to purchase and use efficient vehicles	• Region		• Mid-Term • Implementation should take between 3 to 10 years.	• TDM Evaluation Models • Vehicle Emissions Mode	• Land Use and Built Environment (e.g., Mixed use developments) • Transportation Demand Management Operations and ITS (e.g., traveler information) • Public Transportation
Traffic Impact Fee – A charge on new development to cover the full cost of the additional transportation capacity, including transit, required to serve the development. While fee strategies may vary, in most cases, only those new developments that result in an increase in vehicle trips would be charged. Traffic impact fees can be structured as a single fee for the entire region, multiple fees for individual geographic areas, or multiple fees for specific corridors. Traffic impact fees vary based on the expected new development impact on the transportation system and are often structured with lower fees for developments that promote mixed use development, reduce single occupant vehicle use, and encourage transit and non-motorized travel use.	• Generate revenue to maintain its system and to address transportation improvements regionwide • Provide Incentive to purchase and use efficient vehicles	• Region			• TDM Evaluation Models • Vehicle Emissions Mode	• Land Use and Built Environment (e.g., Mixed use developments) • Transportation Demand Management • Operations and ITS (e.g., traveler information) • Public Transportation • Bicycle and Pedestrian (e.g., pedestrian and bicycle improvements)
Pay-As-You-Drive (PAYD) Insurance (state level) – PAYD insurance considers charging drivers insurance premium costs based in part on annual vehicle miles	• Reduce congestion in corridors and systems • Promote transit, biking and walking	• Region		• Long-Term • While implemented in near-		

Project/Mode Type	Congestion Impacts	Application Scale	Implementation Costs	Implementation Timeframe	Analysis Tools	Grouping
travelled. Other insurance rating factors would still apply to insurance rates, so high risk drivers would pay more than lower risk drivers. All drivers would have the opportunity to save money (reduced insurance fees) by driving fewer miles. The state could require insurance companies to offer PAYD insurance at lower rates and require companies to offer higher rates to encourage fewer vehicle miles travelled.				term, travel behavior changes unclear and associated GHG benefits will be realized after implementation (11+ years).		
Preferential or Free Parking for HOVs and Parking Management – Strategies include reducing the availability of free parking spaces, particularly in congested areas, or providing preferential or free parking for HOVs. This provides an incentive for workers to carpool. A strategy could include a downtown employee parking payroll tax (e.g., all downtown workers pay for parking, $5/day average for users not already paying). Other strategies include dynamic pricing, higher fees on free parking lots, parking permits (see strategies above for Parking Pricing).	• Reduce work VMT • Increase vehicle occupancy	• Corridor • Project	• Relatively low costs, primarily borne by the private sector, include signing, striping, and administrative costs	• Metropolitan and Employer-based • Short-term: 1 to 5 years	• TDM Evaluation Models • Vehicle Emissions Model	• Land Use and Built Environment (e.g., Combined land use and transportation strategies) • Transportation Demand Management Operations and ITS (e.g., traveler information) • Public Transportation • Bicycle and Pedestrian (e.g., pedestrian and bicycle improvements
Local and Regional Excise Taxes – A flat fee-per-space on parking spaces provided by businesses designed to discourage automobile-dependent development, encourage more efficient land use, and - to the extent the fees are passed on to parkers - encourage non-motorized and transit choices. The revenue generated by such a tax (on parking spaces, not their use) could be used for transit and other transportation investments not eligible for highway dollars.	• Generate revenue to maintain its system and to address transportation improvements regionwide • Reduce congestion in corridors and systems • Promote transit, biking, and walking • Increase access to and increase use of alternative modes	• Region		• Mid term: 3 - 10 years for implementation and long-term for strategy to become effective (regarding GHG benefits)		• Land Use and Built Environment (e.g., Combined land use and transportation strategies) • Transportation Demand Management Operations and ITS (e.g., traveler information) • Bicycle and Pedestrian (e.g., pedestrian and bicycle improvements) • Public Transportation
6. Bicycle and Pedestrian Strategies						
New Sidewalks and Designated Bicycle Lanes on Local Streets – Enhancing the visibility of bicycle and pedestrian facilities increases the perception of safety. In many cases, bike lanes can be added to existing roadways through restriping. Use of bicycling and walking is often discouraged by a fragmentary, incomplete network of sidewalks and shared use facilities. Constructing new facilities, such as bike lanes on arterials and/or connecting existing facilities, will encourage greater use of walking and bicycling.	• Increase mobility and access • Increase nonmotorized mode shares • Separate slow moving bicycles from motorized vehicles • Reduce bicycle- and pedestrian-involved incidents • Lower commuting costs	• Region • Corridor • Project	• Design and construction costs for paving, striping, signals, and signing • ROW costs if widening necessary • Bicycle lanes may require improvements to roadway shoulders to ensure acceptable pavement quality	• Short-term: 1 to 5 years (includes planning, engineering, and construction)	• TDM Evaluation Models	• Complete Streets Policy • Road construction projects on local streets should consider new sidewalks and designated bicycle lanes • Interaction with connecting off-street bike trails should be considered • Bicycling promotion events can encourage use of facilities
Improved Bicycle Facilities at Transit Stations and Other Trip Destinations – Bicycle racks and bike lockers at transit stations and other trip destinations increase security. Additional amenities such as locker rooms with showers at workplaces provide further incentives for using bicycles.	• Increase bicycle mode share • Reduce motorized vehicle congestion on access routes	• Corridor • Project	• Capital and maintenance costs for bicycle racks and lockers, locker rooms	• Short-term: 1 to 5 years (includes planning, engineering, and construction)	• TDM Evaluation Models	
Design Guidelines for Pedestrian-Oriented Development – Maximum block lengths, building setback restrictions, and streetscape enhancements are	• Increase pedestrian mode share • Discourage motor vehicle use for short trips • Reduce VMT	• Region • Corridor	• Capital costs largely borne by private sector; developer incentives may be	• Short-term: 1 to 5 years	• TDM Evaluation Models • Regional Travel Model	

Project/Mode Type	Congestion Impacts	Application Scale	Implementation Costs	Implementation Timeframe	Analysis Tools	Grouping
examples of design guidelines that can be codified in zoning ordinances to encourage pedestrian activity.	• Reduce emissions		necessary • Public sector may be responsible for some capital and/or maintenance costs associated with right-of-way improvements • Ordinance development and enforcement costs			
Improved Safety of Existing Bicycle and Pedestrian Facilities – Maintaining lighting, signage, striping, traffic control devices, and pavement quality, and installing curb cuts, curb extensions, median refuges, and raised crosswalks can increase bicycle and pedestrian safety.	• Increase nonmotorized mode share • Reduce bicycle- and pedestrian-involved incidents • Increase monitoring and maintenance costs	• Region • Corridor • Project	• Increased monitoring and maintenance costs • Capital costs of sidewalk improvements and additional traffic control devices	• Short-term: 1 to 5 years	• TDM Evaluation Models • Regional Travel Model	
Exclusive Non-Motorized Rights-of-Way – Abandoned rail rights-of-way and existing parkland can be used for medium- to long distance bike trails, improving safety and reducing travel times.	• Increase mobility • Increase nonmotorized mode shares • Reduce congestion on nearby roads • Separate slow-moving bicycles from motorized vehicles • Reduce bicycle- and pedestrian-involved incidents	• Region • Corridor	• ROW Costs • Construction and Engineering Costs • Maintenance Costs	• Medium-term: 5 to 10 years (includes planning, engineering, and construction)	• TDM Evaluation Models • Regional Travel Model	• Complete Streets Policy • Road construction projects should consider interaction with off-street bike trails • Access management practices that reduce the number of driveways across trails parallel to roadways reduce the risk for bicycle-vehicle crashes • Bicycling promotion events can encourage use of facilities
Bike Sharing Programs – Short-term bicycle rental program supported by a network of automated rental stations	• Increase non-motorized mode share • Discourage motor vehicle use for short trips • Decrease VMT	• Region • Corridor • Project	• Capital and maintenance costs for bicycles and rental stations	• Short-term: 1 to 5 years		• Complete Streets Policy • New Sidewalks and designated bicycle lanes • Improved bicycle facilities at transit stations
Promote Bicycle and Pedestrian Use Through Education and Information Dissemination – Bicycle and pedestrian use can be promoted through educational programs and through distribution of maps of bicycle facility/multi-use path maps.	• Shift trips into non-SOV modes such as walking, bicycling, transit • Increase bicycle/pedestrian mode share	• Region • Corridor	• First-year implementation costs for private-sector • Second-year costs tend to decline • Requires interagency and private sector coordination • Requires public agency support & coordination	• Employer-based • Short-term: 1 to 5 years	• Vehicle Emissions Model	• Complete Streets Policy • New Sidewalks and designated bicycle lanes • Improved bicycle facilities at transit stations • Improved safety • Improved pedestrian facilities
7. Roadway/Mobility (Non-ITS) Strategies						
Access management – Planning and design practices that identify existing and future land use and arterial access points to maximize traffic safety and mobility. Strategies include medians, turn lanes, side/rear access points between businesses, shared access, and local land use ordinances to control access	• Reduction in crashes along a roadway • Improved roadway capacity; greater vehicle throughput • Decreased corridor delay	• Region • Corridor • Project	• Low to high (Costs and complexity of strategies can vary widely and may depend on whether access controls are implemented before development occurs or as a retrofit)	• Short- to medium-term • Some access management strategies can be implemented quickly if there are cooperating property owners. Major access management plans require a greater amount of time for	• Simulation Model	• Access management is enhanced by parking lot/building site designs that incorporate adequate exit/entrance capacity, side or rear access points and walking and transit features. • Growth management plans should incorporate access management

Project/Mode Type	Congestion Impacts	Application Scale	Implementation Costs	Implementation Timeframe	Analysis Tools	Grouping
				planning, negotiation and ultimate benefits related to the full anticipated future development. Capital construction efforts (e.g. medians) take a moderate amount of time.		• Traffic signal coordination
Restricting Turns at Key Intersections – Limits turning vehicles, which can impede traffic flow and are more likely to be involved in crashes	• Increase capacity, efficiency on arterials • Improve mobility on facility • Improve travel times and decrease delay for through traffic • Decrease incidents	• Corridor • Project	• Implementation and maintenance costs vary; range from new signage and striping to more costly permanent median barriers and curbs	• Short-term: 1 to 5 years (includes planning, engineering, and implementation)	• Simulation Model	
Converting Streets to One-Way Operations – Establishes pairs of one-way streets in place of two-way operations. Most effective in downtown or very heavily congested areas.	• Increase traffic flow	• Corridor • Project	• Conversion costs include adjustments to traffic signals, striping, signing and parking meters • May create some confusion, especially for non-local residents	• Short-term: 1 to 5 years (includes planning, engineering, and implementation)	• Simulation Model	
Roadway Signage Improvements – Adequate or additional signage that facilitates route-finding and the decision-making ability of roadway users. Signs with clearer/larger lettering that can be read from a greater distance	• Reduced level of driver uncertainty and fewer erratic driving maneuvers • Reduced delay for upstream approaching vehicles • Psychological encouragement to unsure motorists • Less chance of crashes caused by sudden lane changes, extremely slow-moving vehicles or sudden stops	• Region • Corridor • Project	• Low	• Short-term • Production of signs and installation can occur shortly after site visits and design of new signing plans. Design should follow the guidance of the Manual on Uniform Traffic Control Devices (MUTCD).		• Variable message signs and other ITS applications can provide real-time or temporary information to travelers • Emerging in-vehicle technologies that provide real-time traveler information and route-finding capabilities
Geometric Design Improvements – This includes bottleneck improvements such as roadway widening to provide shoulders, improved sight lines, auxiliary lanes to improve merging and diverging. Interchange modifications to decrease weaving sections on a freeway, paved shoulders and realignment of intersecting streets. Intersection modifications such as adding turning lanes at an intersection, realignment of intersection streets, intersection channelization, or modifying intersection geometrics to improve overall efficiency and operation.	• Increase mobility • Reduce congestion by improving bottlenecks • Increase traffic flow and improve safety • Decrease incidents due to fewer conflict points	• Corridor • Project	• Costs vary by type • Design, implementation, operations and maintenance (O&M) costs vary by type of design	• Short-term: 1 to 5 years (includes planning, engineering, and implementation)	• Regional Travel Model • Simulation Model	
Grade Separations (Non-Added Capacity) – Also called Super Street Arterials, this involves converting existing major arterials with signalized intersections into "super streets" that feature grade-separated intersections and overpasses (non-added capacity).	• Improve mobility • Reduce congestion by improving bottlenecks at intersections	• Corridor	• Construction and engineering substantial for grade separation • Maintenance variable based on area	• Medium-term: 5 to 10 years (includes planning, engineering, and implementation)	• Regional Travel Model • Simulation Model	
Acceleration/Deceleration lanes – Deceleration lane provided on a freeway just before an exit off-ramp allowing vehicles to reduce speed outside the through-lanes. Acceleration lane provided as an extension of a	• Slower-moving turning or exiting vehicles are removed from through lanes resulting in fewer delays for upstream traffic • Accelerating vehicles are provided more	• Corridor • Project	• Low to moderate • Cost is relatively low if right-of-way or bridge widening is not required	• Medium-term • Right-of-way is an important factor in the time required for implementation and	• Simulation Model	• Signs to alert drivers to the availability of acceleration or deceleration lanes can greatly increase the proper use of these lanes

Project/Mode Type	Congestion Impacts	Application Scale	Implementation Costs	Implementation Timeframe	Analysis Tools	Grouping
freeway on-ramp or an arterial street turn-lane for vehicles to increase speed and merge more smoothly into the through-lane.	distance to reach the speed of through traffic, resulting in fewer delays caused by merging and weaving vehicles • In certain situations, can greatly reduce delays (caused by braking) for upstream vehicles during peak traffic flow periods			construction.		
Adopt and implement a Complete Streets policy – Policy that takes into account all users of streets rather than just autos, with a goal of completing the streets with adequate facilities for all users. A "Complete Street" is one designed and operated to enable safe access for all users including pedestrians, bicyclists, motorists, and transit riders of all ages and abilities.	• Increase safety by improving the overall (pedestrian and bicycle) transportation system environment • Reduce congestion in corridors and systems • Provide cost savings by reducing longer distance travel, increasing shorter distance travel, and use by non-motorized modes • Provide travel time savings to users of the system • Increase access to and use of alternative modes • Protect natural environment through sound land use and transportation sustainability policies • Increase community involvement and activity in developing policy and promoting projects • Promote incentive to use transit, bike, or walk	• Region • Corridor		• Near term (1-2 years)		• Pricing • Land Use and Built Environment • Transportation Demand Management • Operations and ITS • Public Transportation
8. Roadway Capacity Expansion Strategies						
New Freeways – Construction of new, access-controlled, high-capacity roadways in areas previously not served by freeways.	• Reduce arterial street network congestion • Reduce travel times & delay • Increased capacity to serve developing areas • Reduced traffic and congestion on parallel streets due to vehicles diverted to the new road	• Corridor	• High • Costs vary by type of highway constructed; cost depends on amount of right-of-way needed and the scale of construction impediments; in dense urban areas can be very expensive • Can create environmental and community impacts	• Medium- to long-term (includes planning, engineering, and construction) • Completion of a new roadway project can take from five to 25 years, including planning, engineering, environmental analysis and construction phases	• Regional Travel Model • Simulation Model	• Active roadway management strategies and newer technology to monitor/control traffic conditions • Transit service can be provided to reduce the demand for vehicle travel on the new road • Land use practices that manage the amount of new development in the area to a level that the roadway system can adequately handle should be enacted
Increasing Number of Lanes without Highway Widening – This takes advantage of "excess" width in the highway cross section used for breakdown lanes or median.	• Increase capacity • Reduce congestion by improving bottlenecks	• Corridor • Project	• Construction and engineering • Maintenance	• Short-term: 1 to 5 years (includes planning, engineering, and implementation)	• Regional Travel Model • IDAS • Simulation Model	
Highway Widening by Adding Lanes – This is the traditional way to deal with congestion.	• Increase capacity, reducing congestion in the short term • Long-term effects on congestion depend on local conditions • Reduced traffic and congestion on parallel streets	• Corridor	• Costs vary by type of highway constructed; in dense urban areas can be very expensive • Can create environmental and community impacts	• Long-term: 10 or more years (includes planning, engineering, and construction)	• Regional Travel Model • Simulation Model	• Active roadway management strategies and newer technology to monitor/control traffic conditions should be implemented during construction • TDM strategies could provide significant benefits during construction and they could carry over following project completion

Project/Mode Type	Congestion Impacts	Application Scale	Implementation Costs	Implementation Timeframe	Analysis Tools	Grouping
						• Incident management programs and service patrols for quick clearance of incidents during construction
New Arterial Streets – Construction of new, higher-capacity roads designed to carry large volumes of traffic between areas in urban settings.	• Provide connectivity • Carry traffic from local & collector streets to other areas	• Corridor	• Can create environmental and community impacts • Construction and engineering costs substantial (grade separate, other design features) • Maintenance variable based on urban region	• Medium-term: 5 to 10 years (includes planning, engineering, and construction	• Regional Travel Model • Simulation Model	
Grade separations (Added capacity) – This involves converting existing major arterials with signalized intersections into "super streets" that feature grade-separated intersections and overpasses with added capacity.	• Increase capacity • Improve mobility	• Corridor	• Construction and engineering substantial for grade separation • Maintenance variable based on area	• Medium-term: 5 to 10 years (includes planning, engineering, and implementation)	• Regional Travel Model • Simulation Model	
Grade separated railroad crossings – Roadway underpass or overpass of a railroad line.	• Significant reduction in travel delays at high volume locations • Likely elimination of car-train crashes • Decreased noise from train horns/whistles	• Corridor • Project	• High - Cost is very high to provide either a roadway or railroad bridge or tunnel	• Medium- to long-term • Implementation requires significant negotiation with railroads and local communities	• Simulation Model	• Grade separations should be planned for in conjunction with new roadways that are built • The capability to provide real-time information on message signs regarding location and time of train crossings has been implemented in other cities
Major Intersection/Interchange Improvements – This includes major intersection/interchange improvements or adding through lanes to provide additional capacity.	• Increase mobility • Reduce congestion by improving bottlenecks • Increase traffic flow and improve safety	• Corridor • Project	• Costs vary by type • Design, implementation, operations and maintenance (O&M) costs vary by type of design	• Medium-term: 5 to 10 years (includes planning, engineering, and implementation)	• Regional Travel Model • Simulation Model	

Sources: Adapted from Denver Regional Council of Governments CMP Toolkit 2.5 (June 2008), Maricopa Association of Governments Baseline Congestion Management Process Report (October 2010), and Mid-American Regional Council Congestion Management Toolbox Update (December 2013)

Public Transportation

Nineteen different public transportation strategies are identified including increasing route coverage and frequency, constructing new fixed guideway travelways, employer incentive programs, signal priority, intelligent transit stops, and other technological improvements.

These strategies range in cost from low to high. Constructing new transit travelways is understandably costlier than improving service frequencies. Predominant benefits include shifting mode share, increasing transit ridership, reducing VMT, and improving air quality. Transit strategies may work well alongside bicycle and pedestrian strategies and densifying land use strategies that aim to further shift mode share away from automobiles.

ITS and Operations

Fourteen ITS and transportation system management (TSM) strategies are identified including signal coordination, ramp metering, traveler information systems, incident management, and service patrols.

Costs of these strategies vary but tend to be low to moderate. Large scale ITS and operations strategies that involve the construction of new infrastructure and devices tend to be higher in cost than other projects. Benefits include reduced travel time, reduced stops, reduced delays, and improved safety. Installation of vehicle detection systems may help ramp metering. Active management will help avoid queues extending to arterial streets.

Pricing

Pricing strategies are regulatory in nature but may also relate to parking systems. Carbon pricing, VMT fees, pay as you drive insurance, and auto and truck restriction zones are all regulations that can be instituted to help alleviate congestion and generate revenue for additional strategies.

Beyond this, a number of parking pricing strategies can help to reduce congestion. These include preferential or free parking for HOVs and local regional excise taxes. This provides an incentive for workers to carpool. A strategy could include a downtown employee parking payroll tax (e.g. downtown workers pay for parking at $5/day average for users not already paying). Other strategies include dynamic pricing, higher fees on free parking lots, and parking permits. Additionally, a local flat fee per space on parking spaces provided by businesses can discourage automobile-dependent development.

Pricing strategies may result in a reduction in VMT and increased vehicle capacity. They also generate revenue to maintain the strategy and system and promote transit, biking, and walking as other forms of travel. These are relatively low cost strategies. They may work well with a number of land use and built environment strategies as well as strategies promoting public transportation, as well as walking and bicycling.

Bicycle and Pedestrian

Seven bicycle and pedestrian strategies are identified. These tend to be low to moderate in cost. Strategies include new sidewalks and bicycle lanes, improved facilities near transit stations, bike sharing, and exclusive non-motorized rights of way. Abandoned rail rights-of-way and existing parkland can be used for medium to long distance bike trails improving safety and reducing travel times. Bicycle and pedestrian policies may work well when grouped with other strategies such as implementation of a complete streets policy, land use and environmental strategies that promote densification, and improved safety strategies.

Benefits of bicycle and pedestrian strategies related to decreasing auto mode share, which in turn reduces VMT and improves regional air quality. Costs of bicycle and pedestrian strategies tend to be low to moderate.

Roadway/Mobility (Non-ITS) Strategies

Eight roadway/mobility (non-ITS) strategies are identified. These strategies are designed to help improve operations and relieve bottlenecks on existing facilities through non-capacity adding improvements. Strategies include access management improvements; turn restrictions at key intersections; converting streets to one-way operations; geometric design improvements to roadways, interchanges, and intersections; non-added capacity grade separations; addition of acceleration or deceleration lanes; and adoption of a Complete Streets policy.

These strategies range in cost low to high based on the type and complexity of strategy implemented. These strategies may be grouped with improved signage and ITS/operations strategies for additional benefits.

Roadway Capacity Expansion

Highway strategies to add roadway capacity include the construction of a new roadway or bypass, major or minor road widening to add additional through lanes on an existing highway, major roadway reconstruction, adding capacity to a corridor by improving many related intersections, new interchange, adding capacity to an existing interchange, or grade separation of existing intersections (that add capacity). Adding capacity should be considered the strategy of last resort due to issues related to sprawl, land preservation, promotion of alternative transportation modes, and cost considerations.

These strategies range in cost from moderate to high based on the type of strategy implemented, with new right-of-way resulting in higher costs than design improvements. Predominant benefits of these strategies include increased capacity as well as improved mobility and traffic flow. For those transportation management areas (TMAs) that are either non-attainment or a maintenance area for ozone or carbon monoxide federal regulations, the CMP must provide an analysis of how capacity expansion projects will reduce congestion.

These types of roadway projects and strategies may be coupled with improved signage and real time information messages for additional benefits to travelers.

7.3 Using the Toolbox

The toolbox can be used by project sponsors to identify alternative strategies for addressing local congestion issues on the CMP network and select the most appropriate strategy (or package of strategies) that has a reasonable potential for providing benefit to the corridor or study area being evaluated. If a strategy shows promise, it can be evaluated in detail using the regional travel demand model and/or applicable analysis tools suggested in the toolbox.

For larger projects (particularly high cost, capacity-adding projects), the toolbox could be used to identify CMP strategies that should be incorporated into these projects as part of the project development process. In terms of benefits, CMP strategies typically will not result in the large capacity gains typical of capacity expansion projects; however, demand management and operational strategies could be incorporated into the capacity improvement project to potentially extend the number of productive years of the facility before additional capacity is needed.

In many cases, there would be no need to do an independent analysis to fulfill CMP requirements, since data collection and analysis using the regional travel model, simulation models, or other tools would take place regardless as part of the project development process. These analysis results could be translated into CMP performance measures (e.g., reduction in crash rate, increase in vehicle throughput, reduction in traveler delay, benefit-cost ratio based on value of travel time savings, fuel consumption, and emissions reduction, etc.) to support congestion management efforts.

7.4 Evaluating Strategies

As shown in the toolbox, a variety of analysis tools are available to H-GAC and its local agency partners to help evaluate the effectiveness (or potential effectiveness) of congestion management strategies. These tools are designed to assess the congestion reduction potential of the projects and strategies carried forward for analysis and screening in H-GAC's congestion management process. These tools, and in some cases combinations of these tools, can be used to identify the impacts of the different strategy types identified in the toolbox (e.g., transportation demand management land use, public transportation, ITS and operations, etc.). A summary of each analysis tool is presented below.

Regional Travel Model

HGAC's traditional four-step Regional Travel Demand Model is used to support a variety of analytical needs such as preparation of various system and subarea analyses, including the RTP, transit projects, toll projects, ongoing evaluations of the region's air quality conformity analysis, and other technical analysis. In some cases, the results from the Regional Travel Model will be used to assess the impacts of alternative strategies, specifically the additional system capacity (freeway, arterial roadway, and new roadway facility construction) projects.

Regional travel demand model outputs (VMT, VHT, and other measures) can be used to illustrate the location, duration, and extent of congestion for the region at baseline conditions. The travel demand model can then be used to forecast congested conditions assuming currently programmed TIP projects. These model outputs can in turn be used as inputs into the ITS Deployment Analysis System (IDAS), the Tool for Operations Benefit/Cost (TOPS-BC), and/or other tools to calculate a variety of performance measures, to evaluate the impacts of many of the types of strategies in the Toolbox, and to help allocate benefits to subregions. These data can include changes in travel time, speed, mode share, or trip reduction, for example, that can either directly measure or indirectly measure the CMP performance measures for the no-build and build conditions.

H-GAC and its planning partners, including Houston METRO, are currently implementing an Activity-Based Model (ABM) to analyze and model Houston's residents' travel behavior. The new ABM is expected to produce more accurate results for project analyses and policy testing since it will model interactions among a wide range of variables that the current trip-based model is incapable of analyzing. The ABM can be applied to the following applications: regional transportation plans (RTP), transit-related ridership forecasting and alternative analyses, FTA New/Small Starts applications, air quality and conformity analyses, and corridor and subarea planning studies. All these can be analyzed to some extent with the current trip-based model that H-GAC uses, but the new ABM can produce more accurate estimates of travel demand for these needs and can also provide more information about the effects of more sophisticated policies such as reversible HOT lanes, environmental justice and Title 6 analysis, livable centers, transit oriented development and other land use scenarios, TIP projects benefit-cost analysis, special event management, as well as transportation policy questions, on a variety of population segments.

It is anticipated that the ABM will be complete by November 2014; however, it will take some time for H-GAC to adapt to and fully test the model before using it for new projects. Therefore, the trip-based regional travel demand model will remain as one of the analysis methods of the CMP Update, at least through 2015, to support many of the different types of congestion management strategies to be tested in the planning process such as operations, ITS, land use, and demand management strategies.

Simulation Model

Simulation models are designed to assess the travel impacts of multimodal and roadway specific projects. The use of simulation models requires that the analysis area be relatively constrained to a small subarea of the regional network, usually a corridor or specific project area. Expansion of the analysis to a broader region would require significantly more resources. These models are effective in evaluating the buildup, dissipation, and duration of traffic congestion, and model outputs can be used to calculate measures of effectiveness such as vehicle/person miles traveled, vehicle/person hours of travel, travel time/queue length, throughput/delay, emissions, and fuel consumption. Simulation results can be used to conduct a benefit valuation of individual strategies or set of strategies. Information on calculation of various measures of effectiveness using simulation outputs is available in FHWA's Traffic Analysis Toolbox[3]. Emerging methods for using simulation model outputs to calculate travel time reliability impacts are detailed in SHRP 2 projects L04, L05 (Technical Reference), and L08.

Intelligent Transportation System Deployment Analysis System (IDAS)

The Intelligent Transportation System Deployment Analysis System (IDAS) is an operations and ITS sketch-planning analysis tool that interfaces with planning data prepared from existing regional travel demand models. IDAS was first developed in 1998 for the Federal Highway Administration (FHWA) and was updated several times through the 2000s. IDAS provides a comprehensive analysis tool for determining the system, subarea, corridor-specific impacts, benefits, and costs of the full spectrum of operations and ITS deployments and strategies. IDAS was designed to meet the needs of MPOs by offering the capability for a systematic assessment of operations and ITS with one analysis tool, with the overall goal of assisting these agencies in integrating ITS into their ongoing transportation planning process. Although IDAS has not been used by H-GAC in the past, it could be linked with the Regional Travel Model to assess the impacts of various operations, ITS, and roadway capacity projects as defined in the CMP Toolbox.

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

TOPS-BC is one of several benefit/cost tools that can be used to evaluate operational and ITS improvements. An early generation of spreadsheet tools was developed by FHWA and state and local agencies for targeted analysis, including SCRITS and CAL-B/C[4]. Following these initial efforts, FHWA developed the ITS Deployment Analysis System (IDAS), which included a

[3] http://ops.fhwa.dot.gov/trafficanalysistools/

[4] http://www.dot.ca.gov/hq/tpp/offices/eab/LCBC_Analysis_Model.html

network-based model able to incorporate regional and statewide travel demand models. The major benefit of IDAS is that by using existing travel demand models, it incorporates the same set of assumptions used for other regional planning activities. The inclusion of an assignment module also allows analysts to account for traffic shifts that may result from operational and ITS deployments. As a network model, however, IDAS has a steeper learning curve than spreadsheet tools and may require a level of effort beyond what is feasible for a relatively limited improvement.

TOPS-BC essentially reflects the incorporation of IDAS into a spreadsheet format, which is accessible to a wider range of users and provides relatively quick assessments of ITS and operational projects with limited data. The tool is supported by the U.S. DOT's benefit[5] and cost[6] databases, allowing users to access and incorporate national experience in impact measurement.

Two separate versions are available: the Standard Version and the Development Version. The TOPS-BC User's Manual[7] provides more instructions on how to use the tool, along with some case studies.

Due to the characteristics described above, TOPS-BC is recommended as a key congestion management toolbox component for H-GAC and its planning partners, as it provides the following features:

- The ability to investigate the expected range of impacts associated with previous deployments and analyze many transportation system management and operational strategies;
- A screening mechanism to help identify appropriate tools and methodologies for conducting a benefit-cost analysis based on analysis needs;
- A framework and default cost data to estimate the life-cycle costs (including capital, replacement, and continuing operating and maintenance costs) of various transportation system management and operational strategies; and
- A framework and suggested impact values for conducting simple sketch planning level benefit-cost analysis for selected transportation system management and operational strategies.

Vehicle Emissions Modeling Software

The U.S. Environmental Protection Agency (EPA) has developed several spreadsheet-based analysis models to evaluate the potential travel and emissions impacts of TDM strategies, including land use, demand management, and

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[5] http://www.itsbenefits.its.dot.gov/

[6] http://www.itscosts.its.dot.gov/

[7] http://ops.fhwa.dot.gov/publications/fhwahop12028/index.htm

transit-based transportation projects. These models are designed to assist an agency in identifying the impacts of these programs at a systemwide, as well as at the corridor, subarea, and employer-specific level. The MOBILE6 vehicle emission factor model, initially developed in 1978 and last updated in 2004, calculates emissions of hydrocarbons (HC), oxides of nitrogen (NOx), and carbon monoxide (CO) from passenger cars, motorcycles, light- and heavy-duty trucks. In 2010, the MOBILE series of models was replaced by the Motor Vehicle Emission Simulator (MOVES) model as EPA's official model for estimating emissions from cars, trucks, and motorcycles. The full modeling system and documentation are available from the U.S. EPA Modeling and Inventories link, http://www.epa.gov/otaq/models/moves/index.htm. H-GAC is currently using the MOBILE model but is transitioning to MOVES.

Transportation Demand Management (TDM) Evaluation Models

Vehicle emissions models are often used in conjunction with the Regional Travel Model (for regionally significant programs) or other tools such as the Center for Urban Transportation Research Trip Reduction Impacts of Mobility Management Strategies (TRIMMS) tool[8] or TDM Effectiveness Evaluation Model[9] (for non-regionally significant strategies) to estimate the number of commuters who would change their mode of travel or trip-making behavior through participation in the program and calculate the resultant changes in vehicle activity (e.g., reduction in VMT). This information can then be used with the emissions model to estimate the emissions that the commuter program would reduce. Additional guidance can be found in the EPA publication, *Commuter Programs: Quantifying and Using Their Emission Benefits in SIPs and Conformity*[10].

8 http://trimms.com/

9 http://mctrans.ce.ufl.edu/store/description.asp?itemID=149

10 http://www.epa.gov/otaq/stateresources/policy/transp/commuter/420b14004.pdf

8.0 Program and Implement CMP Strategies

This section documents the programming and implementation process for the CMP. It describes how CMP projects are programmed and implemented through inclusion of CMP strategies in various components of the metropolitan transportation planning process, including the 2040 Regional Transportation Plan (RTP), Transportation Improvement Program (TIP), corridor plans, and the Regional ITS Architecture. It also presents a process for conducting a CMP analysis for various transportation investment types.

8.1 Integration with the Metropolitan Transportation Planning Process

This section describes how the CMP coordinates with other regional plans, including the 2040 Regional Transportation Plan (RTP), Transportation Improvement Program (TIP), corridor plans, and the Regional ITS Architecture. The CMP both informs and receives information from these elements of the metropolitan transportation planning process.

Relationship to the 2040 Regional Transportation Plan (RTP)

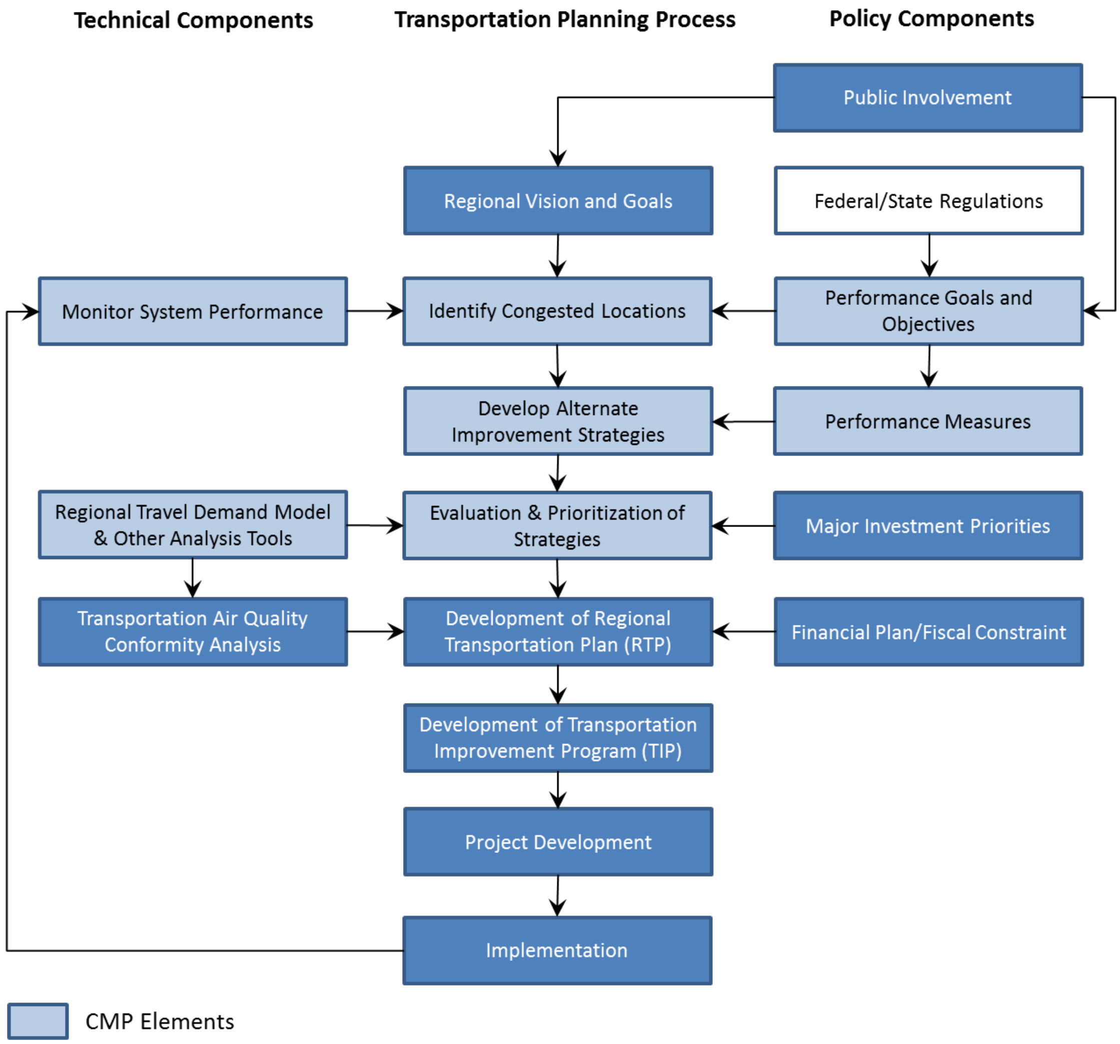
The 2040 RTP Update (currently in development) provides a framework for the Houston region's transportation system by identifying the goals, strategies, and priorities for meeting the region's transportation needs through the year 2040. Updated every four years, the RTP is a multimodal plan that identifies all regionally significant projects and programs planned for the region regardless of the likely funding source. Once a project is included in the RTP, it proceeds through the project development process, including environmental review, preliminary engineering, and right-of-way acquisition. The CMP is an integral part of the long-range planning process and relates to the RTP in the following ways:

- The RTP's vision statement and goals provide a foundation for the development of congestion management objectives and performance measures that are applied through the CMP.
- The CMP provides information the location, duration, and extent of congestion, which can be used by H-GAC and its planning partners to identify congested corridors or segments in need of detailed analysis as part of Corridor or Major Investment Studies.

- The CMP Toolbox provides a framework for developing and evaluating transportation projects and strategies that maintain or reduce recurring and non-recurring congestion. The suggested analysis tools are intended to be used in concert with existing tools such as travel demand modeling, corridor analysis, and traffic simulation to assess how congestion mitigation strategies contribute to achieving regional goals and objectives related to congestion management.
- The CMP defines a process for programming and implementing the most cost-effective strategies by introducing them into the RTP process and subsequently for programming into the TIP. The CMP does not directly obligate funds, but rather it presents a toolbox of congestion mitigation strategies that can be implemented independently or as part of larger projects and programmed in future RTPs and TIPs.
- Once projects are implemented, the CMP provides a mechanism for ongoing system monitoring, both to assess the performance of the system and to evaluate the effectiveness of the congestion management strategies that have been implemented.

Figure 8.1 shows how the CMP is integrated into various technical and policy components of the transportation planning process. The next RTP update will provide policy direction based on analysis and the program- or geography-specific knowledge gained through the CMP. This updated RTP then sets the direction for the next cycle of these planning efforts.

Figure 8.1 Integration of the Congestion Management Process in the Transportation Planning Process



Source: Adapted from *The Transportation Planning Process: Key Issues - A Briefing Book for Transportation Decisionmakers, Officials, and Staff*, Updated September 2007, Publication No. FHWA-HEP-07-039, http://www.planning.dot.gov/documents/BriefingBook/BBook.htm

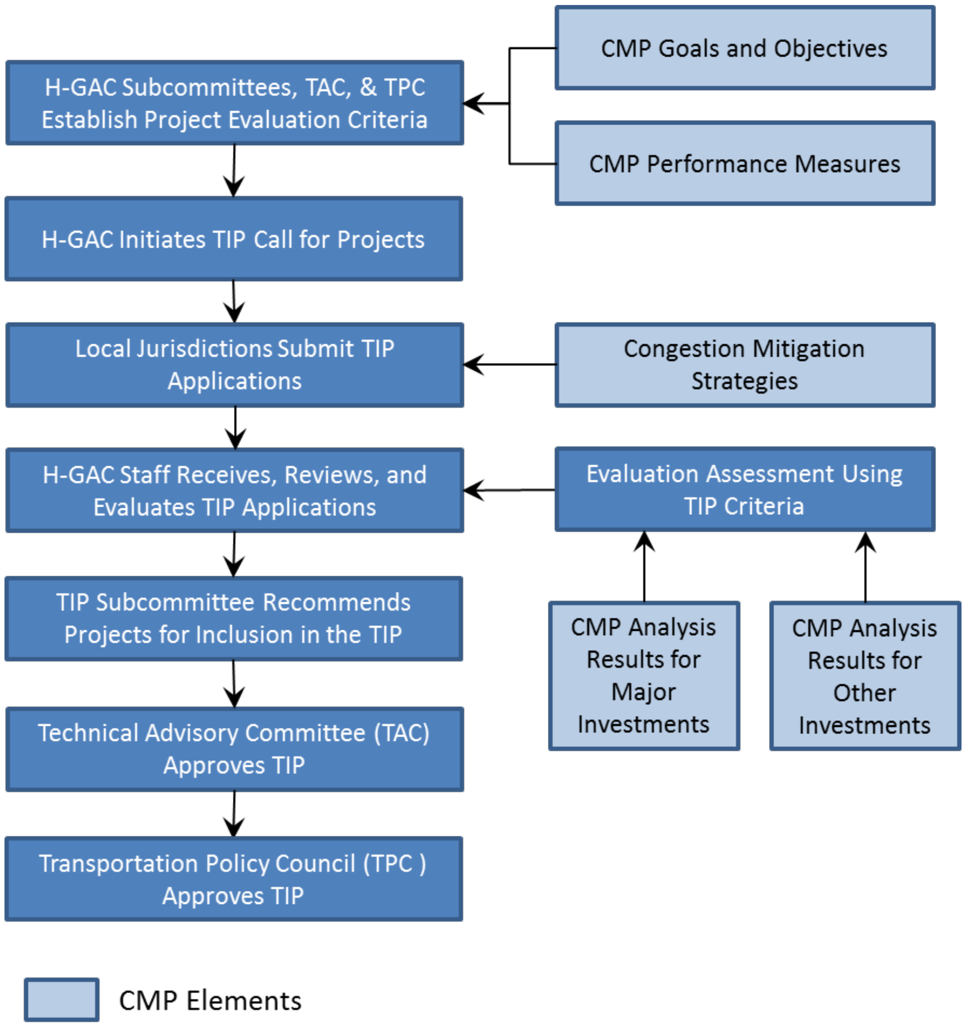
Relationship to the Transportation Improvement Program (TIP)

The TIP is a short-range program that identifies the highest priority projects and programs to be funded and implemented in the Houston region over the next four years. The program identifies federal, state, and local funding for transportation projects that will be implemented within the TIP's four-year timeframe. Updated every two years, the TIP is the implementation plan for projects in the RTP. H-GAC has established project application, programming schedule, project evaluation, and project selection processes in place for the TIP.

H-GAC staff and the TIP Subcommittee evaluate and prioritize Major Investment and Other Investment projects based on criteria approved by the Transportation Policy Council (TPC). Figure 8.2 identifies how the CMP can be integrated into existing TIP processes. The CMP relates to the TIP in the following ways:

- The CMP provides system performance information for use by H-GAC in evaluating projects nominated for inclusion in the TIP.
- The CMP provides system performance information for project sponsors, which may influence their project applications for incorporation in the TIP.
- The CMP Toolbox identifies alternative congestion management strategies for inclusion in SOV capacity-adding projects to be advanced using federal funds.
- The CMP Toolbox identifies potential analysis tools for evaluating project effectiveness in terms of their contribution to a reduction in vehicle miles traveled or traveler hours of delay, number of trips shifted to transit or other alternative modes, and measures of cost effectiveness. The suggested analysis tools are not intended to supplant existing analysis techniques or decision making processes, but rather to complement the approaches currently used.
- The next TIP update should incorporate the CMP objectives and measures into the application scoring process used to select and prioritize projects in the TIP. The CMP is intended to supplement, not replace, the existing TIP project selection process used by H-GAC. It serves as an additional tool for decision-making by the TIP Subcommittee by providing additional information and insight for use by the committee.

Figure 8.2 Integration of the Congestion Management Process in the Transportation Improvement Program (TIP)



Source: Adapted from Transportation Improvement Program: 2015 TIP Call for Projects Application Workshop/Webinar Presentation, October 10, 2014, http://www.h-gac.com/taq/tip/docs/2015/Workshop%20Presentation.pdf

Relationship to the Project Development/NEPA Process

The CMP supports the link between planning and project development by providing information to support project development activities, including corridor alternatives analysis and environmental analyses conducted under the National Environmental Policy Act (NEPA). The CMP relates to these processes in the following ways:

- The CMP provides system performance information that can be used to H-GAC to identify corridors or segments in need of detailed analysis through corridor and NEPA studies.
- Documentation of the need for capacity enhancement (based on the analysis of alternative strategies) should be included in the NEPA project purpose and need statement.
- The CMP Toolbox provides a starting point for identifying alternative congestion mitigation strategies for consideration in corridor and NEPA studies. This does not preclude the corridor/NEPA study from considering other strategies that may not be in the CMP Toolbox, nor does it require that the study select a strategy from the CMP Toolbox as the preferred alternative. However, corridor/NEPA document should include a discussion of how the CMP Toolbox strategies were addressed.
- Congestion mitigation strategies are evaluated as an alternative to the added capacity improvement. If the CMP-only alternative alone cannot meet the travel demand needs in the corridor, supplemental corridor-level CMP strategies that complement the major investment are considered to improve the long-term effectiveness of the improvement.
- The CMP Toolbox identifies potential analysis tools for evaluating project alternatives. Simulation or other appropriate analysis tools from the CMP Toolbox are used to conduct an evaluation of the actions to assess their impacts in the corridor. The extent to which these actions can alleviate travel demand and congestion in the corridor compared to the baseline condition are documented as part of the study.
- Monitoring the effectiveness of implemented improvement projects provides data that supports use of congestion management strategies in future projects.

Relationship to the Regional Intelligent Transportation Systems (ITS) Architecture

The CMP relates to the Regional Intelligent Transportation System (ITS) Architecture in the following ways:

- The Regional ITS Architecture is an important resource for identifying sources of data in the region that can support monitoring and reporting of congestion using CMP performance measures.
- All ITS strategies implemented from the CMP Toolbox should be consistent with the Regional ITS Architecture. The Regional ITS Architecture and the CMP Toolbox should be reviewed for consistency and reconciled as necessary when either is updated.

8.2 CMP ANALYSIS PROCESS

This section presents the CMP analysis process for assessing the congestion reduction potential of CMP strategies in terms of established congestion management objectives and performance measures. A CMP analysis process is defined for each of the following types of transportation investments:

- **Major Investments.** These are Federal and State assisted regionally significant added capacity projects located on the CMP network. Significant added capacity projects tend to have a substantial cost and significantly impact regional or corridor travel patterns. Project descriptions typically include a new roadway or bypass, major or minor road widening to add additional through lanes on an existing highway, major roadway reconstruction, adding capacity to a corridor by improving many related intersections, new interchange, adding capacity to an existing interchange, grade separation of existing intersections (that add capacity), etc.
- **Other Investment Types.** These are Federal and State assisted projects that encompass the following improvement types: transportation demand management, land use, public transportation, bicycle/pedestrian, Intelligent Transportation Systems (ITS) and operations, roadway/mobility (Non-ITS), or added capacity projects located off the CMP Network.
- **Accelerated Projects.** These are projects that are introduced late in the Regional Transportation Plan (RTP) planning cycle due to accelerated growth or congestion relief, connection with an existing project, or new funding opportunities. As a result, the implementation of the projects does not correspond with the typical evaluation process and timeline required for projects already documented in the RTP.
- **Exempted Projects.** Projects are exempt from a CMP analysis if the proposed project solves a safety or bottleneck problem. The criteria for determining whether a project is categorized as a safety or bottleneck project is described at the end of this section.

The CMP analysis process involves conducting either a quantitative or qualitative assessment of the extent to which congestion mitigation strategies can alleviate travel demand and congestion in the corridor. The level of analysis varies depending on the type of transportation investment:

- **Major Investments.** The CMP analysis process for major investments consists of conducting a quantitative analysis of corridor alternatives to assess the extent to which congestion mitigation strategies can alleviate travel demand and congestion in the corridor. Congestion mitigation strategies must be considered as an alternative to capacity. Project sponsors are required to report on the specific strategies that will be implemented as part of the project, as well as quantitatively document the benefits of the project's ability to relieve congestion, improve trip reliability, and/or to define how it meets one or more of the CMP goals and objectives.

- **Other Investment Types.** The CMP analysis process for other investment types is less rigorous compared to that for major investments and consists of a qualitative assessment of the congestion reduction impacts of the project in terms of CMP objectives and performance measures. The assessment criteria are similar to those established for the Transportation Improvement Program.
- **Accelerated Projects.** The CMP analysis process for accelerated projects may be quantitative or qualitative, depending on whether the project is categorized as a major investment or other investment type.
- **Exempted Projects.** Safety and bottleneck projects are exempt and do not require a CMP analysis to be conducted.

Project sponsors are required to complete the *CMP Project Analysis Form* (provided in Appendix C) and submit it to H-GAC. The "Preliminary Questions" section of the form must be completed for all projects, regardless of investment type. For major investments, the "CMP Analysis for Major Investments" section of the form must be completed. For other investment types, the "CMP Analysis for Other Investment Types" section of the form must be completed. Instructions for completing the form are provided in Appendix D. H-GAC staff will review and approve the forms and, if necessary, contact the submitting agency regarding any questions.

An overview of the CMP analysis process for each investment type is summarized in Table 8.1 and Figure 8.3. The table identifies the criteria used to define each investment type (i.e., major investments, other investment types, accelerated projects, exempted projects), an overview of the CMP analysis process for the investment type, *CMP Project Analysis Form* Requirements, and the timing of the CMP analysis within the overall project development process. The figure graphically depicts the criteria for determining investment type, type of CMP analysis, and CMP Project Analysis form requirements. The CMP analysis process for each investment type is discussed in more detail following the table.

Figure 8.3 CMP Analysis Process

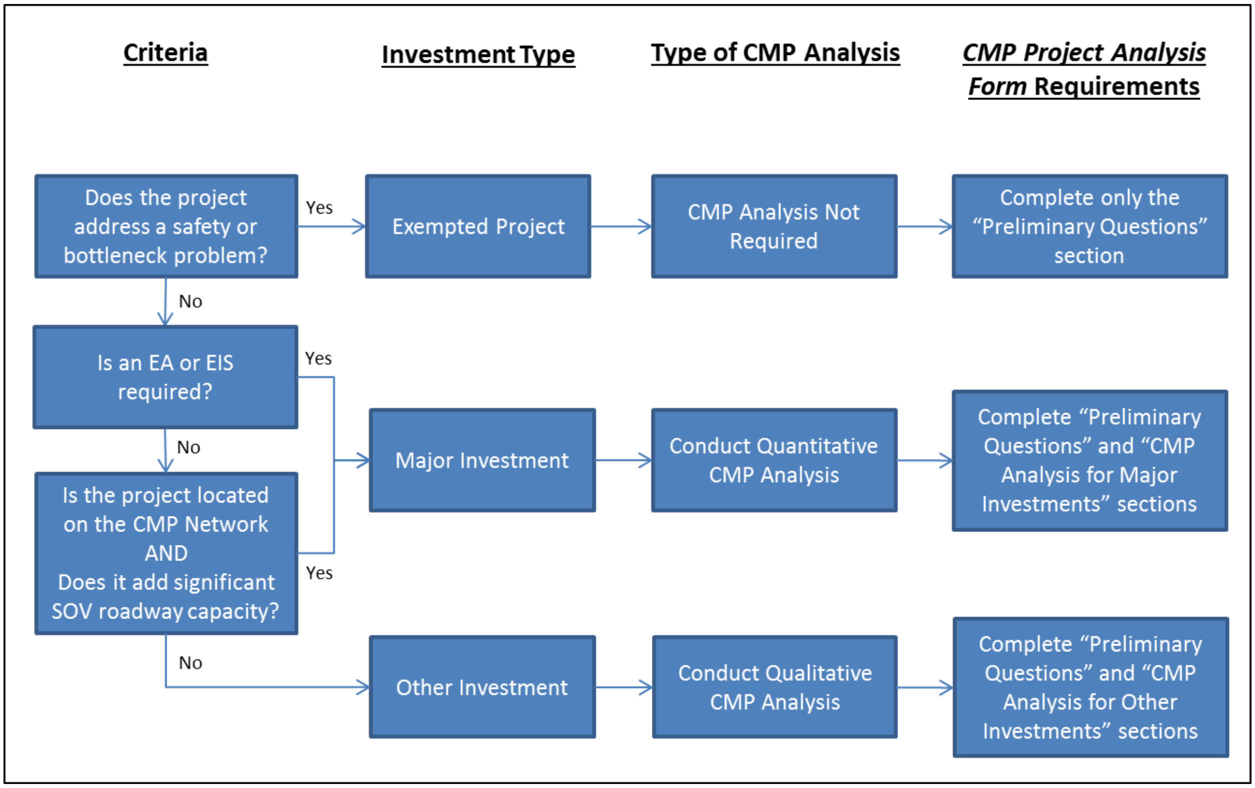


Table 8.1 CMP Analysis Process

	Investment Type			
	Major Investments	Other Investments	Accelerated Projects	Exempted Projects
Criteria for Defining Investment Type	• Environmental Assessment (EA) or Environmental Impact Statement (EIS) required, OR • Project located on CMP Network AND adds significant SOV capacity	• Project not on CMP Network, OR • Project does not add significant SOV capacity • NOTE: Other investment type could include capacity-adding projects not on the CMP Network	• The same criteria as Major Investments or Other Investment Types applies	• Project solves a safety or bottleneck problem, as defined by the Criteria in Table 8.3
CMP Analysis Process	• CMP serves as warrant for justifying additional SOV capacity • Quantitative CMP analysis • Use CMP Report to identify deficiencies on project corridor • Use CMP Toolbox to identify congestion mitigation strategies and/or suggested analysis tools for inclusion in the corridor alternatives analysis and/or NEPA documentation. Consider CMP strategies as an alternative to capacity, and/or bundle CMP strategies into the added capacity project. • Quantitatively document congestion reduction impacts in terms of CMP objectives and measures • Justify reasons for not implementing congestion mitigation strategies	• Other investment projects are subject to less rigorous congestion analysis • Qualitative CMP analysis • Use CMP Toolbox to identify congestion mitigation strategies and/or suggested analysis tools • Conduct qualitative analysis of congestion impacts based on planning factors • Qualitatively document congestion reduction impacts of the project in terms of CMP objectives and measures	• The same CMP analysis process as Major Investments or Other Investment Types applies • H–GAC reviews the CMP analysis process results • H-GAC conducts a scoping meeting with the consultant/project sponsor to discuss alternatives analysis and incorporate CMP strategies into the preferred project alternative • A kickoff meeting is convened, and accelerated environmental assessment, design, and implementation process schedules are defined and implemented	• Project does not require a CMP analysis
CMP Project	• Project sponsors complete both	• Project sponsors complete both	• Project sponsors complete the	• Project sponsors complete only

	Investment Type			
	Major Investments	Other Investments	Accelerated Projects	Exempted Projects
Analysis Form Requirements	the "Preliminary Questions" and "CMP Analysis for Major Investments" sections of the *CMP Project Analysis Form*	the "Preliminary Questions" and "CMP Analysis for Other Investments" sections of the *CMP Project Analysis Form*	"Preliminary Questions" and either the "CMP Analysis for Major Investments" OR the "CMP Analysis for Other Investments" sections of the *CMP Project Analysis Form* (depending on investment type)	the "Preliminary Questions" section of the *CMP Project Analysis Form*
Timing of CMP Analysis	• Conduct CMP analysis as part of corridor alternatives analysis orNEPA document preparation • Pre-requisite for TIP project application	• Conduct CMP analysis as part of mobility study, traffic operations analysis, or local/regional study • Pre-requisite for TIP project application	• The same timing of CMP analysis as Major Investments or Other Investment Types applies (depending on investment type)	• CMP analysis not required • Submit *CMP Project Analysis Form* to H-GAC as part of TIP project application

CMP Analysis for Major Investments

Federal law prohibits regions that are in nonattainment for ozone or carbon monoxide from programming projects that result in a significant increase in carrying capacity for single-occupant vehicles (SOV) in its TIP, unless the project is addressed in the region's CMP. Therefore, a CMP analysis is required for all Federal and State assisted regionally significant added capacity projects located on the CMP network.

The CMP analysis process for major investments consists of conducting a quantitative analysis of corridor alternatives to assess the extent to which congestion mitigation strategies can alleviate travel demand and congestion in the corridor. First, the baseline condition is assessed to determine whether the problem/deficiency can be addressed without building more road capacity. Next, congestion mitigation strategies are evaluated as an alternative to the added capacity improvement. The CMP Toolbox provides a starting point for identifying alternative congestion mitigation strategies, while simulation or other appropriate analysis tools from the CMP Toolbox are used to conduct an evaluation of the actions to assess their impacts in the corridor. If the CMP analysis indicates that congestion mitigation strategies are insufficient to meet the travel demand needs in the corridor and additional SOV capacity is warranted, then the analysis must identify supplemental congestion mitigation strategies to improve the long-term effectiveness of the capacity improvement. The extent to which these actions can alleviate travel demand and congestion in the corridor compared to the baseline condition are documented as part of the CMP analysis. Project sponsors are required to report on the specific strategies that will be implemented as part of the project, as well as quantitatively document the benefits of the project's ability to relieve congestion, improve trip reliability, and/or to define how it meets one or more of the CMP goals and objectives. If congestion mitigation strategies are not feasible or warranted as part of the project, an explanation must be provided as part of the CMP analysis.

Project sponsors are required to complete both the "Preliminary Questions" and "CMP Analysis for Major Investments" sections of the *CMP Project Analysis Form* and submit it to H-GAC. Ideally, a CMP analysis is performed by the project sponsor during the four to ten year short-range planning period in the RTP, prior to submittal of the TIP project application. The CMP analysis could be conducted as part of corridor alternatives analysis or NEPA document preparation, or it could be conducted as a separate analysis. Completing the CMP analysis is a pre-requisite for consideration under H-GAC's TIP project application process.

Because major investment projects are often implemented by other local agencies, project sponsors should contact H-GAC staff at the start of a study or project that will likely add SOV road capacity to the CMP network. H-GAC staff will work with the consultant/project sponsor to discuss the alternatives analysis and incorporate congestion mitigation strategies into the preferred project alternative.

CMP Analysis for Other Investments

The CMP analysis process for other investment types is less rigorous compared to that for major investments and consists of a qualitative assessment of the congestion reduction impacts of the project in terms of CMP objectives and performance measures. Completing the CMP analysis for other investments will assist H-GAC in assessing the project's expected impact on overall congestion goals and objectives for the region.

The CMP Toolbox can be used to identify congestion mitigation strategies to solve a specific problem, or to identify an appropriate analysis tool for evaluating the benefits of a specific strategy type. The congestion reduction impacts of the project are assessed in terms of various qualitative criteria depending on the type of strategy, as shown in Table 8.2. The assessment criteria are similar to those established for the Transportation Improvement Program. The process also includes qualitatively documenting the benefits of the project's ability to relieve congestion, improve trip reliability, and/or to define how it meets one or more of the CMP goals and objectives.

Project sponsors are required to complete both the "Preliminary Questions" and "CMP Analysis for Other Investment Types" sections of the *CMP Project Analysis Form*. The CMP analysis can be conducted as part of a mobility study, traffic operations analysis, or other local/regional study, and it is a pre-requisite for consideration under H-GAC's TIP project application process.

Table 8.2 Qualitative Assessment for Other Investment Types

Strategy Type	Qualitative Criteria
Transportation Demand Management Strategies	• Does the project strongly support or enhance travel demand management programs that are already in place and that have regional significance? If yes, please explain. • Will the project reduce traffic congestion by reducing vehicle trips or VMT? If yes, please explain. • Will the project reduce vehicle emissions? If yes, please explain. • Does the project include marketing, education and incentive programs that encourage shift to alternative modes? If yes, please explain.
Land Use Improvements	• Does the project provide or demonstrate the potential for a transit connection? If yes, please explain. • Does the project provide an accessible pedestrian/bicyclist environment that meets or exceeds TxDOT's policy for Bicycle and Pedestrian Accommodation? If yes, please explain. • Is the project identified within an H-GAC Special Districts Study, an H-GAC Livable Centers Study, or a comparable multi-jurisdictional or local plan study? If yes, please explain.

Strategy Type	Qualitative Criteria
Public Transportation Improvements	• Does the project provide connection to other transit services? If yes, please explain. • Does the project include pedestrian and bicycle accommodations? If yes, please explain. • Is the project an intrinsic part or demonstrate the potential for Transit Oriented Development? If yes, please explain. • Does the project provide access to job opportunities, unmet or enhanced needs? If yes, please explain. • Does the project use intelligent transportation systems and other operation/ service enhancing technologies? If yes, please explain. • Does the project address a need for expanded transit service capacity? If yes, please explain.
Bicycle/ Pedestrian Improvements	• Does the proposed facility meet or exceed TxDOT's policy for Bicycle and Pedestrian Accommodation and AASHTO design guidelines for pedestrian and/or bicycle facilities? If yes, please explain. • Does the proposed facility provide safe and convenient routes across barriers, such as freeways, railroads, and waterways, or does it close a gap in the existing bicycle network that aligns with a regional bikeway shown on the Regional Bikeway Concept Map? If yes, please explain. • Does the proposed facility provide or demonstrate the potential for a transit connection? If yes, please explain. • Does the proposed facility provide connections to regional destinations? If yes, please explain. • Is the project identified within an H-GAC Special Districts Study, an H-GAC Livable Centers Study, or a comparable multi-jurisdictional or local plan study? If yes, please explain.
Intelligent Transportation Systems (ITS) and Operations Strategies	• Is the project an integral part of an incident management system, or will it contribute to a reduction in incident clearance time? If yes, please explain. • Will the system utilize dynamic management of the facility to enhance travel time reliability (e.g., ramp metering, variable speed limits, variable pricing, etc.)? If yes, please explain. • Does the project coordinate traffic signal systems across jurisdictional boundaries and improve progression? If yes, please explain. • Does the project improve accuracy, timeliness, and availability of real-time information to the public? If yes, please explain. • Does the project improve automated traffic data collection and archiving ability? If yes, please explain. • Will the project give priority to emergency vehicles, transit, or high-occupancy vehicles? If yes, please explain. • Is the project consistent with the Regional ITS Architecture? If yes, please explain.
Roadway/ Mobility Improvements (Non-ITS)	• Will the project improve operational efficiency/reliability on a designated freight corridor? If yes, please explain. • Will the project improve a roadway on which fixed route transit service is being provided or otherwise used by other transit services outside of a fixed route

Strategy Type	Qualitative Criteria
	service area? If yes, please explain. • Does the project incorporate access management principles such as raised medians, turn lanes, sharing/combining access points between businesses, or innovative intersections to reduce conflict points (e.g., roundabout, diverging diamond, single point urban interchange, etc.)? If yes, please explain. • Does the project include pedestrian/bicycle accommodations that meet or exceed TxDOT's policy for Bicycle and Pedestrian Accommodation and AASHTO design guidelines? If yes, please explain. • Does the project integrate complete streets design principles? If yes, please explain.
Roadway Capacity Expansion (off the CMP Network)	• Does the project provide a needed connection or additional capacity as identified in an adopted Thoroughfare Plan? If yes, please explain. • Does the project include segments of high congestion, and will the project help to mitigate this congestion? If yes, please explain. • Does the project provide access to existing and/or future business and job activity centers, shopping, educational, cultural, and recreational opportunities? If yes, please explain. • Will the project accommodate or create significant benefits to at least two additional modes of travel, or complete a link to intermodal or freight facilities of regional importance? If yes, please explain. • Does the project impact a network-level change in congestion? If yes, please explain.

CMP Analysis for Accelerated Projects

One gap identified in the 2009 CMP is related to the process of reviewing and planning for accelerated projects not considered and/or documented for programming in the RTP. In previous H-GAC planning cycles, some projects or strategies have been introduced late in the planning process due to one of the following factors:

- Accelerated growth or congestion relief;
- Connection with an existing project; or
- Additional/new funding opportunities.

While these projects typically moved smoothly through H-GAC's planning process, the implementation of the projects did not correspond with the typical evaluation process and timeline required for projects already documented in the RTP. In the 2009 CMP, H-GAC proposed an accelerated project process to ensure that proper analysis was conducted for an accelerated project that was not in the RTP. A similar approach is recommended in this current CMP/RTP Update cycle.

The CMP analysis process for accelerated projects is dependent on whether the project is categorized as a major investment, other investment type, or exempted project, using the same criteria defined previously in Table 8.1. The process includes the following steps:

- Project sponsors complete the "Preliminary Questions" and either the "CMP Analysis for Major Investments" or the "CMP Analysis for Other Investments" sections of the *CMP Project Analysis Form*, depending on the investment type;
- H–GAC reviews the CMP analysis process results;
- H-GAC conducts a scoping meeting with the consultant/project sponsor to discuss alternatives analysis and incorporate congestion mitigation strategies into the preferred project alternative; and
- A kickoff meeting is convened, and accelerated environmental assessment, design, and implementation process schedules are defined and implemented.

The CMP analysis should be completed before start of the environmental assessment process and potential incorporation in the TIP. The congestion mitigation strategies identified to be most beneficial are required to be incorporated into each of these projects. The process also includes documenting the benefits of the project's ability to relieve congestion, improve trip reliability, and/or to define how it meets one or more of the CMP goals and objectives.

H-GAC should meet with TxDOT and other relevant agencies to periodically review projects, determine where they are in the process, identify which elements/documents need to be completed, and identify the agency/jurisdiction responsible for performing the work.

CMP Analysis Exemptions

Projects are exempt from a CMP analysis if the predominant improvement type solves a safety or bottleneck problem. Table 8.3 identifies site characteristics and typical strategies used to distinguish safety and bottleneck improvement projects. Project sponsors must work with H-GAC staff to confirm that a safety or bottleneck issue exists.

No CMP analysis is required to be conducted for safety and bottleneck projects. Project sponsors complete only the "Preliminary Questions" section of the *CMP Project Analysis Form* and submit it to H-GAC as part of the TIP project application.

Table 8.3 Project Types Exempt from CMP Analysis

Project Type	Site Characteristics	Typical Strategies
Safety Projects	Any of the following conditions may exist or help to identify a safety condition: • The predominant improvement type addresses an immediate safety need along a corridor or intersection as documented in a regional/local traffic or safety study • The project location has been identified as a regional crash hotspot or location of high crash incidence by procedures developed by H-GAC	Safety improvements do not include adding capacity and can be accommodated within existing right-of-way. Safety exempt project types include[1]: • Railroad/highway crossing • Projects that correct, improve, or eliminate a hazardous location or feature • Safer non-Federal-aid system roads • Shoulder improvements • Increasing sight distance • Highway Safety Improvement Program (HSIP) implementation projects • Traffic control devices and operating assistance other than signalization projects • Railroad/highway crossing warning devices • Guardrails, median barriers, crash cushions • Pavement resurfacing and/or rehabilitation • Pavement marking • Emergency relief (23 USC 125) • Fencing • Skid treatments • Safety roadside rest areas • Adding medians • Truck climbing lanes outside the urbanized area • Lighting improvements • Widening narrow pavements or reconstructing bridges (no additional travel lanes) • Emergency truck pullovers
Bottleneck Projects	Typical bottleneck locations include lane drops, weaving areas, freeway on-ramps, freeway exit ramps, freeway-to-freeway interchanges, changes in highway alignment, tunnels/underpasses, narrow lanes/lack of shoulders, or at traffic control devices. The following conditions exist or help to identify a recurring bottleneck condition[2]: • A traffic queue exists upstream of the bottleneck, wherein speeds are lower, while free-flow conditions exist elsewhere on the facility. • A beginning point for a queue. There should be a definable point that separates upstream and downstream conditions. The geometry of that point is often coincidently the root cause of the operational deficiency.	Bottleneck improvements are low cost, less than 1 mile in length, and typically include the following strategy types: • Low cost capacity improvements (e.g., auxiliary lanes, shoulder conversions) • Minor intersection/interchange modifications (restriping to change lane configuration, merge/diverge areas, or weaving areas, ramp modifications) • Traffic control device improvements (e.g., ramp metering, signal timing, etc.)

Project Type	Site Characteristics	Typical Strategies
	• Free flow traffic conditions downstream of the bottleneck that have returned to nominal or design conditions. • As it pertains to an operational deficiency, a predictable recurring cause that is theoretically "correctable" by design. • Traffic volumes that exceed the capability of the confluence to process traffic. Note: this applies to recurring events more so than nonrecurring.	

Notes: [1] Safety exempt project types are the same as those defined in federal regulation (40 CFR 92.126) to be exempt from conformity requirements

[2] Source: FHWA Guidance on Localized Bottlenecks, http://ops.fhwa.dot.gov/bn/lbr.htm#g9

9.0 CMP Strategy Effectiveness

Evaluating the effectiveness of implemented congestion mitigation strategies is an essential, required step in the CMP process. The purpose of this step is to ensure that implemented strategies are having the desired effect on congestion, and to modify the CMP Toolbox accordingly to inform the selection and prioritization of future strategies. This could include modifying the expected congestion impacts of strategies, or eliminating a strategy from future consideration if it is ineffective in addressing congestion.

Two general approaches are used for these evaluations:

- **System-Level Performance Evaluation** – A regional analysis of historical trends to identify improvement or degradation in system performance in the region as a whole, in terms of the region's established performance measures; and
- **Strategy Effectiveness Evaluation** – An analysis of before and after conditions for a specific congestion mitigation project or programs implemented in the region, in terms of the region's established performance measures.

It is recommended that both evaluation types be used in the Houston-Galveston region. System level performance should be monitored through data collected as part of the CMP Performance Monitoring Plan, as well as data reported by local agency partners, in order to evaluate system operations on a corridor basis and identify changes in congestion levels from the previous reporting period. System level monitoring will provide feedback on the systemwide effectiveness of congestion mitigation strategies and projects that have been implemented in the region. CMP performance results should be incorporated into H-GAC's Annual Mobility Report and the biennial Houston State of Congestion Report. This will provide a consistent reporting mechanism for the CMP, as well as leverage existing resources for monitoring congestion patterns in the region.

Strategy effectiveness evaluations should be conducted through an analysis of before and after conditions for specific congestion mitigation projects and programs implemented in the region. For major investments, a follow-up evaluation should be conducted 3 years after project completion, and results should be reported in terms of the region's established performance measures. For other investment types, before and after analysis should be conducted on an as-needed basis, or as funding and resources allow. To demonstrate the concept, two examples of strategy effectiveness evaluation using the TOPS-BC analysis tool are provided in Appendices E and F. These examples also demonstrate how the recommended CMP performance measures can be used to evaluate the effectiveness of potential congestion management strategies.

H-GAC could fund these evaluations, or require project sponsors to conduct evaluations of their projects and programs. Focused evaluations of strategy effectiveness can help H-GAC assess how well congestion mitigation strategies are working, whether further improvements are needed, and whether the strategies should be implemented more broadly throughout the region.

A. CMP Network Segment List

Table A.1 CMP Network Segment List

Roadway	Direction	From	To
1st St	Southbound	US 90A	US 59
43rd St	Eastbound	Hempstead Rd	Bingle Rd
		Bingle Rd	US 290
		US 290	Shepherd Rd
61st St	Southbound	Broadway Ave	Seawall Blvd
6th St	Southbound	25th Ave	FM 1764
		FM 1764	FM 1765
6th St/Loop 197	Southbound	FM 1765	SH 3
Airport Blvd	Eastbound	SH 99	SH 6
		SH 6	Eldridge Rd
		Eldridge Pkwy	US 59
		US 59	BW 8
		BW 8	Gessner Dr
		Gessner Dr	Hillcroft Ave
		Hillcroft Ave	Chimney Rock Rd
		Almeda Rd	SH 288
		SH 288	FM 865
		FM 865	Telephone Rd
		Telephone Rd	Broadway St
		Broadway St	IH 45
Alexander Dr	Southbound	SH 146	Spur 55
		Spur 55	SH 146
Alief Clodine Rd	Eastbound	Westpark Toll	SH 6
		SH 6	Eldridge Pkwy
		Eldridge Pkwy	BW 8
Allen Pkwy	Westbound	IH 45	Shepherd Dr
Almeda Rd	Southbound	Old Spanish Trail	IH 610
		IH 610	Airport Blvd
		Airport Blvd	BW 8
Ave 1	Westbound	Lawrence St	SH 36

Roadway	Direction	From	To
		SH 36	Spur 529
Bay Area Blvd	Southbound	Spencer Hwy	Red Bluff Rd
		Red Bluff Rd	SH 3
		SH 3	IH 45
		IH 45	FM 528
		FM 528	Main St
Beaumont Hwy	Eastbound	Mesa Dr	C E King
		C E King	BW 8
		BW 8	US 90
Bellaire Blvd	Eastbound	SH 6	Eldridge Pkwy
		Eldridge Pkwy	BW 8
		BW 8	Gessner Dr
		Gessner Dr	US 59
		US 59	Hillcroft Ave
		Hillcroft Ave	IH 610
		IH 610	Kirby Dr
Beltway 8-East	Northbound	East Toll Plaza	SH-225
		SH-225	Jacinto Port
		Jacinto Port	Wallisville
		Wallisville	Little York
		Little York	Winfield
		Winfield	John Ralston
	Southbound	John Ralston	Winfield
		Winfield	Little York
		Little York	Wallisville
		Wallisville	Jacinto Port
		Jacinto Port	Greenshadow
		Greenshadow	East Toll Plaza
Beltway 8-North	Eastbound	US-290 Northwest	Fallbrook
		Fallbrook	SH-249
		SH-249	Ella
		Ella	Hardy Toll Road
		Hardy Toll Road	John F Kennedy Blvd
		John F Kennedy Blvd	Wilson Rd

Roadway	Direction	From	To
		Wilson Rd	John Ralston
	Westbound	John Ralston	Wilson Rd
		Wilson Rd	John F Kennedy Blvd
		John F Kennedy Blvd	Imperial Valley
		Imperial Valley	Ella
		Ella	SH-249
		SH-249	Fallbrook
		Fallbrook	US-290 Northwest
Beltway 8-South	Eastbound	US-59 Southwest	Fort Bend Parkway
		Fort Bend Parkway	Southwest Toll Plaza
		Southwest Toll Plaza	Southeast Toll Plaza
		Southeast Toll Plaza	Beamer
		Beamer	East Toll Plaza
	Westbound	East Toll Plaza	Beamer
		Beamer	Southeast Toll Plaza
		Southeast Toll Plaza	Southwest Toll Plaza
		Southwest Toll Plaza	Fort Bend Parkway
		Fort Bend Parkway	US-59 Southwest
Beltway 8-West	Northbound	US-59 Southwest	Richmond
		Richmond	Memorial
		Memorial	US-290 Northwest
	Southbound	US-290 Northwest	Memorial
		Memorial	Richmond
		Richmond	US-59 Southwest
Bingle Rd	Southbound	Little York Rd	US 290
		US 290	43rd St
		43rd St	Hempstead Rd
		Hempstead Rd	IH 10
Braeswood Blvd	Eastbound	US 59	Gessner Dr
		Gessner Dr	Hillcroft Ave
		Hillcroft Ave	Post Oak Blvd
Broadway Ave	Eastbound	61st St	Seawall Blvd
Broadway St	Eastbound	SH 288	FM 865
		FM 865	Main St

Roadway	Direction	From	To
		Main St	Edgewood Dr
	Southbound	Navigation Blvd	SH 225
		SH 225	IH 610
		IH 610	IH 45
		IH 45	Airport Blvd
C E King Pkwy	Southbound	BW 8	Ley Rd/Green River Rd
		Ley Rd/Green River Rd	Beaumont Hwy
Clay Rd	Eastbound	SH 6	Eldridge Pkwy
		Eldridge Pkwy	BW 8
		BW 8	Gessner Rd
		Gessner Rd	Hempstead Rd
Clear Lake City Blvd	Southbound	SH 3	IH 45
Clinton Dr	Eastbound	Lockwood Dr	Wayside Dr
		Wayside Dr	IH 610
		IH 610	Federal Rd
College Ave	Eastbound	IH 45	SH 3
Crosstimbers St	Eastbound	Shepherd Rd	IH 45
		IH 45	Hardy Rd
		Hardy Rd	US 59
		US 59	Mesa Dr
Deusson Pkwy	Southbound	Lake Houston Pkwy	N Lake Houston Pkwy
Durham Dr	Southbound	IH 610	IH 10
		IH 10	Shepherd Dr
Eldridge Pkwy	Southbound	FM 1960	US 290
		US 290	FM 529
		FM 529	Clay Rd
		Clay Rd	IH 10
		IH 10	Westheimer Rd
		Westheimer Rd	Westpark Toll
		Westpark Toll	Bellaire Blvd
		Bellaire Blvd	W Bellfort Ave
Eldridge Rd	Southbound	W Bellfort Ave	Airport Blvd
		Airport Blvd	US 90
Fannin St	Southbound	San Jacinto St	IH 45

Roadway	Direction	From	To
		IH 45	US 59
		US 59	Holcombe Blvd
		Holcombe Blvd	Old Spanish Trail
		Old Spanish Trail	IH 610
Federal Rd	Southbound	IH 10	Clinton Dr
Ferry Rd	Southbound	Port Bolivar Bridge	Harborside Dr
FM 1093	Eastbound	SH 99	Westheimer Rd
	Westbound	Westheimer Rd	SH 99
		SH 99	FM 1463
FM 1488	Westbound	IH 45	Woodlands Parkway
		Woodland Parkway	SH 249
		SH 249	FM 1774
FM 1764	Eastbound	SH 6	FM 646
		SH 146	6th St
	Westbound	SH 3	SH 146
		IH 45	SH 3
		FM 646	IH 45
FM 1765	Eastbound	IH 45	SH 3
		SH 3	SH 146
		SH 146	6th St
FM 1960	Eastbound	IH 45	Hardy Rd
		Hardy Rd	US 59
		US 59	Lake Houston Pkwy
		Lake Houston Pkwy	FM 2100
	Westbound	IH 45	Kuykendahl Rd
		Kuykendahl Rd	Veterans Memorial Dr
		Veterans Memorial Dr	SH 249
		SH 249	Eldridge Pkwy
		Eldridge Pkwy	US 290
FM 2004	Eastbound	SH 332	SH 288 Bypass
FM 2100	Southbound	Humble Crosby Rd	FM 1960
		FM 1960	US 90
FM 2100/Crosby Lynchburg Rd/ Main St	Southbound	US 90	IH 10

Roadway	Direction	From	To
FM 2351	Southbound	IH 45	Friendswood Dr
FM 2759	Southbound	US 59	SH 99
FM 2920	Eastbound	US 290/SH 6	SH 249
		SH 249	SH 99
		SH 99	Kuykendahl
		Kuykendahl Rd	Spring Cypress Rd
FM 3083	Southwestbound	IH 45	SH 105
FM 518	Eastbound	Parkwood Ave	Bay Area Blvd
		SH 3	SH 146
FM 521	Southbound	BW 8	SH 6
		SH 6	SH 99
FM 528	Southbound	Friendswood Dr	Loop 409
	Westbound	IH 45	Bay Area Blvd
		Bay Area Blvd	Friendswood Dr
FM 529	Eastbound	SH 99	Fry Rd
		Fry Rd	SH 6
		SH 6	Eldridge Pkwy
		Eldridge Pkwy	US 290
FM 646	Southbound	IH 45	FM 1764
		FM 1764	SH 6
	Westbound	SH 146	SH 3
		SH 3	IH 45
FM 865	Southbound	Old Spanish Trail	IH 610
		IH 610	Airport Blvd
		Airport Blvd	BW 8
		BW 8	Broadway St
Fort Bend Toll	Southbound	US 90	SH 6
FRAZIER	Southbound	Loop 336	SH 105
		SH 105	Loop 336
Friendswood Dr	Southbound	Edgewood Dr	Parkwood Ave
Fry Rd	Southbound	FM 529	IH 10
Gerken Rd	Southbound	US 59	SH 36
Gessner Dr	Southbound	US 290	Hempstead Rd
		Hempstead Rd	Clay Rd

Roadway	Direction	From	To
		Clay Rd	IH 10
		IH 10	Westheimer Rd
		Westheimer Rd	Westpark Toll
		Westpark Toll	Bellaire Blvd
		Bellaire Blvd	US 59
		US 59	Braeswood Blvd
		Braeswood Blvd	Airport Blvd
		Airport Blvd	BW 8
		BW 8	US 90A
Gordon St	Southbound	SH 6	Bypass SH 35
Grogan Mills Rd	Northbound	IH 45	Woodlands Pkwy
	Southbound	Woodlands Pkwy	IH 45
Harborside Dr	Eastbound	IH 45	Seawall Blvd
Hardy Rd	Northbound	IH 10	IH 610
	Southbound	IH 45	Aldine Mail Rt
		Aldine Mail Rt	Little York Rd
		Little York Rd	Crosstimbers St
		Crosstimbers St	IH 610
		IH 610	IH 10
Harwin Dr	Eastbound	BW 8	Gessner Dr
		Gessner Dr	Hillcroft Ave
		Hillcroft Ave	US 59
Hempstead Rd	Eastbound	US 290	Gessner Rd
		Gessner Rd	Clay Rd
		43rd St	Bingle Rd
		Bingle Rd	W 18th St
		W 18th St	IH 610
		IH 610	Wescott St
Hillcroft Ave	Southbound	Westheimer Rd	Westpark Toll
		Westpark Toll	US 59
		US 59	Bellaire Blvd
		Bellaire Blvd	Braeswood Blvd
		Braeswood Blvd	Airport Blvd
		Airport Blvd	US 90

Roadway	Direction	From	To
		US 90	BW 8
Holcombe Blvd	Eastbound	Kirby Dr	Main St
		Main St	US 59
Houston St/SH 321/SH 105	Eastbound	Spur 573	Liberty County Line
IH 10	Eastbound	Spur 330	SH 146
		SH 146	SH 99
		SH 99	SH 73
		SH 73	Chambers County Line
	Westbound	Chambers County Line	SH 73
		SH 73	SH 99
		SH 99	SH 146
		SH 146	Spur 330
IH 45	Eastbound	SH 275	61st St
	Northbound	FM 1488	Loop 336
		Loop 336	SH 105
		SH 105	Loop 336
		Loop 336	FM 3083
		FM 3083	Walker County Line
	Southbound	Walker County Line	FM 3083
		FM 3083	Loop 336
		Loop 336	SH 105
		SH 105	Loop 336
		Loop 336	FM 1488
IH-10 East	Eastbound	Taylor	US-59 Eastex
		US-59 Eastex	Lockwood
		Lockwood	IH-610 East Loop
		IH-610 East Loop	Mercury
		Mercury	Normandy
		Normandy	Sheldon
		Sheldon	Magnolia
		Magnolia	Crosby-Lynchburg
	Westbound	Crosby-Lynchburg	Magnolia
		Magnolia	Sheldon
		Sheldon	Federal

Roadway	Direction	From	To
		Federal	Mercury
		Mercury	IH-610 East Loop
		IH-610 East Loop	Lockwood
		Lockwood	US-59 Eastex
IH-10 Katy	Eastbound	Brazos River	FM-1489
		FM-1489	Woods
		Woods	Pederson
		Pederson	Pin Oak
		Pin Oak	Grand Parkway
		Grand Parkway	Westgreen
		Westgreen	Greenhouse
		Greenhouse	SH-6
		SH-6	Eldridge
		Eldridge	Kirkwood
		Kirkwood	Beltway 8-West
		Beltway 8-West	Blalock
		Blalock	Bingle/Voss
		Bingle/Voss	IH-610 West Loop
		IH-610 West Loop	T.C. Jester
		T.C. Jester	Taylor
	Westbound	US-59 Eastex	Taylor
		Taylor	T.C. Jester
		T.C. Jester	IH-610 West Loop
		IH-610 West Loop	Antoine
		Antoine	Blalock
		Blalock	Beltway 8-West
		Beltway 8-West	Kirkwood
		Kirkwood	SH-6
		SH-6	Greenhouse
		Greenhouse	Westgreen
		Westgreen	Mason
		Mason	Pin Oak
		Pin Oak	Pederson
		Pederson	Woods

Roadway	Direction	From	To
		Woods	FM-1489
		FM-1489	Brazos River
IH-45 Gulf	Northbound	Tiki Island	SH-6/SH-146
		SH-6/SH-146	Vauthier
		Vauthier	Delaney
		Delaney	Holland
		Holland	FM-646
		FM-646	Clear Creek
		Clear Creek	El Dorado
		El Dorado	Dixie Farm Road (FM-1959)
		Dixie Farm Road (FM-1959)	Fuqua
		Fuqua	Edgebrook
		Edgebrook	Monroe
		Monroe	IH-610 South Loop
		IH-610 South Loop	Telephone
		Telephone	Scott
		Scott	Allen Parkway
	Southbound	Allen Parkway	Scott
		Scott	Telephone
		Telephone	IH-610 South Loop
		IH-610 South Loop	Monroe
		Monroe	Edgebrook
		Edgebrook	Fuqua
		Fuqua	Dixie Farm Road (FM-1959)
		Dixie Farm Road (FM-1959)	El Dorado
		El Dorado	Clear Creek
		Clear Creek	FM-646
		FM-646	Holland
		Holland	Delaney
		Delaney	Vauthier
		Vauthier	SH-6/SH-146
		SH-6/SH-146	Tiki Island
		Tiki Island	Harborside
IH-45 North	Northbound	Allen Parkway	Cavalcade

Roadway	Direction	From	To
		Cavalcade	Tidwell
		Tidwell	Little York
		Little York	West
		West	Greens
		Greens	Airtex
		Airtex	FM-1960
		FM-1960	Louetta
		Louetta	Hardy Toll Road
		Hardy Toll Road	Woodlands Parkway
		Woodlands Parkway	Research Forest
		Research Forest	SH-242
		SH-242	FM-1488
	Southbound	FM-1488	SH-242
		SH-242	Research Forest
		Research Forest	Woodlands Parkway
		Woodlands Parkway	Hardy Toll Road
		Hardy Toll Road	Louetta
		Louetta	FM-1960
		FM-1960	Airtex
		Airtex	Greens
		Greens	West
		West	Little York
		Little York	Tidwell
		Tidwell	Cavalcade
		Cavalcade	Allen Parkway
IH-610 East Loop	Northbound	SH-225	Clinton
		Clinton	Wallisville
	Southbound	Wayside	Wallisville
		Wallisville	Clinton
		Clinton	Broadway
IH-610 North Loop	Eastbound	Shepherd/Durham	Irvington
		Irvington	Lockwood
		Lockwood	Wayside
	Westbound	Wallisville	Wayside

Roadway	Direction	From	To
		Wayside	Lockwood
		Lockwood	Irvington
		Irvington	Shepherd/Durham
IH-610 South Loop	Eastbound	South Post Oak	Stella Link
		Stella Link	SH-288
		SH-288	Scott
		Scott	South Wayside
		South Wayside	SH-225
	Westbound	Broadway	South Wayside
		South Wayside	Scott
		Scott	SH-288
		SH-288	Stella Link
		Stella Link	Evergreen
IH-610 West Loop	Northbound	Evergreen	US-59 Southwest
		US-59 Southwest	Westheimer
		Westheimer	IH-10 Katy
		IH-10 Katy	Shepherd
	Southbound	Shepherd	IH-10 Katy
		IH-10 Katy	Westheimer
		Westheimer	US-59 Southwest
		US-59 Southwest	Evergreen
		Evergreen	South Post Oak
John F Kennedy Blvd	Eastbound	Hardy Rd	Will Clayton Pkwy
Kingwood Dr	Eastbound	US 59	Lake Houston Pkwy
Kirby Dr	Southbound	Shepherd Dr	US 59
		US 59	Holcombe Blvd
		Holcombe Blvd	Old Spanish Trail
Kuykendahl Rd	Southbound	Rayford Rd	SH 99
		SH 99	FM 2920
		FM 2920	FM 1960
		FM 1960	IH 45
Lake Houston Pkwy	Eastbound	Kingwood Dr	FM 1960
	Southbound	FM 1960	Deussen Pkwy
	Westbound	Deusson Pkwy	BW 8

Roadway	Direction	From	To
League City Pkwy	Eastbound	IH 45	SH 3
		SH 3	SH 146
Ley Rd	Eastbound	Mesa Dr	King Pkwy
Little York Rd	Eastbound	Hempstead Rd	US 290
		US 290	Bingle Rd
		Bingle Rd	Shepherd Dr
		Shepherd Dr	IH 45
		IH 45	Hardy Rd
		Hardy Rd	US 59
		US 59	Mesa Dr
Lockwood Dr	Southbound	IH 610	IH 10
		IH 10	Clinton Dr
		Clinton Dr	Navigation Blvd
		Navigation Blvd	IH 45
LOOP 336	Eastbound	SH 105	IH 45
		IH 45	Frazier St
		Frazier St	SH 105
		IH 45	SH 105
	Southbound	SH 105	IH 45
	Westbound	IH 45	SH 105
Loop 409	Southbound	SH 35	SH 6
Macario Garcia Dr	Southbound	Clinton Dr	Navigation Blvd
Main St	Eastbound	Bay Area Blvd	IH 45
		IH 45	SH 3
		Bay Area Blvd	SH 146
	Northbound	Post Oak Blvd	Stella Link Rd
		US 90	Layl Dr
	Southbound	IH 10	IH 45
		IH 45	US 59
		US 59	Holcombe Blvd
		Holcombe Blvd	Old Spanish Trail
		Old Spanish Trail	IH 610
		IH 610	Stella Link Rd
		Stella Link Rd	Post Oak Blvd

Roadway	Direction	From	To
		BW 8	Broadway St
Main St/US 90A	Northbound	Hillcroft Ave	Post Oak Blvd
	Southbound	Post Oak Blvd	Hillcroft Ave
Maxey Rd	Southbound	US 90	IH 10
McCarty St	Northbound	IH 10	IH 610
		IH 610	Mesa Dr
Memorial Dr	Eastbound	IH 610	Westcott St
		Westcott St	Shepherd Dr
		Shepherd Dr	IH 45
Mesa Dr	Southbound	Mount Houston Rd	Little York Rd
		Little York Rd	Ley Rd
		Ley Rd	McCarty St
Mount Houston Rd	Westbound	Mesa Dr	US 59
N Houston Rosslyn Rd	Southbound	SH 249	Little York Rd
N Lake Houston Pkwy	Westbound	Deusson Pkwy	BW 8
		BW 8	Mesa Dr
Nasa Pkwy	Westbound	SH 146	SH 3
		SH 3	IH 45
Nasa Rd Bypass	Westbound	Nasa Pkwy	IH 45
Navigation Blvd	Eastbound	US 59	Lockwood Dr
		Lockwood Dr	Macario Garcia Dr
		Macario Garcia Dr	Harrisburg Blvd
Old Spanish Trail	Westbound	IH 45	Spur 5
		Spur 5	FM 865
		FM 865	SH 288
		SH 288	Almeda Rd
		Almeda Rd	Fannin St
		Fannin St	Main St
Post Oak Rd	Southbound	IH 610	Main St
		Main St	BW 8
		BW 8	McHard Rd
Red Bluff Rd	Southbound	Shaver St	SH 225
		SH 225	BW 8

Roadway	Direction	From	To
		BW 8	Spencer Hwy
		Spencer Hwy	Bay Area Blvd
		Bay Area Blvd	SH 146
Reveille St/Telephone Rd	Southbound	IH 610	Airport Blvd
Richey St	Southbound	Shaver St	SH 225
		SH 225	SH 3
S Lake Houston Pkwy	Southbound	Deusson Pkwy	BW 8
		Beaumont Hwy	US 90
San Jacincto St	Southbound	IH 10	IH 45
San Jacinto St	Southbound	IH 45	US 59
		US 59	Fannin St
San Luis Pass Rd	Westbound	61st St	SH 332
Seawall Blvd	Southbound	Harborside Dr	Broadway Ave
	Westbound	Broadway Ave	61st St
Sens Rd	Southbound	SH 225	Spencer Hwy
SH 105	Eastbound	Montgomery County Line	FM 3083
		FM 3083	Loop 336
		Loop 336	IH 45
		IH 45	Frazier St
		Frazier St	Loop 336
		E Loop 336	US 59
		US 59	Spur 573
SH 146	Northbound	Red Bluff Rd	Main St
		Spur 330	Alexander Dr
	Southbound	FM 1960	SH 99
		SH 99	IH 10
		IH 10	Alexander Dr
		Alexander Dr	Spur 330
		Main St	Red Bluff Rd
		Red Bluff Rd	Nasa Pkwy
		Nasa Pkwy	FM 518
		FM 518	League City Pkwy
		League City Pkwy	FM 646

Roadway	Direction	From	To
		FM 646	FM 1764
		FM 1764	FM 1765
		FM 1765	SH 3
SH 249	Northbound	N Houston Rosslyn Rd	BW 8
		Tomball Rd	SH 99
		SH 99	FM 2920
		FM 2920	FM 1488
	Southbound	FM 1488	FM 2920
		FM 2920	SH 99
		SH 99	Tomball Rd
		BW 8	N Houston Rosslyn Rd
	Westbound	IH 45	Veterans Memorial Dr
		Veterans Memorial Dr	N Houston Rosslyn Rd
SH 288	Northbound	SH 36	SH 332
		FM 2004	SH 35
		SH 35	SH 288 Bypass
		SH 288 Bypass	SH 99
		SH 99	SH 6
	Southbound	SH 6	SH 99
		SH 99	SH 288 Bypass
		SH 288 Bypass	SH 35
		SH 35	FM 2004
		SH 332	SH 36
SH 288 Bypass	Southbound	SH 288	SH 35
		SH 35	FM 2004
		FM 2004	SH 332
SH 3	Southbound	Richey St	Spencer Hwy
		Spencer Hwy	Shaver St
		Shaver St	BW 8
		BW 8	Clear Lake City Blvd
		Clear Lake City Blvd	Bay Area Blvd
		Bay Area Blvd	Nasa Pkwy
		Nasa Pkwy	Main St
		Main St	League City Pkwy

Roadway	Direction	From	To
		League City Pkwy	FM 646
		FM 646	FM 1764
		FM 1764	FM 1765
		FM 1765	IH 45
SH 321	Southbound	Norcross Ln	FM 1960
SH 332	Northbound	SH 288 Bypass	FM 2004
	Southbound	FM 2004	SH 288 Bypass
		SH 288 Bypass	Gulf of Mexico
SH 35	Southbound	Gordon St	SH 99
		SH 99	Loop 274
SH 35 Bypass	Northbound	SH 35	SH 6
		SH 6	SH 35
	Southbound	SH 35	SH 6
		SH 6	SH 35
SH 35/Main St	Southbound	Broadway St	Bypass SH 35
SH 35/Mulberry St	Westbound	Loop 274	SH 288
SH 36	Southbound	US 59	Gerken Road
		Gerken Rd	SH 288
		SH 288	FM 1495
	Westbound	Spur 529	Spur 10
		Spur 10	Fort Bend County Line
SH 6	Eastbound	FM 521	SH 288
		SH 288	Loop 409
		Loop 409	Bypass 35
		Bypass 35	FM 1764
		FM 1764	FM 646
		FM 646	IH 45
	Northbound	FM 526	US 290
	Southbound	FM 529	Clay Rd
		Clay Rd	IH 10
		IH 10	Westheimer Rd
		Westheimer Rd	Westpark Toll
		Westpark Toll	Bellaire Blvd
		Bellaire Blvd	Airport Blvd

Roadway	Direction	From	To
		Airport Blvd	US 90
		US 90	US 59
		US 59	Fort Bend Toll
		Fort Bend Toll	FM 521
	Westbound	Bypass 35	Loop 409
SH 73	Eastbound	IH 10	Chambers County Line
	Westbound	Chambers County Line	IH 10
SH 87	Eastbound	Port Bolivar Bridge	SH 124
SH 99	Eastbound	US 290	IH 10
		SH 35 Bypass	FM 646
	Southbound	Airport Blvd	US 90A
		US 90A	US 59
		US 59	SH 35
SH 99 West	Northbound	Airport Blvd	FM 1093
		FM 1093	IH 10
	Southbound	IH 10	FM 1093
		FM 1093	Airport Blvd
SH 99/Spur 55	Southbound	IH 10	Alexander Dr
SH-146	Northbound	Fairmont Parkway	Barbours Cut
		Barbours Cut	Fred Hartman Bridge South
		Fred Hartman Bridge South	Fred Hartman Bridge North
		Fred Hartman Bridge North	W Texas
	Southbound	W Texas	Fred Hartman Bridge North
		Fred Hartman Bridge North	Fred Hartman Bridge South
		Fred Hartman Bridge South	Barbours Cut
SH-225	Eastbound	IH-610 East Loop	Richey
		Richey	Beltway 8-East
		Beltway 8-East	Battleground
		Battleground	SH-146
	Westbound	SH-146	Battleground
		Battleground	Beltway 8-East
		Beltway 8-East	Richey
		Richey	IH-610 East Loop
SH-249	Northbound	Beltway 8-North	Mills

Roadway	Direction	From	To
		Mills	Cypresswood
		Cypresswood	Northpointe
	Southbound	Jones	Cypresswood
		Cypresswood	Mills
		Mills	Beltway 8-North
SH-288	Northbound	SH-6	McHard
		McHard	Beltway 8-South
		Beltway 8-South	Airport
		Airport	IH-610 South Loop
		IH-610 South Loop	US-59 Southwest
	Southbound	US-59 Southwest	IH-610 South Loop
		IH-610 South Loop	Beltway 8-South
		Beltway 8-South	FM-518
		FM-518	SH-6
SH-99 West	Northbound	IH-10 Katy	Morton
		Morton	Clay Rd
		Clay Rd	Beckendorff
		Beckendorff	Longenbaugh
		Longenbaugh	West Rd
		West Rd	House Hahl
		House Hahl	Bridgeland Lake Parkway
		Bridgeland Lake Parkway	US-290 Northwest
	Southbound	US-290 Northwest	Bridgeland Lake Parkway
		Bridgeland Lake Parkway	House Hahl
		House Hahl	West Rd
		West Rd	Longenbaugh
		Longenbaugh	Beckendorff
		Beckendorff	Clay Rd
		Clay Rd	Morton
		Morton	IH-10 Katy
Shaver St	Southbound	Clinton Dr	Red Bluff Rd
		Red Bluff Rd	SH 225
		SH 225	Spencer Hwy
		Spencer Hwy	SH 3

Roadway	Direction	From	To
		SH 3	IH 45
Shepherd Dr	Southbound	Stuebner Airline Rd	Little York Rd
		Little York Rd	Crosstimbers St
		Crosstimbers St	IH 610
		IH 610	IH 10
		IH 10	Allen Pkwy
Spencer Hwy	Eastbound	SH 3	Shaver St
		Shaver St	BW 8
		BW 8	Red Bluff Rd
		Red Bluff Rd	Bay Area Blvd
Spur 10	Southbound	SH 36	US 59
Spur 5	Northbound	Old Spanish Trail	IH 45
	Southbound	IH 45	Old Spanish Trail
Spur 527	Northbound	US 59	IH 45
	Southbound	IH 45	US 59
Spur 529	Southbound	SH 36	US 59
Spur 573	Northbound	US 59	SH 105
		SH 105	Houston St
		Houston St	US 59
	Southbound	US 59	Houston St
		Houston St	SH 105
		SH 105	US 59
Spur-330	Eastbound	IH-10 East@Crosby-Lynchburg	Bayway
		Bayway	W Texas
	Westbound	W Texas	Wade Road
		Wade Road	IH-10 East@Crosby-Lynchburg
Stuebner Airline Rd	Southbound	FM 2920	FM 1960
		FM 1960	BW 8
Telephone Rd	Southbound	Airport Blvd	BW 8
US 290	Eastbound	Waller County Line	FM 1817
	Westbound	FM 1817	Waller County Line
US 59	Northbound	Fort Bend County Line	Spur 10
		Spur 10	SH 36
		SH 36	SH 99

Roadway	Direction	From	To
		FM 1960	Kingwood Dr
		Kingwood Dr	SH 99
		SH 99	Spur 573
		Spur 573	SH 105
		SH 105	Spur 573
		Spur 573	Liberty County Line
	Southbound	Liberty County Line	Spur 573
		Spur 573	SH 105
		SH 105	Spur 573
		Spur 573	SH 99
		SH 99	Kingwood Dr
		Kingwood Dr	FM 1960
		SH 99	1st St
		1st St	Spur 10
		Spur 10	Fort Bend County Line
US 90	Eastbound	IH 10	Maxey Rd
		Maxey Rd	BW 8
		BW 8	FM 2100/Crossby Lynchburg Rd
		FM 2100/Crossby Lynchburg Rd	SH 99
		SH 99	SH 146
		SH 146	Main St
		Main St	Layl Dr
	Westbound	SH 99	FM 2100/Crosby Lynchburg Rd
		FM 2100/Crosby Lynchburg Rd	BW 8
		BW 8	Maxey Rd
		Maxey Rd	IH 10
US 90A	Eastbound	SH 99	SH 6
		SH 6	Eldridge Rd
		Eldridge Rd	US 59
		US 59	BW 8
	Northbound	BW8	Hillcroft Ave
	Southbound	Hillcroft Ave	BW 8
	Westbound	BW 8	US 59
		US 59	Eldridge Rd

Roadway	Direction	From	To
		Eldridge Rd	SH 6
		SH 6	SH 99
		SH 99	1st St
		1st St	SH 36
US-290 Northwest	Eastbound	SH-6 North in Hempstead	FM-1488
		FM-1488	FM-1098
		FM-1098	FM-362
		FM-362	FM-2920
		FM-2920	Kickapoo Rd
		Kickapoo Rd	Roberts Rd
		Roberts Rd	Bauer Rd
		Bauer Rd	Mueschke Rd
		Mueschke Rd	Barker-Cypress
		Barker-Cypress	Huffmeister
		Huffmeister	SH-6/FM-1960
		SH-6/FM-1960	West
		West	Senate
		Senate	Fairbanks-North Houston
		Fairbanks-North Houston	Pinemont
		Pinemont	West 34th
		West 34th	IH-610 West Loop
	Westbound	IH-610 West Loop	West 34th
		West 34th	Pinemont
		Pinemont	Fairbanks-North Houston
		Fairbanks-North Houston	Senate
		Senate	West
		West	SH-6/FM-1960
		SH-6/FM-1960	Huffmeister
		Huffmeister	Barker-Cypress
		Barker-Cypress	Mueschke Rd
		Mueschke Rd	Bauer Rd
		Bauer Rd	Roberts Rd
		Roberts Rd	Kickapoo Rd
		Kickapoo Rd	FM-2920

Roadway	Direction	From	To
		FM-2920	FM-362
		FM-362	FM-1098
		FM-1098	FM-1488
		FM-1488	SH-6 North in Hempstead
US-59 Eastex	Northbound	IH-45 Gulf	Quitman
		Quitman	IH-610 North Loop
		IH-610 North Loop	Tidwell
		Tidwell	Aldine Mail Route
		Aldine Mail Route	Beltway 8-North
		Beltway 8-North	Will Clayton
		Will Clayton	Townsen
	Southbound	Townsen	Will Clayton
		Will Clayton	Beltway 8-North
		Beltway 8-North	Aldine Mail Route
		Aldine Mail Route	Tidwell
		Tidwell	IH-610 North Loop
		IH-610 North Loop	Quitman
		Quitman	IH-45 Gulf
US-59 Southwest	Northbound	SH-99	Sweetwater
		Sweetwater	Williams Trace
		Williams Trace	Wilcrest
		Wilcrest	Bissonnet
		Bissonnet	Hillcroft
		Hillcroft	IH-610 West Loop
		Newcastle	Hazard
		IH-610 West Loop	Newcastle
		Hazard	Fannin
		Fannin	IH-45 Gulf
	Southbound	IH-45 Gulf	Fannin
		Fannin	Hazard
		Hazard	Newcastle
		Newcastle	IH-610 West Loop
		IH-610 West Loop	Hillcroft
		Hillcroft	Bissonnet

Roadway	Direction	From	To
		Bissonnet	Wilcrest
		Wilcrest	Williams Trace
		Williams Trace	Sweetwater
		Sweetwater	SH-99
Veteran Memorial Dr	Southbound	BW 8	SH 249
Veterans Memorial Dr	Southbound	SH 249	IH 45
Voss Rd	Southbound	IH 10	Westheimer Rd
W 18th St	Eastbound	Hempstead Rd	T C Jester Blvd
Wayside Dr	Southbound	IH 10	Clinton Dr
		Navigation Blvd	IH 45
Westcott St	Southbound	IH 10	Memorial Dr
Westheimer Rd	Westbound	IH 610	Hillcroft Ave
		Hillcroft Ave	Gessner Dr
		Gessner Dr	BW 8
		BW 8	Eldridge Pkwy
		Eldridge Pkwy	SH 6
		SH 6	FM 1093
Westpark Dr	Eastbound	Eldridge Pkwy	BW 8
		BW 8	Gessner Dr
		Gessner Dr	Hillcroft Ave
		Hillcroft Ave	US 59
Westpark Toll	Eastbound	Westheimer Rd	IH 610
Will Clayton Pkwy	Northbound	BW 8	US 59
	Southbound	US 59	BW 8
Winkler Dr	Westbound	Richey St	IH 45
Woodlands Pkwy	Eastbound	FM 1488	Grogans Mill Rd
		Grogans Mill Rd	IH 45
	Westbound	IH 45	Grogan Mills Rd
		Grogans Mill Rd	FM 1488

Source: H-GAC CMP Network GIS Layer

B. Tier 2 Network Segment List

Table B.1 Tier 2 Network Segments

Roadway	Direction	From	To
ALMEDA GENOA	Eastbound	Almeda	SH 288
	Westbound	SH 288	Almeda
ANTOINE	Northbound	Hempstead	US 290
		US 290	43rd
		43rd	Little York
		Little York	SH 249
	Southbound	SH 249	Little York
		Little York	43rd
		43rd	US 290
		US 290	Hempstead
BARKER CYPRESS	Northbound	IH 10	Clay
		Clay	Little York
		Little York	FM 529
		FM 529	US 290
	Southbound	US 290	FM 529
		FM 529	Little York
		Little York	Clay
		Clay	IH 10
BEECHNUT	Eastbound	Eldridge	Dairy Ashford
		Dairy Ashford	Wilcrest
		Wilcrest	Beltway 8
		Beltway 8	Gessner
		Gessner	US 59
		US 59	Fondren
		Fondren	Bissonnet
		Bissonnet	Hillcroft
		Hillcroft	IH 610
	Westbound	IH 610	Hillcroft
		Hillcroft	Bissonnet
		Bissonnet	Fondren

Roadway	Direction	From	To
		Fondren	US 59
		US 59	Gessner
		Gessner	Beltway 8
		Beltway 8	Wilcrest
		Wilcrest	Dairy Ashford
		Dairy Ashford	Eldridge
BELLFORT	Eastbound	Eldridge	Dairy Ashford
		Dairy Ashford	Wilcrest
		Wilcrest	US 59
		US 59	Beltway 8
		Beltway 8	Gessner
		Gessner	Fondren
		Fondren	Hilcroft
		Hilcroft	Post Oak
	Westbound	Post Oak	Hilcroft
		Hilcroft	Fondren
		Fondren	Gessner
		Gessner	Beltway 8
		Beltway 8	US 59
		US 59	Wilcrest
		Wilcrest	Dairy Ashford
		Dairy Ashford	Eldridge
BISSONNET	Eastbound	FM 1464	SH 6
		SH 6	Eldridge
		Eldridge	Dairy Ashford
		Dairy Ashford	Wilcrest
		Wilcrest	Beltway 8
		Beltway 8	US 59
		US 59	Gessner
		Gessner	Fondren
		Fondren	Beechnut
		Beechnut	Hilcroft
		Hilcroft	Bellaire
		Bellaire	IH 610

Roadway	Direction	From	To
		IH 610	Kirby
		Kirby	Main
	Westbound	Main	Kirby
		Kirby	IH 610
		IH 610	Bellaire
		Bellaire	Hilcroft
		Hilcroft	Beechnut
		Beechnut	Fondren
		Fondren	Gessner
		Gessner	US 59
		US 59	Beltway 8
		Beltway 8	Wilcrest
		Wilcrest	Dairy Ashford
		Dairy Ashford	Eldridge
		Eldridge	SH 6
		SH 6	FM 1464
BLALOCK	Northbound	IH 10	Clay
		Clay	Hempstead
	Southbound	Hempstead	Clay
		Clay	IH 10
BRIAR FOREST	Eastbound	SH 6	Eldridge
		Eldridge	Dairy Ashford
		Dairy Ashford	Wilcrest
		Wilcrest	Beltway 8
		Beltway 8	Memorial
	Westbound	Memorial	Beltway 8
		Beltway 8	Wilcrest
		Wilcrest	Dairy Ashford
		Dairy Ashford	Eldridge
		Eldridge	SH 6
CLAY	Eastbound	Barker Cypress	SH 6
	Westbound	SH 6	Barker Cypress
DAIRY ASHFORD	Northbound	US 90A	Airport
		Airport	Bellfort

Roadway	Direction	From	To
		Bellfort	Bissonnet
		Bissonnet	Beechnut
		Beechnut	Bellaire
		Bellaire	Alief Clodine
		Alief Clodine	Westpark
		Westpark	Richmond
		Richmond	Westheimer
		Westheimer	Briar Forest
		Briar Forest	Memorial
		Memorial	IH 10
	Southbound	IH 10	Memorial
		Memorial	Briar Forest
		Briar Forest	Westheimer
		Westheimer	Richmond
		Richmond	Westpark
		Westpark	Alief Clodine
		Alief Clodine	Bellaire
		Bellaire	Beechnut
		Beechnut	Bissonnet
		Bissonnet	Bellfort
		Bellfort	Airport
		Airport	US 90A
DULLES	Northbound	SH 6	FM 3345/Cartwright
		FM 3345/Cartwright	Lexington
		Lexington	US 90A
	Southbound	US 90A	Lexington
		Lexington	FM 3345/Cartwright
		FM 3345/Cartwright	SH 6
EDGEBROOK	Eastbound	IH 45	SH 3
		SH 3	Shaver
	Westbound	Shaver	SH 3
		SH 3	IH 45
ELGIN	Eastbound	Westheimer	Brazos
	Westbound	Brazos	Westheimer

Roadway	Direction	From	To
FAIRBANKS N HOUSTON	Northbound	Hempstead	US 290
		US 290	Little York
		Little York	Beltway 8
	Southbound	Beltway 8	Little York
		Little York	US 290
		US 290	Hempstead
FAIRMONT PKWY	Eastbound	Bay Area	SH 146
		Beltway 8	Red Bluff
		Red Bluff	Bay Area
		Shaver	Beltway 8
	Westbound	Bay Area	Red Bluff
		Beltway 8	Shaver
		Red Bluff	Beltway 8
		SH 146	Bay Area
FM 1092	Northbound	US 90A	Airport
		Airport	US 59
	Southbound	US 59	Airport
		Airport	US 90A
FM 1092/MURPHY	Northbound	SH 6	FM 3345/Cartwright
		FM 3345/Cartwright	Lexington
		Lexington	US 90A
	Southbound	US 90A	Lexington
		Lexington	FM 3345/Cartwright
		FM 3345/Cartwright	SH 6
FM 2234	Northbound	FM 3345/Cartwright	Fuqua
		Fuqua	US 90A
	Southbound	US 90A	Fuqua
		Fuqua	FM 3345/Cartwright
FM 3345/ CARTWRIGHT	Eastbound	Dulles	FM 1092/Murphy
		FM 1092/Murphy	FM 2234
	Westbound	FM 2234	FM 1092/Murphy
		FM 1092/Murphy	Dulles
FONDREN	Northbound	Hillcroft	Fuqua

Roadway	Direction	From	To
		Fuqua	Beltway 8
		Beltway 8	Main
		Main	Airport
		Airport	Bellfort
		Bellfort	Braeswood
		Braeswood	Bissonnet
		Bissonnet	Beechnut
		Beechnut	US 59
		US 59	Bellaire
		Bellaire	Harwin
		Harwin	Westpark
		Westpark	Richmond
		Richmond	Westheimer
	Southbound	Westheimer	Richmond
		Richmond	Westpark
		Westpark	Harwin
		Harwin	Bellaire
		Bellaire	US 59
		US 59	Beechnut
		Beechnut	Bissonnet
		Bissonnet	Braeswood
		Braeswood	Bellfort
		Bellfort	Airport
		Airport	Main
		Main	Beltway 8
		Beltway 8	Fuqua
		Fuqua	Hillcroft
FUQUA	Eastbound	FM 2234	Fondren
		Fondren	Hillcroft
		Hillcroft	Beltway 8
		Beltway 8	Post Oak
		Post Oak	Almeda
	Westbound	Almeda	Post Oak
		Post Oak	Beltway 8

Roadway	Direction	From	To
		Beltway 8	Hillcroft
		Hillcroft	Fondren
		Fondren	FM 2234
JONES	Northbound	US 290	FM 1960
		FM 1960	Louetta
		Louetta	SH 249
	Southbound	SH 249	Louetta
		Louetta	FM 1960
		FM 1960	US 290
KIRKWOOD	Northbound	US 90A	US 59
	Southbound	US 59	US 90A
LEXINGTON	Eastbound	Louetta	Hardy
	Westbound	Hardy	Louetta
LEXINGTON (south)	Eastbound	SH 6	Dulles
		Dulles	FM 1092/Murphy
	Westbound	FM 1092/Murphy	Dulles
		Dulles	SH 6
LITTLE YORK	Eastbound	Barker Cypress	SH 6
		SH 6	Eldridge
		Eldridge	Beltway 8
	Westbound	Beltway 8	Eldridge
		Eldridge	SH 6
		SH 6	Barker Cypress
LOUETTA	Eastbound	Jones	SH 249
		SH 249	Stuebner Airline
		Stuebner Airline	Kuykendahl
		Kuykendahl	IH 45
		IH 45	Lexington
	Westbound	Lexington	IH 45
		IH 45	Kuykendahl
		Kuykendahl	Stuebner Airline
		Stuebner Airline	SH 249
		SH 249	Jones
MASON	Northbound	FM 1093	IH 10

Roadway	Direction	From	To
	Southbound	IH 10	FM 1093
MEMORIAL	Eastbound	SH 6	Eldridge
		Eldridge	Dairy Ashford
		Dairy Ashford	Wilcrest
		Wilcrest	Beltway 8
		Beltway 8	Gessner
		Briar Forest	San Felipe
	Westbound	San Felipe	Briar Forest
		Gessner	Beltway 8
		Beltway 8	Wilcrest
		Wilcrest	Dairy Ashford
		Dairy Ashford	Eldridge
		Eldridge	SH 6
RANKIN	Eastbound	Ella	Kuykendahl
		Kuykendahl	IH 45
		IH 45	Hardy
	Westbound	Hardy	IH 45
		IH 45	Kuykendahl
		Kuykendahl	Ella
RICHMOND	Eastbound	SH 6	Eldridge
		Eldridge	Dairy Ashford
		Dairy Ashford	Wilcrest
		Wilcrest	Beltway 8
		Beltway 8	Gessner
		Gessner	Fondren
		Fondren	Hillcroft
		Hillcroft	Post Oak
		Post Oak	Kirby
		Kirby	Spur 527
	Westbound	Spur 527	Kirby
		Kirby	Post Oak
		Post Oak	Hillcroft
		Hillcroft	Fondren
		Fondren	Gessner

Roadway	Direction	From	To
		Gessner	Beltway 8
		Beltway 8	Wilcrest
		Wilcrest	Dairy Ashford
		Dairy Ashford	Eldridge
		Eldridge	SH 6
SAN FELIPE	Eastbound	Memorial	Hillcroft
		Hillcroft	IH 610
		IH 610	Kirby
	Westbound	Kirby	IH 610
		IH 610	Hillcroft
		Hillcroft	Memorial
SPEARS	Eastbound	Veterans Memorial	Ella
	Westbound	Ella	Veterans Memorial
WESTHEIMER	Eastbound	IH 610	Kirby
		Kirby	Bagby
	Westbound	Bagby	Kirby
		Kirby	IH 610
WILCREST	Northbound	US 59	Bellfort
		Bellfort	Bissonnet
		Bissonnet	Beechnut
		Beechnut	Bellaire
		Bellaire	Harwin
		Harwin	Westpark
		Westpark	Richmond
		Richmond	Westheimer
		Westheimer	Briar Forest
		Briar Forest	Memorial
		Memorial	IH 10
	Southbound	IH 10	Memorial
		Memorial	Briar Forest
		Briar Forest	Westheimer
		Westheimer	Richmond
		Richmond	Westpark
		Westpark	Harwin

Roadway	Direction	From	To
		Harwin	Bellaire
		Bellaire	Beechnut
		Beechnut	Bissonnet
		Bissonnet	Bellfort
		Bellfort	US 59
WOODWAY	Eastbound	Voss	IH 610
	Westbound	IH 610	Voss

Source: H-GAC Travel Demand Model Network GIS Layer

C. CMP Project Analysis Form

CMP Project Analysis Form

Applicant Information

Agency Name: Click here to enter text.

Agency Address: Click here to enter text.

Person Submitting Form: Click here to enter text.

Email: Click here to enter text.

Telephone Number: Click here to enter text.

Date: Click here to enter a date.

Preliminary Questions

This section is REQUIRED to be completed for all projects.

1. **Describe the proposed improvement (Facility, Limits, Project Description).**

   Click here to enter text.

2. **Does the project address a safety or bottleneck problem?**

   ☐ Yes ☐ No

   If yes, please explain. Click here to enter text.

   If "yes", the project is exempt from further CMP analysis; stop and submit form to H-GAC. If "no", continue to next question.

3. **Is an Environmental Assessment (EA) or Environmental Impact Statement (EIS) required for the project?**

   ☐ Yes ☐ No

   If "yes", complete the CMP Analysis for Major Investments section (Questions 6-12). If "no", continue to the next question.

4. **Is the project located on the CMP Network?**

   ☐ Yes ☐ No

   If "yes", continue to the next question. If "no", complete *CMP Analysis for Other Investments* section (Questions 13-15).

5. **Does the project add significant SOV roadway capacity?**

☐ Yes ☐ No

If yes, please explain. Click here to enter text.

If "yes", complete CMP Analysis for Major Investments section (Questions 6-12). If "no", complete CMP Analysis for Other Investments section (Questions 13-15).

CMP Analysis for Major Investments

This section is to be completed for projects requiring an EA/EIS, or for significant SOV capacity-adding projects located on the CMP Network.

6. **Are there other congestion mitigation projects (e.g., transportation demand management, land use, public transportation, ITS and operations, pricing, bicycle and pedestrian, and bottleneck relief) within the project corridor that are programmed into the current TIP?**

☐ Yes ☐ No

If yes, identify the project name(s), state project identification number (CSJ number), and MPO project identification number.

Project Name	Click here to enter text.	CSJ #	Click here to enter text.
		MPO Project #	Click here to enter text.
Project Name	Click here to enter text.	CSJ #	Click here to enter text.
		MPO Project #	Click here to enter text.
Project Name	Click here to enter text.	CSJ #	Click here to enter text.
		MPO Project #	Click here to enter text.

7. **Using the CMP Report, is the corridor identified as deficient or needs improvement in any of the performance areas?**

☐ Yes ☐ No

If yes, which performance areas?

Click here to enter text.

8. **Can the problem / deficiency be addressed without building more road capacity?**

Click here to enter text.

9. **Describe any congestion mitigation alternatives to the proposed improvement that have been considered or will be evaluated to correct the deficiencies and manage the facility effectively (or facilitate its management in the future).**

Click here to enter text.

10. **Specify congestion mitigation strategies that will be implemented as part of the project.**

Click here to enter text.

11. **What are the specific congestion reduction impacts of the implemented strategies?**

Click here to enter text.

12. **If not implementing a congestion mitigation strategy, please explain reason.**

Click here to enter text.

Stop and submit completed form to H-GAC.

CMP Analysis for Other Investments

This section is to be completed for other investment types, or for capacity-adding projects that are not located on the CMP Network.

13. What type(s) of congestion management strategy(ies) is encompassed by the project / program according to the following strategy types:

- ☐ Transportation Demand Management Improvements
- ☐ Land Use Improvements
- ☐ Public Transportation Improvements
- ☐ Bicycle/Pedestrian Improvements
- ☐ Intelligent Transportation Systems (ITS) and Operations Strategies
- ☐ Roadway/Mobility (Non-ITS) Improvements

☐ Roadway Capacity Expansion (Off the CMP Network)

14. Complete the following qualitative criteria for the strategy type(s) encompassed by the project/program:

Transportation Demand Management Strategies

- Does the project strongly support or enhance travel demand management programs that are already in place and that have regional significance?
  ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Will the project reduce traffic congestion by reducing vehicle trips or VMT?
  ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Will the project reduce vehicle emissions? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Does the project include marketing, education and incentive programs that encourage shift to alternative modes? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

Land Use Improvements

- Does the project provide or demonstrate the potential for a transit connection? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Does the project provide an accessible pedestrian/bicyclist environment that meets or exceeds TxDOT's policy for Bicycle and Pedestrian Accommodation?
  ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Is the project identified within an H-GAC Special Districts Study, an H-GAC Livable Centers Study, or a comparable multi-jurisdictional or local plan study? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

Public Transportation Improvements

- Does the project provide connection to other transit services?
  ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Does the project include pedestrian and bicycle accommodations?
  ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Is the project an intrinsic part or demonstrate the potential for Transit Oriented Development? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Does the project provide access to job opportunities, unmet or enhanced needs? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Does the project use intelligent transportation systems and other operation/ service enhancing technologies? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Does the project address a need for expanded transit service capacity?
  ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

Bicycle/Pedestrian Improvements

- Does the proposed facility meet or exceed TxDOT's policy for Bicycle and Pedestrian Accommodation and AASHTO design guidelines for pedestrian and/or bicycle facilities? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Does the proposed facility provide safe and convenient routes across barriers, such as freeways, railroads, and waterways, or does it close a gap in the existing bicycle network that aligns with a regional bikeway shown on the Regional Bikeway Concept Map? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Does the proposed facility provide or demonstrate the potential for a transit connection? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Does the proposed facility provide connections to regional destinations?
  ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Is the project identified within an H-GAC Special Districts Study, an H-GAC Livable Centers Study, or a comparable multi-jurisdictional or local plan study? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

Intelligent Transportation Systems (ITS) and Operations Strategies

- Is the project an integral part of an incident management system, or will it contribute to a reduction in incident clearance time? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Will the system utilize dynamic management of the facility to enhance travel time reliability (e.g., ramp metering, variable speed limits, variable pricing, etc.)? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Does the project coordinate traffic signal systems across jurisdictional boundaries and improve progression? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Does the project improve accuracy, timeliness, and availability of real-time information to the public? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Does the project improve automated traffic data collection and archiving ability? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Will the project give priority to emergency vehicles, transit, or high-occupancy vehicles? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Is the project consistent with the Regional ITS Architecture?
  ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

Roadway/Mobility Improvements (Non-ITS)

- Will the project improve operational efficiency/reliability on a designated freight corridor? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Will the project improve a roadway on which fixed route transit service is being provided or otherwise used by other transit services outside of a fixed route service area? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Does the project incorporate access management principles such as raised medians, turn lanes, sharing/combining access points between businesses, or

innovative intersections to reduce conflict points (e.g., roundabout, diverging diamond, single point urban interchange, etc.)? ☐ Yes ☐ No
If yes, please explain. Click here to enter text.

- Does the project include pedestrian/bicycle accommodations that meet or exceed TxDOT's policy for Bicycle and Pedestrian Accommodation and AASHTO design guidelines? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Does the project integrate complete streets design principles?
  ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

Roadway Capacity Expansion (Capacity-adding projects that are not located on the CMP Network)

- Does the project provide a needed connection or additional capacity as identified in an adopted Thoroughfare Plan? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Does the project include segments of high congestion, and will the project help to mitigate this congestion? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Does the project provide access to existing and/or future business and job activity centers, shopping, educational, cultural, and recreational opportunities? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Will the project accommodate or create significant benefits to at least two additional modes of travel, or complete a link to intermodal or freight facilities of regional importance? ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

- Does the project impact a network-level change in congestion?
  ☐ Yes ☐ No
  If yes, please explain. Click here to enter text.

15. **What are the specific congestion reduction impacts of the implemented strategies?**

    Click here to enter text.

Stop and submit completed form to H-GAC.

D. CMP Project Analysis Form Instructions

CMP Project Analysis Form Instructions

Applicant Information

Provide agency name, address, and contact information for person submitting the CMP Project Analysis Form.

Preliminary Questions

This section is REQUIRED to be completed for all projects.

1. **Describe the proposed improvement (Facility, Limits, Project Description).**

   Specify the location of the proposed project, project limits, and description of the proposed improvement.

2. **Does the project address a safety or bottleneck problem? If yes, please explain.**

   Compare the site and project type characteristics to the safety and bottleneck criteria in Table 2.3. Project sponsors must confirm with H-GAC staff that a safety or bottleneck issue exists. If "yes", the project is exempt from further CMP analysis. If "no", continue to next question.

3. **Is an Environmental Assessment (EA) or Environmental Impact Statement (EIS) required for the project?**

   Determine whether an Environment Assessment (EA) or Environmental Impact Statement (EIS) is required for the project. If "yes", complete the *CMP Analysis for Major Investments* section (Questions 6-12). If "no", continue to the next question.

4. **Is the project located on the CMP Network? If yes, please explain.**

   Check the CMP Network maps and segment list in the CMP Report. If "yes", provide a brief explanation and continue to the next question. If "no", complete *CMP Analysis for Other Investments* section (Questions 13-15).

5. **Does the project add significant SOV roadway capacity? If yes, please explain.**

   Significant SOV capacity-adding projects impact regional or corridor travel patterns. Project descriptions typically include a new roadway or bypass, major or minor road widening to add additional through lanes on an existing highway, major roadway reconstruction, adding capacity to a corridor by improving many related intersections, new interchange, adding capacity to an existing interchange, grade separation of existing intersections (that add capacity), etc. If "yes", provide a brief explanation and complete *CMP Analysis for Major Investments* section (Questions 6-12). If "no", complete *CMP Analysis for Other Investments* section (Questions 13-15).

CMP Analysis for Major Investments

This section is to be completed for projects requiring an EA/EIS, or for significant SOV capacity-adding projects located on the CMP Network.

6. Are there other congestion mitigation projects (e.g., transportation demand management, land use, public transportation, ITS and operations, pricing, bicycle and pedestrian, and bottleneck relief) within the project corridor that are programmed into the current TIP?

Check project list in H-GAC's current TIP to identify committed projects. If "yes", identify the project name(s), description of improvement, state project identification number (CSJ number), and MPO project identification number.

7. Using the CMP Report, is the corridor identified as deficient or needs improvement in any of the performance areas? If so, which performance areas?

See congestion analysis section of the CMP Report to identify performance areas of deficiency or in need of improvement.

8. Can the problem/deficiency be addressed without building more road capacity?

Using simulation or other appropriate analysis tool from the CMP Toolbox, conduct an alternatives analysis to determine whether the problem/deficiency can be addressed without building more road capacity.

9. Describe any congestion mitigation alternatives to the proposed improvement that have been considered or will be evaluated to correct the deficiencies and manage the facility effectively (or facilitate its management in the future).

Using the CMP Toolbox or other available resources, identify corridor-level congestion mitigation strategies that will be evaluated to address the problems and deficiencies in the corridor. Consider strategies as an alternative to the added capacity project, and/or bundle congestion mitigation strategies into the added capacity project. Using simulation or other appropriate analysis tool from the CMP Toolbox, conduct an evaluation of the actions to assess the extent to which these actions can alleviate travel demand and congestion in the corridor compared to the baseline condition.

10. Specify congestion mitigation strategies that will be implemented as part of the project.

Identify which congestion mitigation strategies will be implemented as part of the project.

11. What are the specific congestion reduction impacts of the implemented strategies?

Based on the results of the CMP analysis, quantitatively document the benefits of the project's ability to relieve congestion, improve trip reliability, and/or how it meets one or more of the CMP goals and objectives. Benefits should be documented in terms of specific CMP performance measures when possible.

12. If not implementing a congestion mitigation strategy, please explain reason.

Include an explanation that highlights the reason why no congestion mitigation strategies are feasible or warranted as part of the project.

CMP Analysis for Other Investments

This section is to be completed for other investment types, or for capacity-adding projects that are not located on the CMP Network.

13. What type(s) of congestion management strategy(ies) is encompassed by the project/program according to the following strategy types:

Identify the type of congestion management strategy(ies) encompassed by the project/Program according to the following types: Transportation Demand Management, Land Use, Public Transportation, Bicycle/Pedestrian, Intelligent Transportation Systems (ITS) and Operations, Roadway/Mobility (Non-ITS), or Roadway Capacity Expansion (off the CMP Network).

14. Complete the following qualitative criteria for the strategy type(s) encompassed by the project/program:

Answer the questions for the strategy type(s) identified above.

Transportation Demand Management Strategies

- Does the project strongly support or enhance travel demand management programs that are already in place and that have regional significance? If yes, please explain.
- Will the project reduce traffic congestion by reducing vehicle trips or VMT? If yes, please explain.

- Will the project reduce vehicle emissions? If yes, please explain.

- Does the project include marketing, education and incentive programs that encourage shift to alternative modes? If yes, please explain.

Land Use Improvements

- Does the project provide or demonstrate the potential for a transit connection? If yes, please explain.

- Does the project provide an accessible pedestrian/bicyclist environment that meets or exceeds TxDOT's policy for Bicycle and Pedestrian Accommodation? If yes, please explain.

- Is the project identified within an H-GAC Special Districts Study, an H-GAC Livable Centers Study, or a comparable multi-jurisdictional or local plan study? If yes, please explain.

Public Transportation Improvements

- Does the project provide connection to other transit services? If yes, please explain.

- Does the project include pedestrian and bicycle accommodations? If yes, please explain.

- Is the project an intrinsic part or demonstrate the potential for Transit Oriented Development? If yes, please explain.

- Does the project provide access to job opportunities, unmet or enhanced needs? If yes, please explain.

- Does the project use intelligent transportation systems and other operation/ service enhancing technologies? If yes, please explain.

- Does the project address a need for expanded transit service capacity? If yes, please explain.

Bicycle/Pedestrian Improvements

- Does the proposed facility meet or exceed TxDOT's policy for Bicycle and Pedestrian Accommodation and AASHTO design guidelines for pedestrian and/or bicycle facilities? If yes, please explain.

- Does the proposed facility provide safe and convenient routes across barriers, such as freeways, railroads, and waterways, or does it close a gap in the existing bicycle network that aligns with a regional bikeway shown on the Regional Bikeway Concept Map? If yes, please explain.

- Does the proposed facility provide or demonstrate the potential for a transit connection? If yes, please explain.
- Does the proposed facility provide connections to regional destinations? If yes, please explain.
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Intelligent Transportation Systems (ITS) and Operations Strategies

- Is the project an integral part of an incident management system, or will it contribute to a reduction in incident clearance time? If yes, please explain.
- Will the system utilize dynamic management of the facility to enhance travel time reliability (e.g., ramp metering, variable speed limits, variable pricing, etc.)? If yes, please explain.
- Does the project coordinate traffic signal systems across jurisdictional boundaries and improve progression? If yes, please explain.
- Does the project improve accuracy, timeliness, and availability of real-time information to the public? If yes, please explain.
- Does the project improve automated traffic data collection and archiving ability? If yes, please explain.
- Will the project give priority to emergency vehicles, transit, or high-occupancy vehicles? If yes, please explain.
- Is the project consistent with the Regional ITS Architecture? If yes, please explain.

Roadway/Mobility Improvements (Non-ITS)

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- Will the project improve a roadway on which fixed route transit service is being provided or otherwise used by other transit services outside of a fixed route service area? If yes, please explain.
- Does the project incorporate access management principles such as raised medians, turn lanes, sharing/combining access points between businesses, or innovative intersections to reduce conflict points (e.g., roundabout, diverging diamond, single point urban interchange, etc.)? If yes, please explain.

- Does the project include pedestrian/bicycle accommodations that meet or exceed TxDOT's policy for Bicycle and Pedestrian Accommodation and AASHTO design guidelines? If yes, please explain.

- Does the project integrate complete streets design principles? If yes, please explain.

Roadway Capacity Expansion (Capacity-adding projects that are not located on the CMP Network)

- Does the project provide a needed connection or additional capacity as identified in an adopted Thoroughfare Plan? If yes, please explain.

- Does the project include segments of high congestion, and will the project help to mitigate this congestion? If yes, please explain.

- Does the project provide access to existing and/or future business and job activity centers, shopping, educational, cultural, and recreational opportunities? If yes, please explain.

- Will the project accommodate or create significant benefits to at least two additional modes of travel, or complete a link to intermodal or freight facilities of regional importance? If yes, please explain.

- Does the project impact a network-level change in congestion? If yes, please explain.

15. What are the general congestion reduction impacts of the implemented strategies?

Qualitatively document the benefits of the project's ability to relieve congestion, improve trip reliability, and/or how it meets one or more of the CMP goals and objectives. Specific CMP performance measures should be used for documenting benefits when possible. Quantitative impacts may also be reported if desired (i.e., using analysis tools from the CMP Toolbox or other methods as appropriate to conduct an evaluation of project benefits).

E. Example Strategy Effectiveness Evaluation

The proposed analysis tool for strategy effectiveness for the CMP is the Tool for Operations Benefit/Cost (TOPS-BC) developed by FHWA to provide benefit and cost estimates for a variety of ITS and operational alternatives. TOPS-BC was developed as a follow-up tool to the ITS Deployment Analysis System (IDAS), which is a network model that evaluated ITS and operational options based on the regional travel demand model. IDAS is now over 15 years old and is no longer supported by FHWA. TOPS-BC operates in a spreadsheet format, is easy to learn and highly-transparent. It provides the ability to conduct numerous "what-if" analyses of different assumptions related to both benefits and costs. The program contains a range of default values for both benefits and costs and provides documentation of various studies used to derive those values.

As noted above, TOPS-BC is a spreadsheet-based tool that does not require a transportation network to operate. The analysis is based on roadway segments and analysis can thus be confined only to those segments that are part of the ITS/Operations project. As such it well suited to the analysis requirements of the Congestion Management Plan, which tends to focus on short-term improvements. Like similar benefit/cost tools TOPS-BC annualizes capital costs based on assumed equipment life and adds this to operations and maintenance costs to get a total annualized cost. Default parameters used to estimate project benefits are based on studies compiled by FHWA and disseminated through the ITS website: http://www.itskrs.its.dot.gov. Benefits are calculated include travel time savings, improved travel time reliability, crash reduction savings and reduced fuel consumption Each of these are assigned economic values and in TOPS-BC they are rolled together to provide a single dollar value of benefits.

Default costs and benefits can be easily modified within the spreadsheet to reflect available localized data. A range of parameters may be tested; particularly on the benefits side where there is less certainty regarding the actual impacts of ITS improvements.

H-GAC recently used TOPS-BC to evaluate a series of operational improvements across the region's freeway system. The treatments proposed including included:

- Improved pre-trip information
- Dynamic Message Signs; and

- Traffic Incident Management services.

An illustration of how inputs and results were compiled for project evaluation is shown below in Tables E-1 and E-2.

Table E-1 TOPS-BC Freeway Project Inputs

Project	Road	Type	Segment	Seg. Length	AM Peak Capacity	VDT	VHT	Vehicles passing DMS	Pre Trip Views	Avg. Vehicles for TIM	Avg Speed	Speed Limit	Lanes
699	East Fwy	Freeway	69901	4.49	19734	36608	627	8914	2229	8153	65	65	3
699	East Fwy	Freeway	69902	4.49	19734	23188	395	5363	1341	5164	65	65	3

Table E-2 TOPS-BC Freeway Project Outputs

Project	Road	Type	AM Benefit	TotBenefit	Project Cost	B/C Ratio
699	East Fwy	Freeway	$5,015,010	$ 10,030,020	$2,847,075	6.1
699	East Fwy	Freeway	$3,657,427	$ 7,314,854		

The tables above show how the project was divided by roadway segments, in this case based on change in direction of travel for the segment. Calculations are directional as well. For this analysis AM peak period was evaluated and benefits doubled to account for evening peak. The benefits estimate is a conservative one in that mid-day conditions were not considered in the analysis. Since transit projects are connected to ridership data these can also be easily evaluated. Other projects such as common radio, advanced traffic management systems and backbone communications systems are supporting technologies for those deployments that interface directly with the public. As such their costs should be included but they do not provide benefits directly.

The screenshots provided below illustrate the process of populating the TOPS-BC spreadsheets. Input sheets for traveler information services generally require the traffic volume impacted by the improvement and parameters related to travelers' use of the information. In Figure E-1, Dynamic Message Signs, this includes the percentage of time useful information is being disseminated, the percent of drivers acting on the information and the estimated minutes saved by each driver. Total hours saved are then accumulated for the period analyzed and can be monetized using hourly value of time estimates. Similar inputs are provided in Figure E-2, for Pre-Trip Traveler information. Figure E-3 shows inputs for Traffic Incident Management systems, which require traffic volumes, number of lanes and/or capacity and free flow speed. Default values can be used to estimate the impact of TIM improvements on capacity, and the program then uses a speed-flow curve to calculate hours saved. It should be noted that the speed improvement can be directly input by the user as well, and any of the default parameters can be overridden. TOPS-BC also estimates improvements in crash rates resulting from TIM implementation. Base rates can be calculated by the program or input directly. Benefits are then monetized and compared to costs. Figure E-4 shows how results are summarized using monetary values of the benefit parameters, life cycle of the equipment/systems used and annualized estimates for the benefits.

Figure E-1 Dynamic Message Sign Inputs

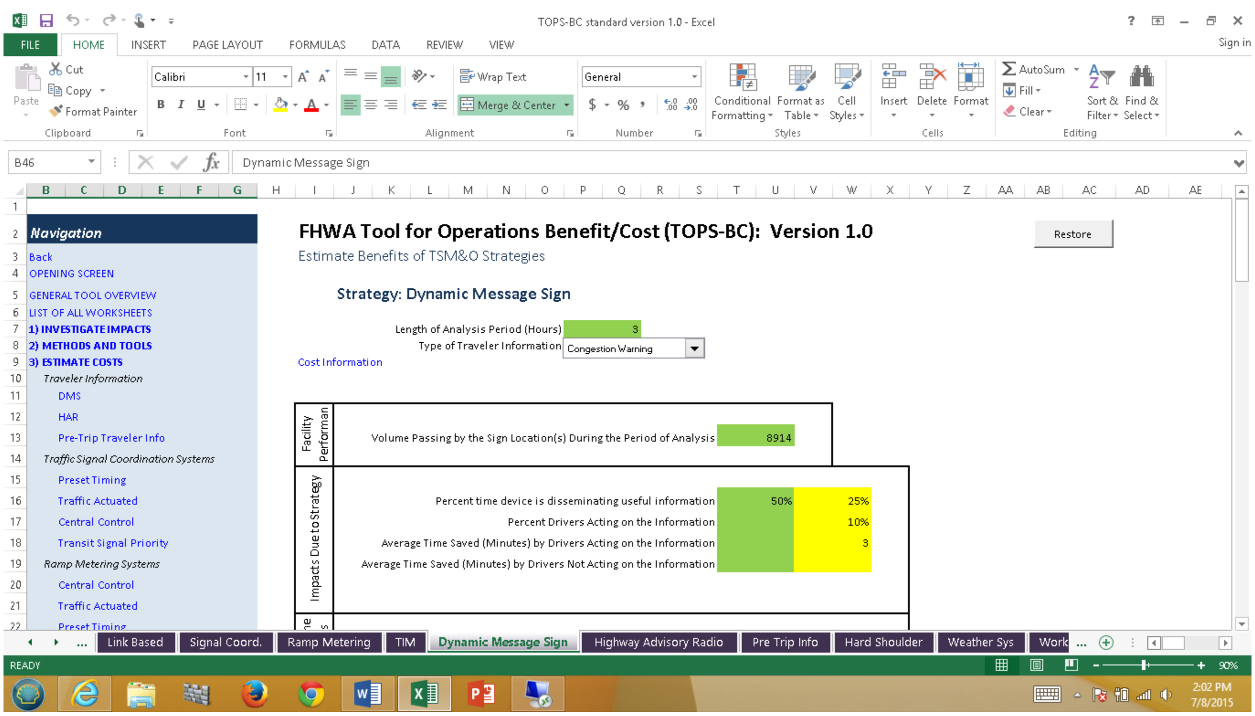


Figure E-2 Pre Trip Traveler Information

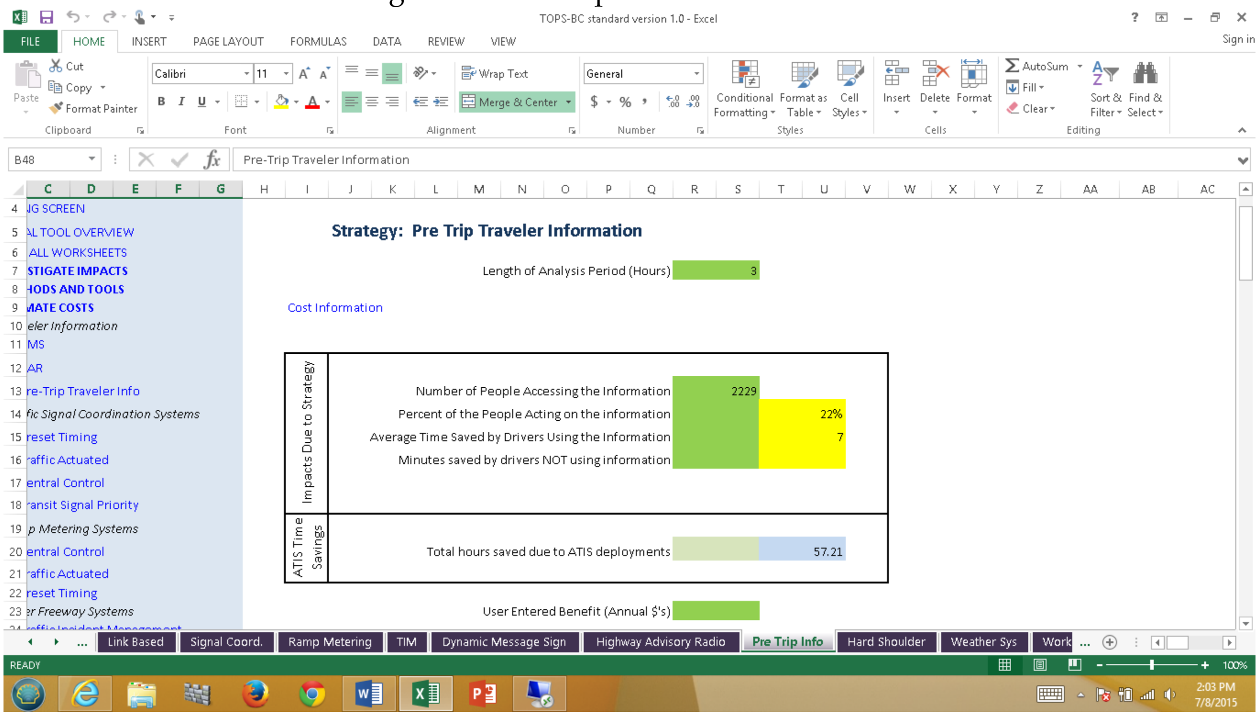


Figure E-3 Incident Management Inputs

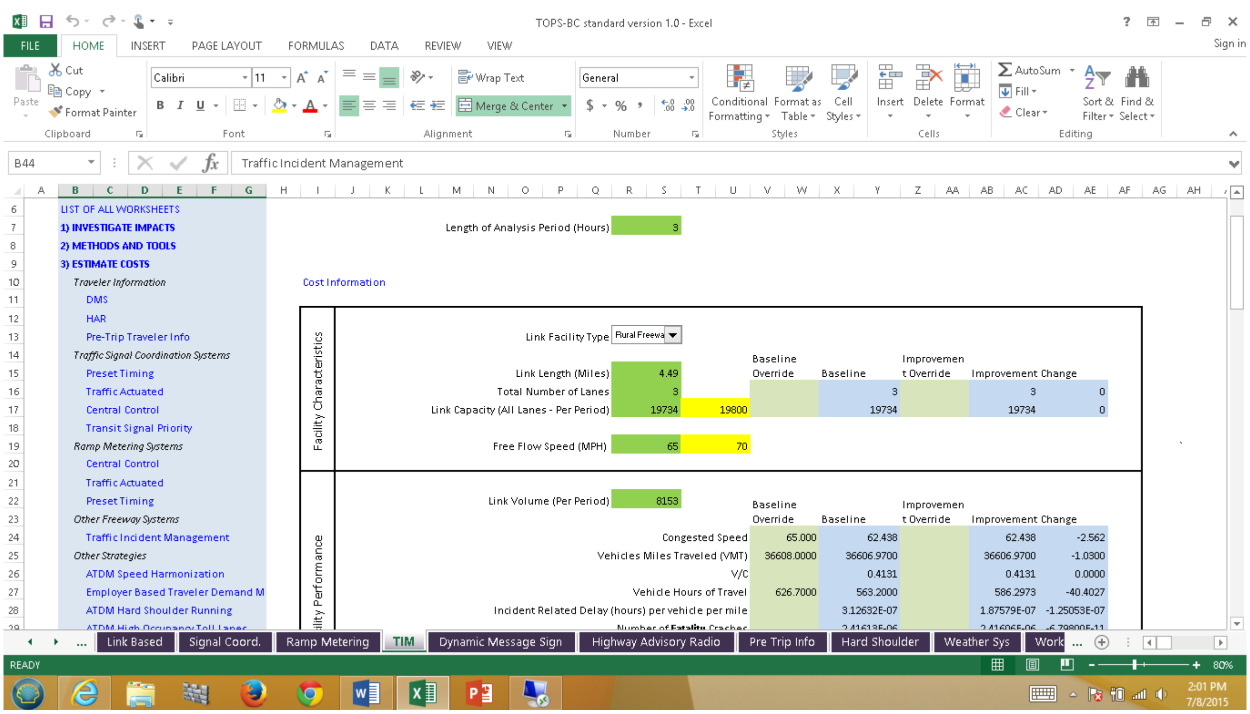
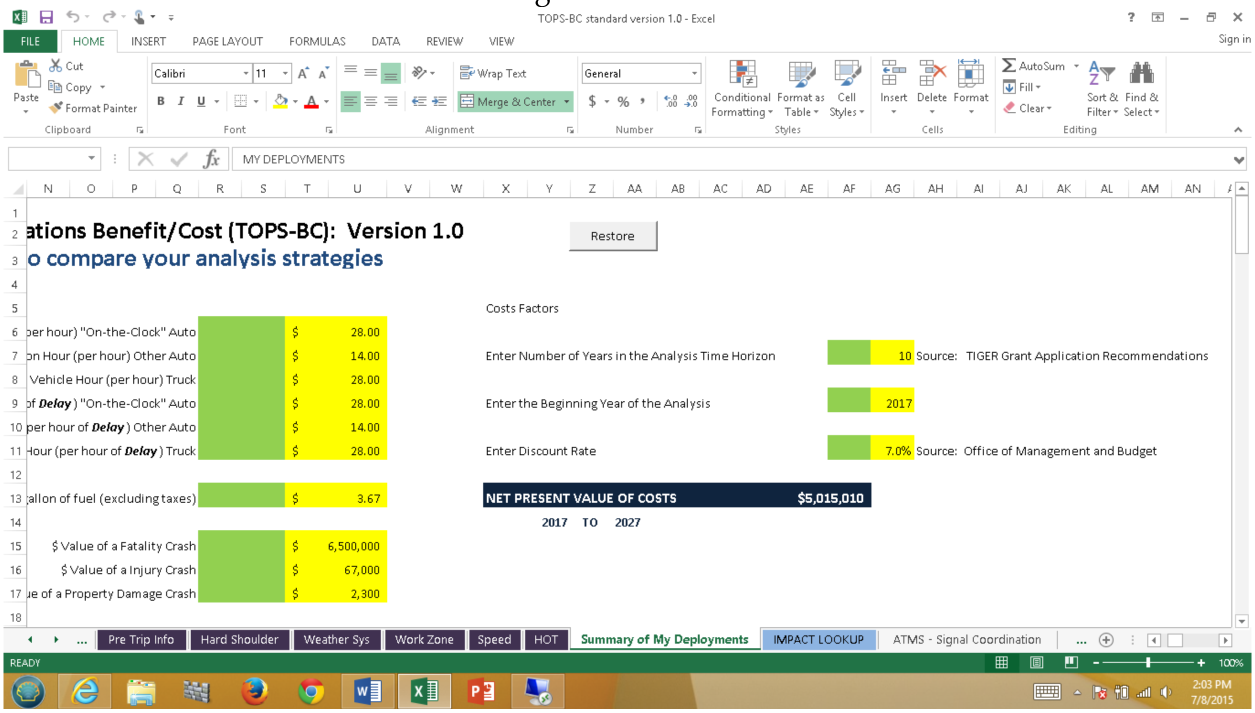


Figure E-4 Results



As noted above, the TOPS-BC benefits estimate combines the following benefit categories, monetizes them and converts them to annual estimate shown above in Table E-2:

- Travel Time Savings
- Improved Travel Time Reliability
- Crash Reduction
- Fuel Consumption Savings

Additional information, including both sample spreadsheet tools and documentation of the TOPS-BC, can be obtained at FHWA's TOPS-BC website: http://www.ops.fhwa.dot.gov/plan4ops/topsbctool/index.htm

Arterial improvements can also be analyzed and can include both signal timing improvements and ITS improvements along arterial corridors, such as incident management programs and Dynamic Message Signs. Signal coordination categories include preset timing, traffic actuated, central control and traffic signal priority.