Pima Association of Governments

Prepared by:

Morrison Maierle, Inc.
An Employee-Owned Company

*FINAL REPORT*

*June 2010*

# *Pima Association of Governments*

# *CONGESTION MANAGEMENT PROCESS*

# FINAL REPORT

## Pima Association of Governments
## Congestion Management Process

***Prepared for***

Pima Association of Governments

***Prepared by***

MORRISON MAIERLE, INC.
*An Employee-Owned Company*

***In association with***

L&A LIMA & ASSOCIATES
Transportation - G.I.S.

**&**

**ROBERT H. BOHANNON, AICP**

**June 2010**

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# 1. INTRODUCTION AND BACKGROUND

## PROJECT BACKGROUND

The Pima Association of Governments (PAG) first completed a Congestion Management System (CMS) for the region in 1993. The original PAG CMS, referred to locally as the Mobility Management Plan (MMP) was developed in anticipation of the Federal requirements for management systems contained in the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. This initial MMP was completed before the final Federal ruling on the Congestion Management System (CMS) was published[1], and was one of the first congestion management systems developed in the country. At that time, PAG was ahead of the curve in the development of a CMS and the MMP became an example used in a National Highway Institute (NHI) training course on CMS development for technical staff after the final Federal ruling was published. The basic elements of the original PAG MMP became the framework for the development of many other congestion management systems across the country. In 2000, PAG completed an update of the original MMP to keep pace with changing conditions and meet the provisions of the Transportation Equity Act for the 21st Century (TEA-21) of 1998.

With the passage of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) of 2005, and the publication of the Final Rule on Statewide and Metropolitan Transportation Planning in 2007[2], PAG is updating its Congestion Management Process (CMP) to ensure consistency with the new provisions and to ensure best planning practices are in place for congestion management in the PAG region.

## PROJECT OBJECTIVES

PAG identified the primary project objectives for this project:

- Establish a CMP that is fully integrated into the transportation planning process.
- Provide a CMP that is regionally accepted by stakeholders and meets Federal requirements.
- Establish a CMP that is ongoing and sustainable in terms of congestion mitigation strategy identification.
- Provide a CMP performance measurement component that is regionally accepted, ongoing, and sustainable.

Aside from the Federal requirements, PAG has recognized that a congestion management process constitutes good planning practice especially in a rapidly growing metropolitan area. It is important for the CMP to be fully integrated into the programming and transportation decision making process at the regional and local level.

It is intended that the CMP will enable the region to:

1. Identify congested locations.
2. Determine the causes of congestion.
3. Develop alternative strategies to mitigate congestion.
4. Evaluate the potential of different strategies.

[1] Pima Association of Governments, *PAG 1992 Mobility Management Plan Summary Report*, prepared by JHK & Associates, December 1993.
[2] Federal Register, Part III, Department of Transportation, Federal Highway Administration 23 CFR Parts 450 and 500, Federal Transit Administration 49 CFR Part 613, *Statewide Transportation Planning; Metropolitan Transportation Planning; Final Rule*, Wednesday, February 14, 2007.

5. Propose alternative strategies that best address the causes and impacts of congestion.
6. Track and evaluate the impact of previously implemented congestion management strategies.
7. Identify congestion management strategies for possible inclusion in the Regional Transportation Plan (RTP).
8. Set priorities among projects for incorporation into the Transportation Improvement Program (TIP).
9. Provide information for environmental analysis of proposed projects.
10. Develop more detailed assessments of the potential for congestion reduction at the corridor or activity-center level.
11. Monitor and evaluate projects and congestion mitigation strategies and programs implemented throughout the region.

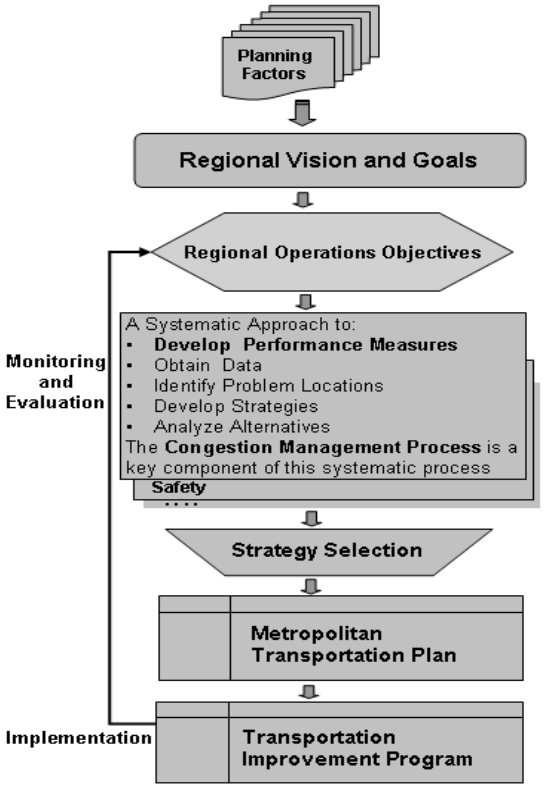
This project is to provide a framework for the PAG CMP that will:

1. Establish a technical evaluation process through regional consensus that links to regional objectives and is driven by the goals reflected in the Regional Transportation Plan.
2. Consider congestion, its causes, and possible remedies in a holistic way, encompassing a broad range of multimodal transportation and non-transportation elements.
3. Focus comprehensively on management and operations, demand management, access management, land use, and new capacity as ways to manage congestion.
4. Define systematic methods to monitor and evaluate system performance.
5. Establish agreed upon and achievable performance measures to identify, evaluate, and monitor congestion and congestion management strategies.
6. Define an appropriate program of data collection and management, preferably incorporating existing data sources (including archived ITS data if available), and coordinated with system operations managers throughout the metropolitan area that balances costs with effectiveness.
7. Update previously established protocols for integration of congestion data into Geographic Information System (GIS) for Air Quality Analysis and other needs.
8. Detail technical capabilities for evaluating the potential effectiveness of demand management and operational strategies.
9. Identify proposed congestion management strategies for possible inclusion in the Regional Transportation Plan (RTP) and define implementation schedules or timetables for delivery of Management and Operations (M&O) strategies, including assignment of resources and responsibilities as well as cost effectiveness.
10. Set priorities among projects for possible incorporation into the Transportation Improvement Program.
11. Define procedures for periodic review of the effectiveness of strategies selected for implementation, as well as assessments of the usefulness of performance measures and supporting data.
12. Satisfy the Federal requirements for Congestion Management Process (CMP) development and maintenance.

The vision of the CMP, as expressed through the above statements, is consistent with the FHWA and FTA vision of the CMP framework for an objectives-driven, performance-based approach, which is illustrated in Exhibit 1. It is envisioned by FHWA and FTA that a CMP will be implemented through an 8-step program. The eight steps illustrated in Exhibit 2 represent the

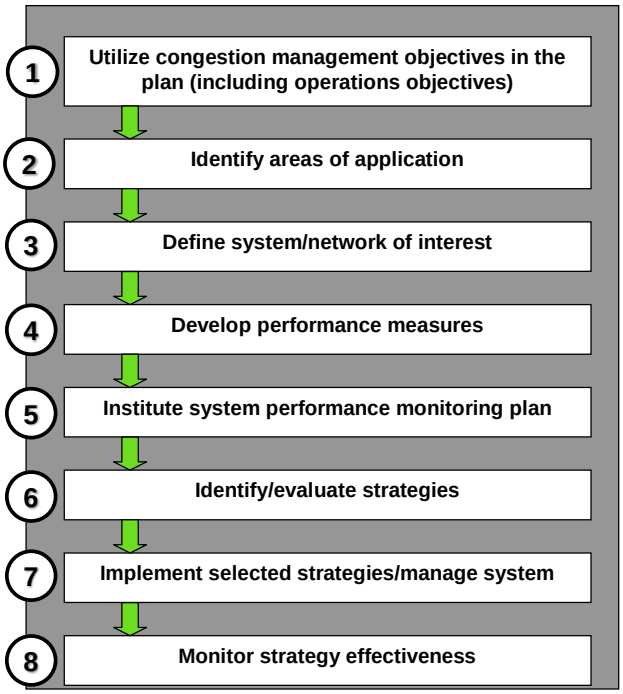
activities necessary to develop and implement a CMP that meets the Federal requirements. The last seven of these eight steps represent the key components of a CMP.

**Exhibit 1**
**FRAMEWORK FOR AN OBJECTIVES-DRIVEN, PERFORMANCE-BASED APPROACH**




Source: *Management & Operations in the Metropolitan Transportation Plan: A Guidebook for Creating an Objectives-Driven, Performance-Based Approach, FHWA,* November 2007, page 2-3.

## Exhibit 2
## CMP EIGHT-STEP PROGRAM




Source: *Incorporating Management and Operations and the Congestion Management Process into Metropolitan Transportation Planning,* FHWA/FTA Webinar, June 24, 2008.

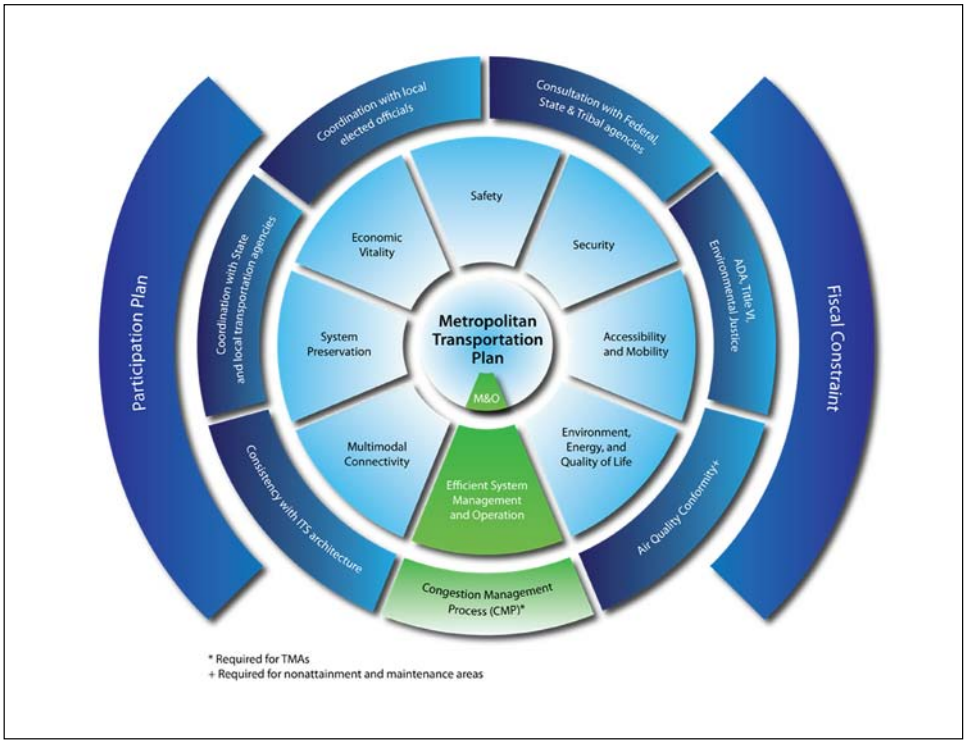
# 2. FEDERAL LEGISLATION

## EVOLUTION OF FEDERAL REQUIREMENTS

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the Transportation Equity Act for the 21st Century of 1998 (TEA-21) required each Metropolitan Planning Organization (MPO) in a Transportation Management Area (TMA – urban areas over 200,000 in population) to develop and implement a Congestion Management System (CMS). The Safe, Accountable, Flexible, Efficient Transportation Equity Act – A Legacy for Users of 2005 (SAFETEA-LU) reaffirms the Federal requirements established in ISTEA and continued in TEA-21 for CMS. SAFETEA-LU retains the structure established by ISTEA, requiring that Congestion Management be part of the metropolitan transportation planning process for TMAs. The 2005 SAFETEA-LU legislation refers to a "congestion management process" as opposed to a "congestion management system." This change reflects the underlying goal of implementing a process that is an integral component of metropolitan transportation planning.

Exhibit 3 illustrates the intended relationship between the Congestion Management Process and the Metropolitan Transportation Plan known locally as the Regional Transportation Plan (RTP). Transportation planning in a TMA is to address congestion management through a process that provides for safe and effective integrated management and operation of the multimodal transportation system. The development of a CMP is to result in multimodal system performance measures and strategies that can be reflected in the RTP and the Transportation Improvement Program (TIP).[3]

**Exhibit 3**
**RELATIONSHIP BETWEEN THE CMP AND THE METROPOLITAN TRANSPORTATION PLAN**




Source: *Incorporating Management and Operations and the Congestion Management Process into Metropolitan Transportation Planning,* FHWA/FTA Webinar, June 24, 2008.

[3] *Federal Register*, Wednesday, February 14, 2007, Part III Department of Transportation, Federal Highway Administration 23 CFR Parts 450 and 500, Federal transit Administration 49 CFR Part 613, Statewide Transportation Planning; Metropolitan Transportation Planning; Final Rule.

SAFETEA-LU requires that in TMAs, the MPO "shall address congestion management through a process that provides for effective management and operation, based on a cooperatively developed and implemented metropolitan-wide strategy, of new and existing transportation facilities... through the use of travel demand reduction and operational management strategies."

According to the Final Rule on Statewide and Metropolitan Transportation Planning a CMP shall include:

1. Methods to:
    - Monitor and evaluate the performance of the multimodal transportation system.
    - Identify the causes of recurring and nonrecurring congestion.
    - Identify and evaluate alternative strategies.
    - Provide information supporting the implementation of actions.
    - Evaluate the efficiency and effectiveness of implemented actions.

2. A definition of congestion management objectives and appropriate performance measures to:
    - Assess the extent of congestion.
    - Support the evaluation of the effectiveness of congestion reduction and mobility enhancement strategies for the movement of people and goods.

    Performance measures should be tailored to the specific needs of the area and established cooperatively by the state(s), affected MPO(s), and local officials in consultation with the operators of major modes of transportation in the coverage area;

3. Establishment of a coordinated program for data collection and system performance monitoring to:
    - Define the extent and duration of congestion.
    - Contribute in determining the causes of congestion.
    - Evaluate the efficiency and effectiveness of implemented actions.

    To the extent possible, this data collection program should be coordinated with existing data sources (including archived operational/ITS data) and coordinated with operations managers in the metropolitan area;

4. Identification and evaluation of the anticipated performance and expected benefits of appropriate congestion management strategies that will contribute to the more effective use and improved safety of existing and future transportation systems based on the established performance measures. The following categories of strategies, or combinations of strategies, are some examples of what should be appropriately considered for each area:
    - Demand management measures, including growth management and congestion pricing;
    - Traffic operational improvements;
    - Public transportation improvements;
    - ITS technologies as related to the regional ITS architecture; and
    - Where necessary additional system capacity.

5. Identification of:
    - An implementation schedule.
    - Implementation responsibilities

- Possible funding sources for each strategy (or combination of strategies) proposed for implementation

6. Implementation of:
    - A process for periodic assessment of the effectiveness of implemented strategies, in terms of the area's established performance measures. The results of this evaluation shall be provided to decision makers to provide guidance on selection of effective strategies for future implementation.[4]

SAFETEA-LU indicates that the Metropolitan Transportation Plan (MTP), known locally as the Regional Transportation Plan (RTP) shall include "operational and management strategies to improve the performance of existing transportation facilities to relieve vehicular congestion and maximize the safety and mobility of peoples and goods." One of eight planning factors to be considered in metropolitan and statewide planning is to "promote efficient system management and operations."

**TMAs DESIGNATED NONATTAINMENT FOR OZONE OR CARBON MONOXIDE**

It is very important to understand that the Federal Rules are much more restrictive for TMAs designated as nonattainment for either ozone or carbon monoxide. SAFETEA-LU requires that "…for transportation management areas classified as nonattainment for ozone or carbon monoxide pursuant to the Clean Air Act, Federal funds may not be advanced in such areas for any highway project that will result in a significant increase in the carrying capacity for single-occupant vehicles unless the project is addressed through a congestion management process." Safety improvements and the elimination of bottlenecks are exceptions to this restriction.

The PAG Transportation Management Area (TMA) is in attainment for carbon monoxide since year 2000 under the limited maintenance plan, and has historically been in attainment for ozone. A nonattainment designation would have significant impacts on the PAG planning process, and elevate the importance of the CMP. In January 2010, The Environmental Protection Agency (EPA) proposed strengthening the ozone standards to a level more stringent than the current standards. The proposed change in the ozone standards will likely result in a nonattainment designation for the Tucson region. EPA is expected to finalize the ozone standards by August 31, 2010.

In a TMA designated as nonattainment for ozone or carbon monoxide, Federal funds may not be programmed for any project that will result in a significant increase in capacity for single occupant vehicles (SOVs) (i.e., a new general purpose highway on a new locations or adding general purpose lanes, with the exception of safety improvements or the elimination of bottlenecks), unless the project is addressed through a CMP. The CMP is to provide an appropriate analysis of reasonable multimodal travel demand reduction and operational management strategies for SOV capacity projects that will use Federal funds. If the analysis demonstrates that travel demand reduction and operational management strategies cannot fully satisfy the need for additional capacity and the SOV capacity is warranted, then the CMP shall identify all reasonable strategies to manage the SOV facility and be incorporated into the project or committed to by the State or the MPO. Failure to implement the CMP could place additional pressure on the PAG region to identify alternative funding sources other than Federal funds for SOV projects.

[4] *Federal Register*, Wednesday, February 14, 2007, Part III Department of Transportation, Federal Highway Administration 23 CFR Parts 450 and 500, Federal transit Administration 49 CFR Part 613, Statewide Transportation Planning; Metropolitan Transportation Planning; Final Rule.

While capacity-expanding projects are not prohibited, the CMP requirements mean that the MPO must consider alternatives to capacity increases, and that measures be incorporated into the project to make the most efficient use of the new capacity once it has been constructed. In all TMAs, attainment or non-attainment, the CMP should identify strategies that complement proposed improvements. These may be measures such as ramp meters for new freeway lanes or access management on a parallel arterial. These complementary strategies extend the life of the SOV capacity project. In nonattainment TMAs, MPOs must establish a congestion management process that gives priority to strategies that reduce congestion and improve the movement of people and goods without requiring the construction of new highway capacity. The decision process in dealing with this restriction on SOV capacity-expanding projects must be documented as part of the CMP in these areas.[5]

**INCORPORATING THE CMP INTO THE PLANNING AND PROGRAMMING PROCESS**

As illustrated in Exhibit 3, the CMP is intended to be an integral part of the metropolitan planning process, rather than a stand-alone program or system. SAFETEA-LU Titles III and VI, Section 3005 and 6001, updated the requirement for addressing congestion in Transportation Management Areas (TMAs), mandating the incorporation of CMP within the metropolitan planning process.[6] The integration of the CMP into the planning process is intended to provide decision makers better tools for project prioritization.

The basics of the new approach to integrate the CMP into the planning process include the following:

- The CMP is to be fully integrated into the planning process.
- Specific congestion management objectives drive the process.
- There is an increased emphasis on incorporating management and operations strategies for congestion mitigation.
- The CMP focuses on ongoing efforts to collect, analyze, and preserve data resources to monitor performance over time.

[5] *An Interim Guidebook on the Congestion Management Process in Metropolitan Transportation Planning*, FHWA & FTA, February 2008, page 4-5.

[6] An Interim Guidebook on the Congestion Management Process in Metropolitan Transportation Planning, FHWA & FTA, February 2008, page 2-1.

# 3. ELEMENTS OF THE CONGESTION MANAGEMENT PROCESS

## INTRODUCTION

The purpose of this section of the report is to explore the basic elements of a Congestion Management Process as envisioned by the FHWA and FTA, and provide recommendations on how these elements can be developed and employed by PAG. The basic elements of the CMP are summarized in Exhibit 2, presented earlier in this report as the CMP eight-step program.

The CMP is to be an integral part of the planning process that influences decision making. The CMP is to focus on on-going efforts to collect, analyze and preserve data resources to monitor performance over time. There is an increased Federal emphasis on incorporating management and operations for congestion mitigation.

The recommendations contained in this chapter were developed through a process that included the following:

- Research on the Federal requirements and guidelines for development and implementation of a CMP provided through the literature and online sources.
- Research on how the Federal requirements for a CMP have been implemented by other MPOs across the country.
- Review of the 2040 Regional Transportation Plan vision and goals to identify how these might support and interact with the goals and objectives of the CMP.
- Review of the goals and objectives of the CMP with PAG staff and members of the project Technical Advisory Committee (TAC), made up of representatives of local transportation agencies.
- Interaction with and guidance from PAG staff and staff from other local agencies on the regional capabilities to collect and maintain the data necessary to implement the performance measurement element of the CMP.
- Review of the tools and technology available to collect and analyze data.
- Interaction with the project TAC to review and comment on the policy and procedural options available to implement the CMP.

This chapter presents materials and recommendations on the following elements of the CMP:

- Congestion management objectives.
- Area of Application for the CMP.
- Transportation system and network elements evaluated as part of the CMP.
- Roadway system performance measures
- Transit and multimodal system performance measures

Additional elements of the CMP are contained in subsequent chapters of this report.

## CONGESTION MANAGEMENT OBJECTIVES

### The Federal Perspective

There is supposed to be a direct link between the regional vision, goals, and operations objectives, as expressed the regional long-range transportation plan, and the CMP. The transportation planning process is intended to be objectives driven and performance based. There is also an increased emphasis on incorporating management and operations (M&O) goals into the long range plan.

The goals expressed in the Regional Transportation Pan (RTP) are to describe the desired end state that is to be achieved through the transportation system improvements. Examples of M&O goals supporting an objectives driven, performance based approach are provided in Exhibit 4. Other goals in the RTP may focus on safety, economy, land use, environmental priorities, etc.

**Exhibit 4**
**EXAMPLES OF M&O GOALS**

- "Maximize Transportation System Management and Operations" *Baltimore Regional Transportation Board (BRTB) – 2035 Regional Transportation Plan*
- "Improve transportation system performance" *Chicago Metropolitan Agency for Planning (CMAP) – 2030 Regional Transportation Plan*
- "A reliable commute" - *Metropolitan Transportation Commission - 2030 Plan*

Source: *Incorporating Management and Operations and the Congestion Management Process into Metropolitan Transportation Planning*, FHWA/FTA Webinar, June 24 2008.

The regional operations objectives should be linked to the regional goals, and should be intended to realize these goals. The objectives should be specific, measurable statements relating to the attainment of the goals. These objectives should be developed collaboratively with the affected jurisdictions and used to prioritize investment decisions.

> "While the goals in the MTP may be couched in general terms, congestion management objectives should be defined in terms that enable participants in the process to focus on specific aspects of congestion, and to advance a timeframe within which the objectives would be attained. For example, congestion management objectives may be different for commute trips than for other travel purposes. Alternatively, objectives may be established for peak period travel as opposed to off-peak travel.
>
> Specific congestion management objectives might also be developed for freight movement, and may be focused on activity areas or corridors where the movement of goods is particularly important, such as a port, terminal and warehousing district, or freight corridor. Such objectives could refer to achievement of the goals by a certain date, or in more general terms, such as 'by the end of the decade.'" [7]

**The PAG 2040 RTP Vision, Goals, and Objectives**

PAG has developed a vision statement and statement of goals as part of the on-going development the 2040 RTP. The latest version of the PAG 2040 RTP vision and goals is provided in Exhibit 5.

[7] *An Interim Guidebook on the Congestion Management Process in Metropolitan Transportation Planning,* FHWA/FTA, February 2008, page 3-3.

**Exhibit 5**
**2040 RTP VISION AND GOALS**

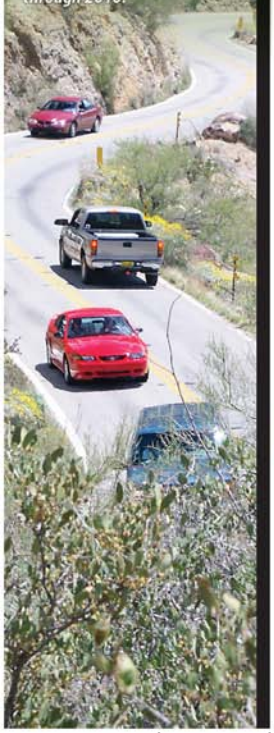
2040 MOBILITY MATTERS

# Vision and Goals

PAG
Pima Association of Governments

*In March 2009, the 2040 Task Force developed a new vision and new goals for the 2040 RTP. Using the vision and goals for the most recent long-range transportation plan as a starting point, the task force reviewed input from 19 stakeholder sessions and crafted the following vision and goals that reflect the diversity of our region.*

*Pima Association of Governments (PAG) is developing a new long-range transportation plan for eastern Pima County and the Tucson metropolitan area. PAG's 2040 Regional Transportation Plan (RTP) will be a 30-year plan that provides a framework for transportation investments in the PAG region by identifying projects that could potentially be developed with federal, state and local funding through 2040.*



## Vision

The 2040 RTP envisions a premier, energy-efficient, and environmentally responsible regional transportation system that is interconnected, multi-modal, technologically advanced and integrated with sustainable land use patterns.

## Goals for the System

**Expand Regional Multi-Modal Choices:** Develop a balance of rail, highway, mass transit, roadway, bicycle, and pedestrian mobility that creates a mix of travel choices and encourages alternatives to driving alone.

**Integrate Transportation Choices:** Optimize the mobility of people and goods by creating a user-friendly transportation network that links modes with the region and connects to facilities outside the region.

**Promote Sustainable Land Use:** Fully link land use, transportation planning and transportation funding to create vibrant, sustainable communities.

**Foster a Vibrant Economy:** Ensure the transportation network promotes a healthy growing economy.

**Enhance Safety:** Maximize safety and security for all transportation users across the region.

**Foster Environmental Stewardship:** Advance environmental stewardship, natural resource protection, and energy efficiency throughout the planning, design, construction and management of transportation infrastructure and services.

**Increase Accessibility:** Expand transportation options and access for all users including youth, elderly, low-income, and individuals with disabilities.

**Optimize Transportation System Performance:** Manage the transportation system to reduce traveler delay, ease congestion and improve mobility.

## How We Get There

**Engage the Public:** Provide early and on-going opportunities for meaningful public participation for all users.

**Employ Advanced Technologies:** Use new and upgraded technologies to deliver services, preserve and improve facilities, increase reliability, and reduce capital costs.

**Ensure Funding and Timely Project Delivery:** Maintain existing and pursue new revenue sources and strategies to ensure ample transportation funding and timely project development.

**Deliver Accountability:** Improve transparency, responsiveness, and coordination in developing and implementing the regional transportation system.

Source: Pima Association of Governments, April 2010.

There are numerous key words and phrases included in the 2040 RTP vision and goals statement suggesting that they could be directly linked to regional management and operations objectives that are measureable. These include:

- From the Vision Statement:
  - Energy efficient
  - Environmentally responsible
  - Interconnected
  - Multi-modal
  - Technologically advanced
  - Integrated with sustainable land uses

- From the Goals for the System:
  - Multi-Modal Expansion
  - Fully link land use
  - Optimize mobility
  - Maximize safety
  - Natural resource protection and energy efficiency
  - Expand transportation options
  - Optimize transportation system performance
  - Improve mobility
  - Reduce traveler delay
  - Ease congestion

The vision and goals statements for the 2040 RTP appear to provide a sound basis for the development of measurable regional operations objectives for incorporation in the CMP. The challenge is to develop the regional congestion management and operations objectives that are linked back to the vision and goals statements and can be linked forward to specific performance measures in the CMP.

**REGIONAL CONGESTION MANAGEMENT AND OPERATIONS OBJECTIVES FOR THE CMP**

The latest Federal requirements and guidelines provide a new perspective and purpose for the CMP in that it is supposed to directly support the goals of the regional transportation plan and assist in performance-based, objectives-driven decision making. The FHWA and FTA provide the following guidance on developing congestion management objectives in light of this new perspective and purpose for the CMP:

> "Objectives are specific, measurable statements relating to the attainment of goals. In the MTP, congestion objectives should be regional or multi-jurisdictional in nature and cannot be achieved by a single entity or jurisdiction. In conjunction with selecting congestion objectives, performance measures are developed to assess whether or not the objective has been met. In all cases, objectives should have "SMART" characteristics, as defined below:
>
> - **Specific –** It provides sufficient specificity to guide formulation of viable approaches to achieving the objective without dictating the approach.
> - **Measurable –** It includes quantitative measurements, saying how many or how much should be accomplished. Tracking progress against the objective enables an assessment of effectiveness of actions.
> - **Achievable –** Objectives should be realistic and within the reach of the

various participants in the CMP. Objectives should not represent a "wish list," but should take into consideration projections and trends used elsewhere in the metropolitan transportation planning process.

- **Realistic –** The objective can reasonably be accomplished within the limitations of resources and other demands. Still, the objective may be a "stretch" and require substantial coordination, collaboration, and investment to achieve. Since a judgment on how realistic the objective is cannot be fully evaluated until after strategies and approaches are defined, the objective may need to be adjusted iteratively.
- **Time-bound –** The objective identifies a timeframe within which it will be achieved (e.g., "by the year 2020").

By developing "SMART" objectives, system performance can be examined and monitored over time."[8]

Using the vision and goals of the 2040 Regional Transportation Plan (RTP) as a basis, congestion management objectives were developed referencing PAG planning documents, a review of CMP documents from other jurisdictions, and discussions with PAG staff and representatives of local agencies. Exhibit 6 lists the congestion management process objectives developed through this study. Each of the objectives is linked to at least one of the 2040 RTP vision and goals.

[8] *An Interim Guidebook on the Congestion Management Process in Metropolitan Transportation Planning,* FHWA/FTA, February 2008, page 4-3.

## Exhibit 6
## CMP OBJECTIVES AND RELATIONSHIP TO 2040 RTP GOALS

| 2040 RTP Goals for the System: | CMP Objectives |
|---|---|
| **Expand Regional Multi-Modal Choices** | Increase the use of alternate transportation modes (walking, bicycling, transit, carpool, and vanpool) to reduce congestion on roadways.<br>• Improve or sustain transit system performance to help reduce congestion.<br>• Improve the quality, quantity, accessibility and use of multi-modal traveler information services.<br>• Provide modal options.<br>• Enhance intermodal connectivity. |
| **Integrate Transportation Choices** | Maximize the efficiency of the interface between transportation modes.<br>• Reduce congestion and improve safety at railroad crossings.<br>• Improve the efficiency of transit boarding.<br>• Improve the efficiency of freight transfer. |
| **Promote Sustainable Land Use** | Promote programs and land use planning that advance efficient trip-making.<br>• Coordinate corridor and land use strategies.<br>• Coordinate regional transportation systems and land use planning. |
| **Foster a Vibrant Economy** | Make transportation investment decisions that use public resources effectively and efficiently, using performance based planning. |
| **Enhance Safety** | Improve traveler safety through efficient system operations.<br>• Reduce crashes consistent with the Arizona Strategic Highway Safety Plan reduction goals.<br>• Reduce the regional annual crash rate and fatal crash rate below the national average rates.<br>• Reduce the number of secondary incidents/crashes at incident scenes and work zones.<br>• Reduce the number of crashes involving bicyclists or pedestrians.<br>• Improve safety at railroad crossings. |
| **Foster Environmental Stewardship** | Make transportation decisions that are compatible with air quality conformity.<br>• Reduce per capita fuel consumption<br>• Reduce vehicle emissions. |
| **Increase Accessibility** | Address the needs of population groups with special transportation needs.<br>• Reduce congestion for special transportation needs population groups.<br>• Improve paratransit system performance to help reduce congestion. |
| **Optimize Transportation System Performance** | Provide reasonable and reliable travel time and level of service on transportation systems.<br>• Improve traffic signal timing, coordination and management across all jurisdictional boundaries.<br>• Improve work zone management to reduce event duration and traveler delay.<br>• Improve incident management to reduce incident duration and traveler delay.<br>• Maintain congestion levels for major arterials.<br>• Maintain delay per traveler not to exceed 40 percent of the free flow travel time. |

## CMP AREA OF APPLICATION

### The Federal Perspective

The second step in the FHWA eight step CMP program is to define the "area of application". The federal rule does not define requirements for establishing the CMP area of application, but instead, provides flexibility to Metropolitan Planning Organizations to develop tailored plans to meet the needs of the region. The FHWA and FTA provide the following guidance on defining the area of application:

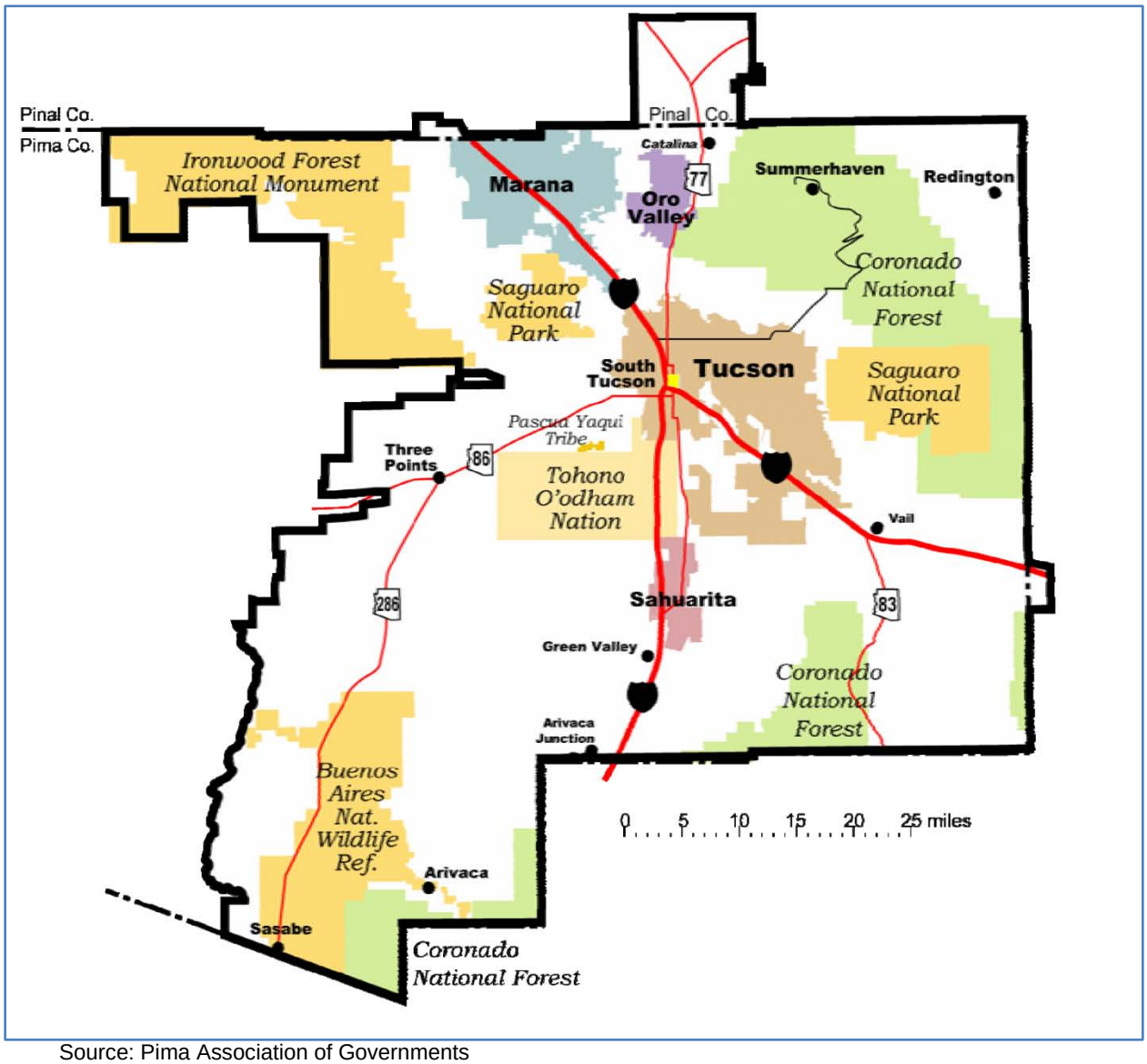
> "A congestion management process should be applied to a specific geographic area and network of surface transportation facilities. Often an area of application may align with the same geographic area contained in the Regional ITS Architecture. This alignment would allow system inventories and network descriptions to directly link to the CMP to the Regional ITS Architecture. As previously noted, "acceptable" levels of system performance may vary by type of transportation facility, geographic location, and time, including time of day and weekday/weekend patterns.
>
> In TMAs, the geographic limits of the CMP must encompass at least the TMA boundary. It would be advantageous to include the entire metropolitan area boundary, which is the TMA boundary plus the area that will become urbanized within twenty years, or some other rational criteria, such as the limits of an air-quality nonattainment area. In non-TMA MPOs, the preferential CMP boundary would most likely be the MPO planning area boundary. In areas where significant facilities or activity centers border the limits of a given metropolitan area, it may be appropriate to expand the CMP boundaries to include a broader analysis area."[9]

### Recommended Area of Application for the PAG CMP

It is recommended that the current PAG urbanized planning area serve as the area of application for the CMP. The PAG urbanized planning area as defined in the 2040 Regional Transportation Plan is illustrated in Exhibit 7. This area addresses transportation facilities and services in eastern Pima County, which includes unincorporated Pima County, the City of Tucson, the City of South Tucson, the Town of Marana, the Town of Oro Valley, the Town of Sahuarita, the Pascua Yaqui Tribe, the San Xavier District of the Tohono O'odham Nation, and the State of Arizona. Key areas outside of Pima County are also considered for planning purposes to help determine direct outside impacts. As recommended by FHWA and the FTA, this area encompasses the Tucson metropolitan area, the PAG region transportation modeling area, the Tucson Air Planning Area (TAPA) and contains areas likely to become urbanized within twenty years.

[9] *An Interim Guidebook on the Congestion Management Process in Metropolitan Transportation Planning,* FHWA/FTA, February 2008, page 3-3.

**Exhibit 7**
**RECOMMENDED CMP AREA OF APPLICATION - PAG URBANIZED PLANNING AREA**




Source: Pima Association of Governments

## CMP SYSTEM / NETWORK OF INTEREST

### The Federal Perspective

The Federal rule does not provide requirements for defining the CMP system and network of interest, but allows Metropolitan Planning Organizations to develop networks according to the unique characteristics of the region. The FHWA and FTA provide the following guidance on establishing the CMP network of interest:

"Whatever the geo-political boundaries of the CMP, the CMP network should identify the characteristics of the surface transportation network under consideration. The CMP should be multimodal, so the network should include both highway and transit facilities. Depending upon the nature of the region, and the congestion problems experienced by system operators, it may be appropriate to incorporate freight facilities such as marine or airport facilities, as well as rail transportation assets (commuter or intercity passenger as well as freight) that may be subject to congested conditions.

The CMP could consider particular corridors or activity centers, in addition to encompassing an entire metropolitan area. A CMP may also comprise a combination of regional, corridor, and activity area definitions, with each component serving different, specific purposes."[10]

**Recommended CMP Roadway Network**

To identify the roadway network for the CMP a GIS map was created to identify roadways by FHWA functional classification. Roadways defined as principal arterials, including interstates, freeways and expressways, and minor arterials were determined to be reasonable for inclusion in the network. This network of minor arterials and above was overlaid on the City of Tucson's "Synchro" regional traffic modeling network[11]. (Synchro is a traffic operations analysis software package capable of estimating roadway system performance using a variety of widely accepted performance measures, including travel delay and travel time. A City of Tucson project expanded the roadway system network included in the Synchro model to include all but twelve of the regions traffic signals.) Finally, corridors included in the PAG Mobility Management Plan (MMP) network, but not classified as arterials or within the "Synchro" modeling network were added for analysis. The resulting map of combined corridors is shown in Exhibit 8.

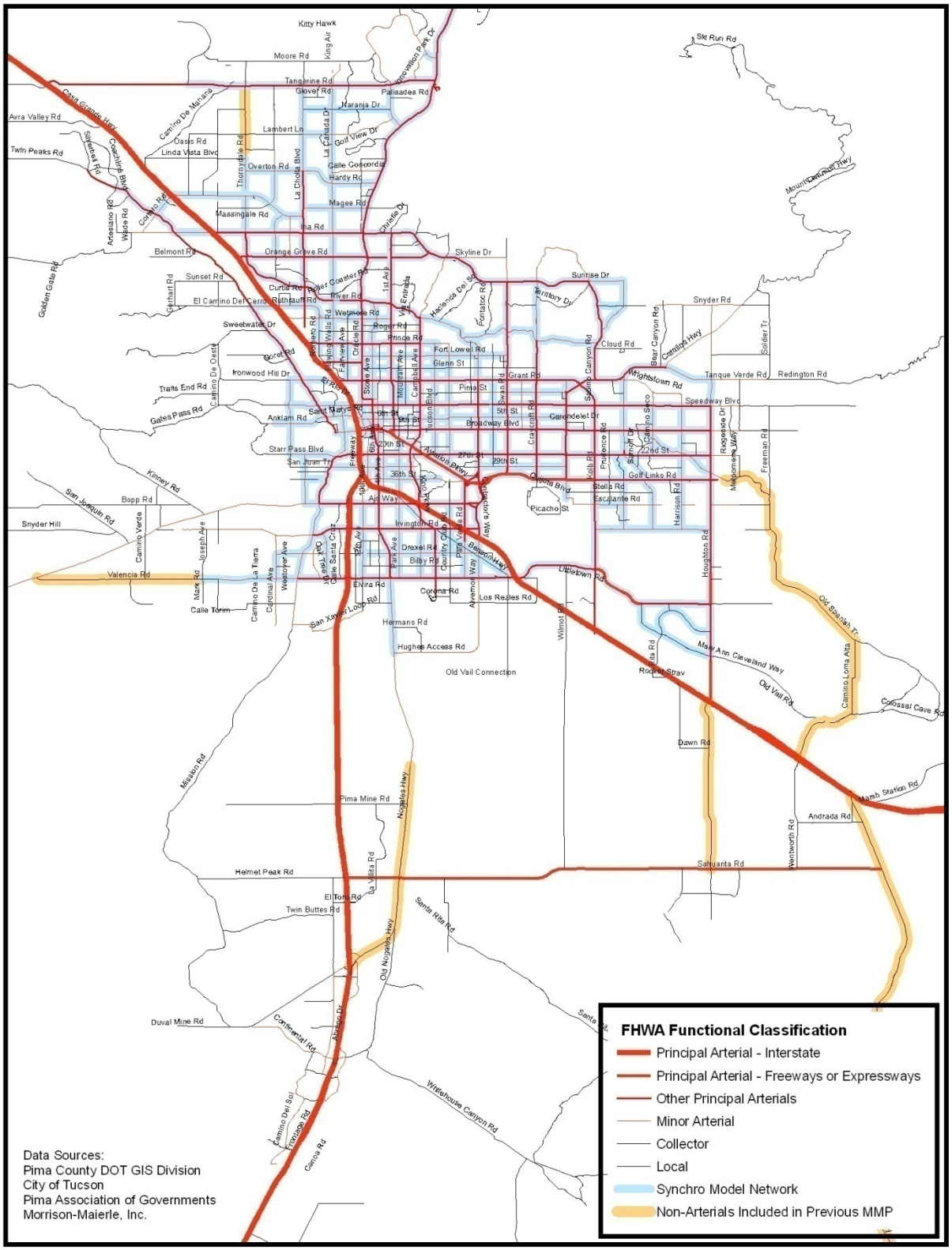
The major mobility corridors identified were consolidated into a composite map and refined for consideration by the CMP Technical advisory Committee as the CMP Network of Interest. The composite map is shown in Exhibit 9.

The network includes:

- All Interstate Highways.
- All major mobility corridors, including minor arterials and above, streets included in the City of Tucson's Synchro regional traffic operations modeling network, and other roadways considered to be of regional significance.
- Intersections and railroad crossings within the defined corridors.

[10] *An Interim Guidebook on the Congestion Management Process in Metropolitan Transportation Planning,* FHWA/FTA, February 2008, page 3-3.
[11] *Phase 2 Synchro Modeling Project,* Final Report, prepared for the City of Tucson by Morrison-Maierle, Inc., June 2009.

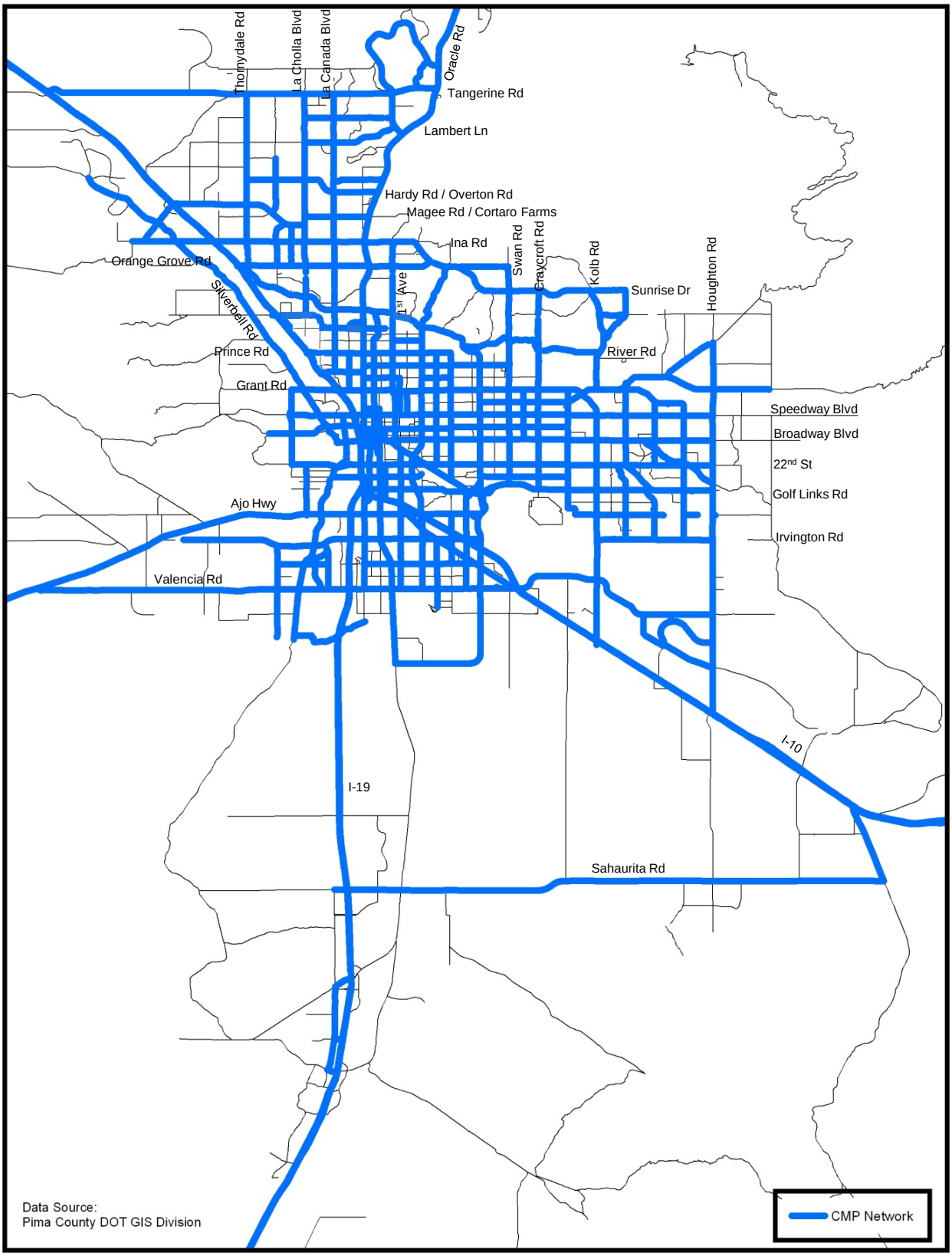
**Exhibit 8**
**MAJOR ROADWAY NETWORKS**






MORRISON MAIERLE, INC.
An Employee-Owned Company

## Exhibit 9
## CMP ROADWAY SYSTEM NETWORK



### Transit System Network

The transit system is viewed within the PAG region as a strategy in the toolbox for reducing roadway congestion rather than as an element requiring congestion management. Transit service is evaluated by established performance measures as a means of reducing roadway congestion by maintaining effective transit service in congested corridors. The transit system network includes the entire fixed route network and paratransit services. The performance assessment is focused on providing information that can be used to identify service improvements, ways to improve system operation efficiency, and opportunities to increase transit mode share and better serve public needs.

### Bicycle and Pedestrian Systems

The bicycle and pedestrian systems are also viewed within the PAG region as strategies for reducing roadway congestion rather than as elements requiring congestion management. These alternative modes are to be evaluated as candidates for implementation to alleviate congestion, but bicycle routes and pedestrian systems will not be evaluated to the extent of the roadway and transit systems. The CMP will track the development and integration of these systems into the overall transportation system and report on the level of deployment of these pedestrian and bicycle facilities.

## ROADWAY SYSTEM PERFORMANCE MEASURES

### The Federal Perspective and Guidance

The identification of appropriate performance measures is a critical step in the establishment of a Congestion Management Process. The development of performance measures is Step 4 in the FHWA/FTA eight-step program for the development of a CMP.

Over the last decade, federal guidance has increasingly emphasized the principle that congestion management processes should be objectives driven and performance based. Increased public sector accountability combined with increased customer expectation has led to an increased focus on the importance of performance measurement. Performance measurement uses statistical information to determine if a highway system is meeting the objectives of effectively serving the traveling public. Transportation agencies have instituted performance measures and the associated monitoring, evaluation and reporting processes for a variety of reasons, including:

- To provide better information about the transportation system to the public and decision makers.
- To improve management access to relevant performance data.
- To generally improve agency efficiency and effectiveness, particularly where demands on the transportation agency have increased while the available resources have become more limited.[12]

Several studies and documents have evaluated and recommended various transportation system performance measures, and numerous Metropolitan Planning Organizations (MPOs) have established performance measures for their CMP. However, no single organized framework or comprehensive set of measures for roadway performance assessment has gained widespread acceptance to serve the needs of the full range of potential users of performance information.

[12] *Performance Measurement Framework and Congestion Management Update – Review of Best Practices*, Maricopa Association of Governments, July 2008.

As the public sector innovation guidebook *Reinventing Government* [13] states:

- If you don't measure results, you can't tell success from failure.
- If you can't see success, you can't reward it.
- If you can't see failure, you can't correct it.

Performance measures provide metrics that can be used as a basis to track system-wide performance or to identify specific deficiencies within the system at a corridor, roadway or intersection level. Performance measures can be either quantitative or qualitative.

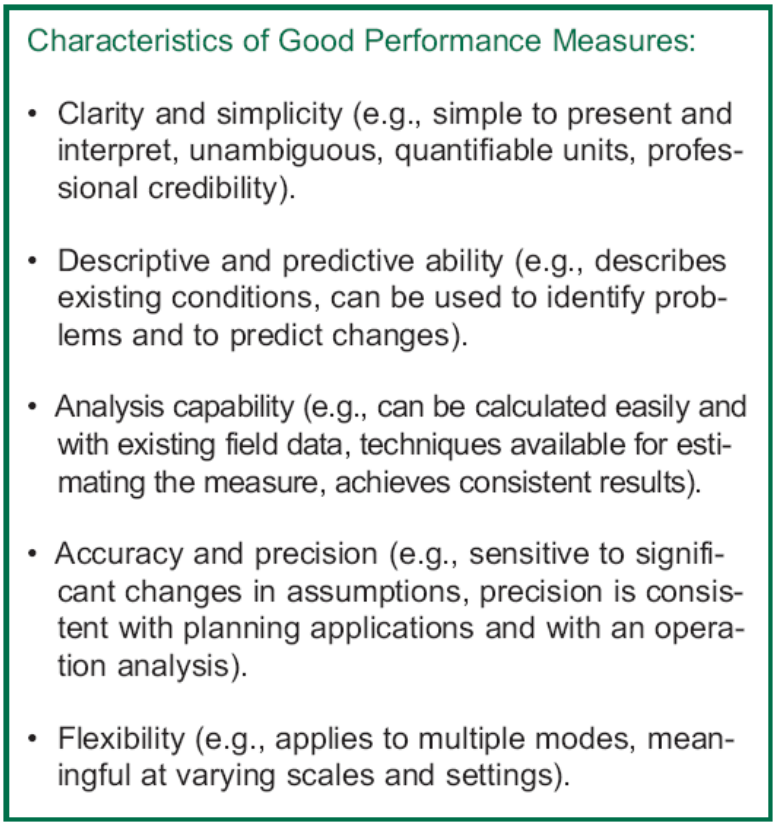
The Federal Rule on Statewide Transportation Planning states the following:

> "The development of a congestion management process should result in multimodal system performance measures and strategies that can be reflected in the metropolitan transportation plan and the TIP… The congestion management process shall include:
>
> - Methods to monitor and evaluate the performance of the multimodal transportation system, identify the causes of recurring and non-recurring congestion, identify and evaluate alternative strategies, provide information supporting the implementation of actions, and evaluate the effectiveness of implemented actions.
> - Since levels of acceptable system performance may vary among local communities, performance measures should be tailored to the specific needs of the area…
> - Establishment of a coordinated program for data collection and system performance monitoring to define the extent and duration of congestion, to contribute to determining the causes of congestion, and evaluate the efficiency and effectiveness of implemented actions. To the extent possible, this data collection program should be coordinated with existing data sources…
> - Identification and evaluation of the anticipated performance and expected benefits of appropriate congestion management strategies that will contribute to the more effective use and improved safety of existing and future transportation systems based on the established performance measures…
> - Implementation of a process for periodic assessment of the effectiveness of implemented strategies, in terms of the area's established performance measures. The results of this evaluation shall be provided to decision makers and the public to provide guidance on selection of effective strategies for future implementation."[14]

The FHWA and FTA *Guidebook on the Congestion Management Process in Metropolitan Transportation Planning* identifies several characteristics of good performance measures as shown in Exhibit 10.

[13] *Reinventing Government*, David Osborne and Ted Gaebler, Addison Wesley Publishing Co., 1992, page 147.
[14] *Statewide Transportation Planning; Metropolitan Transportation Planning; Final Rule*, 450.320(b), FHWA/FTA, February 14, 2007, page 7274.

**Exhibit 10**
**CHARACTERISTICS OF GOOD PERFORMANCE MEASURES**




Source: *An Interim Guidebook on the Congestion Management Process in Metropolitan Transportation Planning,* FHWA/FTA, February 2008, page 3-3.

In addition, FHWA and FTA provide the following guidance on the development of performance measures.[15]

- CMP performance measures should be derived from the vision, goals, and objectives established for the region during the metropolitan transportation planning process. The CMP itself is designed to put into action the vision and goals defined in the planning process by transforming goals into specific objectives, identifying where goals are not being achieved, and coming up with strategies that will help to achieve these goals. The CMP also provides ways to follow up and determine whether the strategies are contributing to success.
- Define for the region what congestion means, and what indicators best illustrate the impact of congestion on travelers and on economic activity. Recognize also that the best indicators or criteria may change over time.
- Review the most commonly used performance measures, and consider those that have been identified as the most useful.
- Adopt key performance measures relevant to the operations objectives and to the congestion problems facing the region. Most regions use a variety of measures to identify congested locations and to track system performance over time.

[15] *An Interim Guidebook on the Congestion Management Process in Metropolitan Transportation Planning,* FHWA/FTA, February 2008, page 3-5.

- Include multimodal measures. For example, measures related to highway congestion should be accompanied by those related to transit, goods movement, and non-motorized modes.
- Recognize that performance measures can be applied flexibly. Different levels of congestion, for instance, may be acceptable in different places and at different times.

FHWA cites the National Performance Review study *Serving the American Public: Best Practices in Performance Measurement,*[16] stating that a successful performance measurement system:

- Comprises a balanced set of a limited vital few measures.
- Produces timely and useful reports at a reasonable cost.
- Displays and makes readily available information that is shared, understood, and used by an organization.
- Supports the organization's values and the relationship the organization has with customers, suppliers, and stakeholders.[17]

**National Transportation Operations Coalition (NTOC) Performance Measures Initiative**

The National Transportation Operations Coalition (NTOC) Action Team on Performance Measurement compiled a short list of selected performance measures which are commonly accepted by Federal, state and local transportation officials. The NTOC Action Team is a group of experts in performance measurement, facilitation and transportation operations and management, with oversight from a committee of staff from state DOTs, MPOs and local government agencies. Exhibit 11 summarizes these selected measures, which are further detailed in Appendix A, NTOC Detailed Performance Measures Definitions.

[16] *Serving the American Public: Best Practices in Performance Measurement*, National Performance Review, June 1997.
[17] http://ops.fhwa.dot.gov/perf_measurement/fundamentals/purpose

**Exhibit 11**
**PERFORMANCE MEASURES FROM NTOC PERFORMANCE MEASURES INITIATIVE**

| Measure | Definition | Sample Units of Measurement |
|---|---|---|
| Customer Satisfaction | A qualitative measure of customers' opinions related to the roadway management and operations services provided in a specified region. | Very satisfied/Somewhat satisfied/Neutral/Somewhat dissatisfied/Very dissatisfied/Don't know/Not applicable. |
| Extent of Congestion – Spatial | Miles of roadway within a predefined area and time period for which average travel times are 30 percent longer than unconstrained travel times. | Lane miles of congested conditions or percent of congested roadways. Calculated as a ratio = 100 percent x (Congested Lane Miles)/(Total Lane Miles). |
| Extent of Congestion – Temporal | The time duration during which more than 20 percent of the roadway sections in a predefined area are congested as defined by the "Extent of Congestion – Spatial" performance measure. | Hours of congestion. |
| Incident Duration | The time elapsed from the notification of an incident until all evidence of the incident has been removed from the incident scene. | Median minutes per incident. |
| Non-Recurring Delay | Vehicle delays in excess of recurring delay for the current time-of-day, day-of-week, and day type. | Vehicle-hours. |
| Recurring Delay | Vehicle delays that are repeatable for the current time-of-day, day-of-week, and day type. | Vehicle-hours. |
| Speed | The average speed of vehicles measured in a single lane, for a single direction of flow, at a specific location on a roadway. | Miles per hour, feet per second, or kilometers per hour. |
| Throughput – Person | Number of persons including private vehicle occupants, transit riders, pedestrians, and bicyclists traversing a roadway section in one direction per unit time – by mode. May also be the number of persons traversing a screen line in one direction per unit time. | Persons per hour. |
| Throughput – Vehicle | Number of vehicles traversing a roadway section in one direction per unit time. May also be number of vehicles traversing a screen line per unit time. | Vehicles per hour. |
| Travel Time – Link | The average time required to traverse a section of roadway in a given direction. | Minutes per trip. |
| Travel Time – Reliability (Buffer Index) | The Buffer Time is the additional time that must be added to a trip (measured as defined by Travel Time – Trip) to ensure that travelers making the trip will arrive at their destination at, or before, the intended time 95 percent of the time. | Minutes. This measure may also be expressed as a percent of total trip time or as an index. |
| Travel Time – Trip | The average time required to travel from an origin to a destination on a trip that might include multiple modes of travel. | Minutes per trip. |

Source: *An Interim Guidebook on the Congestion Management Process in Metropolitan Transportation Planning,* FHWA/FTA, February 2008, page 3-4.

## NCHRP Guide to Effective Freeway Performance Measurement

The National Cooperative Highway Research Program (NCHRP) produced a guidebook to provide an organized framework for the effective use of performance measures for freeways. Exhibit 12 summarizes the set of principles developed by the research team to develop the guidance on performance measurement. Appendix B contains Tables 9 and 10 from the guidebook, listing the core performance measures and supplemental performance measures recommended for use by transportation agencies where the necessary data are available.

**Exhibit 12**
**BASIC PRINCIPLES FOR FREEWAY PERFORMANCE MONITORING**

| | |
|---|---|
| **Principle 1** | Mobility performance measures must be based on the measurement or estimation of travel time. |
| **Principle 2** | Measure where you can – model everything else. |
| **Principle 3** | Multiple metrics should be used to report freeway performance, especially for mobility. |
| **Principle 4** | Traditional HCM-based performance measures for mobility (V/C [1] ratio and level of service) should not be ignored but should serve as supplementary, not primary, measures of performance in most cases. |
| **Principle 5** | Both vehicle- and person-based performance measures of throughput are useful and should be developed, depending on the application. |
| **Principle 6** | Both quality-of-service (outcome) and activity-based (output) performance measures are required for freeway performance monitoring. |
| **Principle 7** | Activity-based measures should be chosen so that improvements in them can be linked to improvements in quality-of-service measures. |
| **Principle 8** | Customer satisfaction measures should be included with quality of service measures for monitoring freeway performance. |
| **Principle 9** | The measurement of travel time reliability is a key aspect of freeway performance measurement and reliability measures should be developed and applied. |
| **Principle 10** | Three dimensions of freeway mobility/congestion should be tracked with mobility performance measures: source of congestion, temporal aspects, and spatial detail. |
| **Principle 11** | Communication of freeway performance measurement should be done with graphics that resonate with various technical and nontechnical audiences. |
| **Principle 12** | Continuity should be maintained in performance measures across applications and time horizons; the same performance measures should be used for trend monitoring, project design, forecasting, and evaluations. |

1. Volume-to-capacity

Source: *Research Results Digest 312, Guide to Effective Freeway Performance Measurement*, National Cooperative Highway Research Program, February, 2007, page 28.

## Candidate CMP Roadway Performance Measures

Following a review of federal guidance, the performance measures in the current PAG MMP, and best practices literature, a draft listing of recommended performance measures for roadways was prepared. In the interest of developing a CMP that is ongoing and sustainable by PAG and its member jurisdictions, strong consideration was given to the utilization of existing data, and resources required for data processing.

Exhibit 13 depicts the candidate roadway performance measures considered by the Technical Advisory Committee and PAG staff. Performance measures are presented in a matrix format to indicate their applicability to freeways/expressways, arterials and/or intersections. In order to provide a robust picture of congestion in the PAG region, performance measures have been identified in three descriptive categories:

1. System Size / Extent – these measures allow for tracking the supply of transportation system facilities year-to-year and measure system expansion/contraction.
2. Level of Use – these measures assess the demand on the transportation system elements and allow for tracking the growth in demand over time.
3. System Performance – these measures generally relate demand to supply and provide an assessment of the transportation system operation under existing demand conditions.

## Exhibit 13
## CANDIDATE ROADWAY PERFORMANCE MEASURES CONSIDERED

| Measure | Level of Application | | | | | Primary Information Source |
|---|---|---|---|---|---|---|
| | Regional | Subarea | Freeways/ Expressways | Arterials | Intersections | |
| **System Size / Extent** | | | | | | |
| • Lane miles by facility type/functional class | x | x | | | | Regional traffic model |
| • Lane miles per capita by facility type/functional class | x | x | | | | Regional traffic model |
| • Number of signalized intersections and locations (with map) | x | x | | | | Local jurisdictions |
| • Number of HAWK/ other pedestrian / bike signals (with map) | x | x | | | | Local jurisdictions |
| • New lane miles per year on CMP network and location (with map) | x | x | x | x | | Local jurisdictions |
| • Number of intersection turn lane / safety improvements | | | | | x | Local jurisdictions |
| • Number of new facilities providing intermodal connections | x | x | | | | Local jurisdictions |
| **Level of Use** | | | | | | |
| • Daily vehicle miles traveled and per capita (VMT and VMT/P) | x | x | x | x | | Regional traffic model |
| • Average daily traffic – sample of roadways | x | x | x | x | | Traffic counts |
| • Peak-hour volume – sample of roadways | x | x | x | x | | Traffic counts |
| • Intersection daily entering volume – sample of intersections | x | | | | x | Traffic counts |
| • Intersection peak-hour entering volume – sample of intersections | x | x | | | x | Traffic counts |
| • Vehicle or person through-put (at established screenlines) | | | | | | |
| - Daily through-put (vehicles or persons per day) | x | x | x | x | | Regional traffic model and transit ridership data |
| - Peak-hour through-put (vehicles or persons per hour) | x | x | x | x | | Regional traffic model or Synchro model, and transit ridership data |
| **System Performance** | | | | | | |
| • Roadway Peak Hour V/C, LOS or congestion category (with map) | x | x | x | x | | Regional traffic model |
| • Intersection Peak Hour V/C, LOS or congestion category (with map) | x | x | | | x | Regional Synchro model |
| • Lane (or centerline) miles by LOS E (congestion category) or worse | | | x | x | | Regional traffic model |
| • Lane (or centerline) miles by congestion category during peak hours | x | x | x | x | | Regional Synchro model |
| • Number of Intersections by congestion category during peak hours | x | x | | | x | Regional Synchro model |
| • Roadway delay as a percentage of total travel time (peak hours) | | | | x | | Regional Synchro model |
| • Most congested locations – roadways / intersections (top 10 – 20) | | | x | x | x | Regional traffic model / Regional Synchro model |
| • Locations where signal timing improvements may be beneficial | | | | | x | Regional Synchro model |
| • Additional traffic delay due to railroad crossings | | | | | x | Field measurement |
| • Recurring delay estimates (peak-hours ) (hours of intersection delay) | x | x | | | | Regional Synchro model |
| • Non-recurring congestion: | | | | | | |
| - Average incident clearance time (minutes) | x | x | | | | TransView and STOC data |
| - Incident locations (map) | x | x | | | | TransView and STOC data |
| • Travel time or speed estimates (peak hour) | x | x | x | x | | Regional Synchro model with periodic field data collection for calibration. |
| • Regional travel time index | x | x | | | | TTI methodology computed from regional data[18] |
| • Customer satisfaction (regional assessment) | x | | | | | Survey |
| • Lane miles of roadway impacted by roadway construction | x | x | | | | State and local agencies |
| • Daily vehicle hours traveled and per capita (VHT and VHT/P) | x | x | x | x | | Regional traffic model |
| **Safety:** | | | | | | |
| • Number of crashes / year (vehicle, pedestrian, bike, railroad crossings, etc.) | x | x | x | x | x | Crash report database |
| • Number of fatal crashes / year | x | x | x | x | x | Crash report database |
| • Number of injury crashes / year | x | x | x | x | x | Crash report database |
| • Annual crash rate (crashes per million vehicle miles or entering) | x | x | x | x | x | Computed |
| • Annual fatality rate (fatal crashes per million vehicle miles or entering) | x | x | x | x | x | Computed |
| **System Integration:** | | | | | | |
| • CO (tailpipe), NOx, and VOC levels with and without TIP projects | x | | | | | PAG air quality model |
| • Number of employers in Travel Reduction Program | x | | | | | PAG TRP database |
| • Number of registered carpool, vanpool, and alternate mode commuters | x | | | | | PAG TRP database |

[18] *2009 Urban Mobility Report,* The Texas Transportation Institute, The Texas A & M University System, July 2009.

**Potential Performance Measure Data Sources**

Exhibit 13 also identifies a preliminary source for the primary data to be used in developing each of the performance measures. A brief description of the primary data source and application is provided below.

- Regional Traffic Model - This is the PAG regional traffic forecasting model. The indicated performance measure would generally be estimated using the PAG database for the existing (current base year) traffic conditions, but could also be used to estimate the measure for the Regional Transportation Plan future forecast year. It is preferable that actual traffic counts be used to compute volume/capacity (V/C) ratios using the roadway capacity values contained in the regional traffic forecasting model. The use of forecast traffic volumes is problematic in that the model will assign traffic to elements of the network that are well in excess of roadway capacity, which may substantially exceed the actual volumes on the network. This is particularly true for interstate freeway facilities.
- Local jurisdictions – This refers to data and information typically collected and managed by the PAG member jurisdictions for the operation of the roadway system.
- PAG traffic counts – This refers to the weekday 24-hour traffic data collected and managed by PAG in their ongoing annual traffic data collection program. These data are generally updated so that no data are more than three years old. This data collection would have to continue into the future to support the assessment of the indicated performance measures.
- Regional Synchro model – A large scale traffic operations model has recently been completed under a contract to the City of Tucson[19]. This model was developed using the Synchro/SimTraffic software suite for traffic analysis. The Synchro model was expanded as part of this recent project to include the roadway network containing 549 of the regions 561 traffic signals. All of the roadway geometry, traffic signal timing, and current traffic count data for this roadway system representing existing AM and PM peak-hour conditions are contained in the model.

  There are only 12 signalized intersections in the PAG region that are not included in the model. The model does not include the Interstate highways between interchanges, but does include the interchange traffic signals on I-10 and I-19. This model could easily be expanded to include the remaining traffic signals not in the model and to include the Interstate highways between interchanges.

  The previous project also developed automated procedures for ranking intersections and roadway segments based on Synchro estimates of delay on the roadway system. The automated procedures for ranking intersections and roadway segments by delay estimates could also be modified and expanded to estimate several of the recommended performance measures.

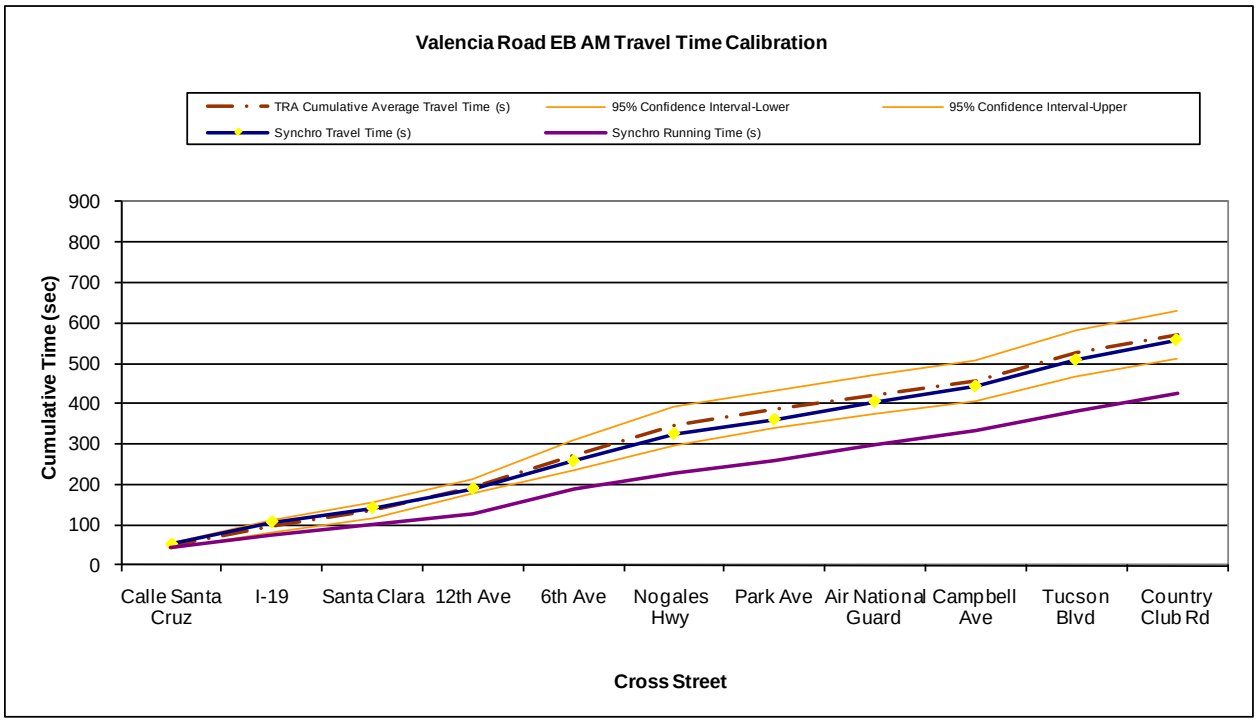
  The model also provides estimates of travel time along arterial roadways that were shown in the previous study to be consistent with travel time data collected in the field. An example of the comparison of the Synchro travel time estimate to the measured travel time along a corridor is provided in Exhibit 14. Exhibit 14 shows the average cumulative travel time measured in the field, 95$^{th}$ percentile confidence intervals for the average travel time, the Synchro estimated travel time, and the Synchro estimated running time along a roadway corridor. In this example, Synchro provides a very close estimate of the measured average travel time, although the results varied. The

[19] *Phase 2 Synchro Modeling Project,* Final Report Volumes 1 and 2, June 2009, prepared for the City of Tucson, prepared by Morrison-Maierle, Inc.

difference between the estimated travel time and the running time is an estimate of the recurring delay along the roadway.

The use of this model for providing estimates of the CMP performance measures would benefit by being expanded to include the Interstates and the remaining signalized intersections in the region. The model database would also need to be maintained and updated on a regular basis. The application of the Synchro model to estimate arterial travel time would require the periodic collection of travel time data along a small sample of corridors to verify and recalibrate the model. However, the use of the Synchro model would eliminate the need for widespread and more frequent travel time data collection.

**Exhibit 14**
**COMPARISON OF SYNCHRO MODEL ESTIMATED TRAVEL TIME TO MEASURED TRAVEL TIME**




Source: *Draft Working Paper #1: Synchro Modeling Phase 2, Before Period Data Collection Summary and Analysis,* prepared for the City of Tucson, prepared by Morrison-Maierle, Inc., September 9, 2008.

- TransView Database – TransView is a traveler information website maintained and operated by the City of Tucson. This website contains a webpage that displays current daily traffic related incidents in the City of Tucson as reported by the Tucson Police Department. It is updated every 2 minutes with the current list of open incidents. This service is provided to help travelers avoid delays associated with traffic incidents and other problems. Exhibit 15 illustrates the traffic incident data that are displayed on the website and archived by TransView as part of a traffic incident database. These data were initially only provided for incidents within the City of Tucson, but the service was recently expanded to include incidents reported by the Pima County Sheriff's Department, and the database could be expanded to include all area incidents. The Case Number included in the data is the same number used for the crash report filed by the Tucson Police Department, which allows each incident to be referenced to the filed crash report. The only data missing that is required to compute incident duration is the time that the traffic lanes are cleared at the scene and traffic is restored to normal operation, which could be added to the database if this were called in to the dispatcher

by the police officer on the scene. The Pima County Sheriff's Department does report the time when an incident is cleared.

**Exhibit 15**
**TRANSVIEW WEBSITE TRAFFIC INCIDENT INFORMATION**

**Current Traffic Incidents**

| Case Number | Description | Location | Time of call |
|---|---|---|---|
| P0907220173 | ACCIDENT NO INJURY | E NICARAGUA DR/S WILMOT RD ,DM | 7/22 07:56 |
| P0907220163 | ACCIDENT NO INJURY | W GRANT RD/N I10 ,TUC | 7/22 07:34 |
| P0907220162 | HIT AND RUN ACCIDENT NEG INJ | 2938 E 30 ST ,TUC | 7/22 07:30 |

**Traffic Incident Details**

**P0907220173**

| Description | Location | Location Detail | Time of call |
|---|---|---|---|
| ACCIDENT NO INJURY | E NICARAGUA DR/S WILMOT RD ,DM | NEAR QUIK MART | 07:55 |

| Time call entered | Time Dispatched | Time En-route | Time On Scene |
|---|---|---|---|
| 07:56 | 07:59 | 07:59 | 08:05 |

Source: http://www.transview.org/traffic/

- Through activities at the Southern Traffic Operations Center (STOC), the Arizona Department of Transportation manually captures incident data for those sections of Interstate 10 in the Tucson metro area that are monitored via video camera. These data include incident location, time of day, number of lanes blocked, and incident duration. These data are currently maintained in hard copy only by the STOC management firm and by ADOT. It would be very beneficial if incident data could be maintained electronically and provided to PAG for use in evaluating freeway incident duration and non-recurring congestion due to freeway incidents.
- Survey – This refers to the use of periodic customer satisfaction survey as a qualitative assessment of customers' opinions related to the roadway management and operations. A sample survey type and questions, as developed by the National Transportation Operations Coalition (NTOC) Performance Measurement Initiative are provided in Appendix A. A survey document of this type could be disseminated at public transportation open houses, such as those for the TIP or RTP, or those for other transportation projects, through the annual Travel Reduction Program (TRP) annual survey, and could be made available online at the PAG website.
- Crash report database – Crash reports are maintained by the jurisdiction responsible for preparing them and are forwarded to the Arizona Department of Transportation (ADOT) for inclusion in the annual statewide crash database. No comprehensive database currently exists representing exclusively the PAG CMP roadway system, but this could be approximated from the Pima County and local jurisdiction data summarized by ADOT. A sample of the summary data provided by ADOT is provided in Exhibit 16.

**Exhibit 16**
**2008 ADOT CRASH REPORT SUMMARY FOR PIMA COUNTY**
**Analysis by Jurisdiction**

| COUNTIES Cities | Number of Crashes | | | | No. of Persons | | Alcohol Related | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | Fatal | Injury | PDO | Killed | Injured | Crashes | Killed | Injured |
| Pima County | 3,855 | 39 | 1,163 | 2,653 | 40 | 1,856 | 282 | 25 | 215 |
| Pima County State Rural Roads | 997 | 22 | 339 | 636 | 27 | 571 | 54 | 8 | 36 |
| South Tucson | 163 | 1 | 46 | 116 | 1 | 61 | 5 | 1 | 2 |
| Tucson | 11,618 | 51 | 4,254 | 7,313 | 54 | 6,249 | 595 | 22 | 443 |
| Sahuarita | 194 | 4 | 45 | 145 | 4 | 69 | 11 | 1 | 5 |
| Oro Valley | 427 | 3 | 101 | 323 | 3 | 165 | 8 | 2 | 4 |
| Marana | 964 | 7 | 228 | 729 | 8 | 346 | 29 | 3 | 16 |
| **TOTAL** | **18,218** | **127** | **6,176** | **11,915** | **137** | **9,317** | **984** | **62** | **721** |

Source: *Arizona Motor Vehicle Crash Facts 2008*, Arizona Department of Transportation, June 2009, page 14.

- TTI Travel Time Index – The Texas Transportation Institute has developed a method to estimate congestion and travel time indices, and other performance measures.[20] The methodology is a spreadsheet-based technique that uses formulas and constants along with a set of procedures that can be viewed and modified by the user. The index is calculated using regional long range transportation planning model output statistics and a combination of other processing steps to provide a comprehensive estimate of congestion levels. The regional models produce estimates of the vehicle-miles and vehicle-hours of travel for each roadway link. These links include the major mobility-producing portions of the transportation network for current and future conditions. This approach could be used to develop system performance measures for the existing condition and for the condition represented by the PAG 2040 Regional Transportation Plan for comparison.
- PAG air quality model - This is the model used by PAG to evaluate the air quality conformity of the Regional Transportation Plan and the five-year Transportation Improvement Program (TIP).
- PAG TRP – This is the PAG Travel Reduction Program which monitors and tracks the number of employers participating in the program to reduce the number of single occupant vehicle work trips in the region.

## Long Term Options for Measuring System Performance

### GPS Tracking Devices

A long term option for the collection of travel time data for use in system performance assessment exists in the form of automated cell phone tracking, or the use of Global Positioning System (GPS) devices on commercial truck fleets and passenger vehicles. Cell phones equipped with GPS devices can also be tracked. The use of cell phone tracking requires an agreement with the wireless service provider, which can be difficult to obtain, and a mathematical model to convert the tracking data to travel time information.

Tracking GPS equipped vehicles or cell phones is also possible and there are companies that provide this service (for example, INRIX (**www.inrix.com/technology.asp**), and Discrete Wireless (**www.discretewireless.com/**)). This would require an agreement with truck fleet companies and individual cell phone owners to obtain tracking information for the purpose of

[20] Lomax, T., et.al., *The Texas Congestion Index: Concept and Methodology,* Texas Transportation Institute, Texas Department of Transportation, FHWA/TX-05/5-4853-01-P6, September 2005.

computing travel time. A mathematical model would also be needed to convert the tracking data to travel time information along specific routes of the regional network. Such a system could provide the long-term technological approach to collecting data and evaluating system performance. It could be used to identify any of the following:

- Travel time by time of day, day of week, season of the year.
- Typical recurring delay (comparing travel time during peak and off-peak periods of the day).
- Non-recurring delay (evaluating travel time along a roadway where an incident is known to have occurred and comparing to typical recurring delay).
- Location of congestion.
- Time of day and duration of congestion.
- The impact of implemented congestion management measures (comparing before and after travel time data on the network).

### Aerial Photography

Another method of tracking travel demand and system performance is through the use of periodic aerial photography and photo analysis. Such services are provided commercially by Skycomp Inc. (**http://www.skycomp.com/survey.html**) and have been used by the Maricopa Association of Governments to periodically evaluate roadway system performance. Photo-density surveys and bottleneck inventories can be periodically repeated to document changes in system performance and the impacts of improvements. The photographs are used to quantify roadway traffic density, particularly along freeways, and traffic queues at signalized intersections along major arterials. The analysis and data are limited by the number of still images taken during defined time period.

### Real-Time Traffic Information Systems

In 2005, Section 1201 of SAFETEA-LU required that the Secretary of Transportation establish a program to provide all states the capability to monitor, in real-time, the traffic and travel conditions of major highways, and share that information to facilitate national and regional highway traveler information, among other things.[21] To fulfill requirements in SAFETEA-LU, the Federal Highway Administration (FHWA) issued a Notice of Proposed Rulemaking in January 2009 to establish the Real-Time System Management Information Program.[22] The proposed rule contains minimum requirements for states to make information on traffic and travel conditions available through real-time information programs and to share this information. FHWA plans to issue a final rule in February 2010.

The FHWA proposes to require real-time information programs be capable of delivering traffic and travel conditions on: traffic incidents that block roadway travel, roadway weather condition, and construction activities affecting travel conditions for Metropolitan Areas exceeding a population of 1 million also would provide travel times for highway segments. The proposed rule would require that real-time information programs be established in two stages:

1. For Interstate highways in each State, to be completed within two years from publication of the Final Rule.
2. Along other Metropolitan Area, non-Interstate highways that sustain local mobility and that serve a diversion routes that alleviate congested locations, to be completed within four years from publication of the Final Rule.

[21] *SURFACE TRANSPORTATION: Efforts to address Highway Congestion Through Real-Time Traffic Information Systems are Expanding but Face Implementation Challenges,* Government Accountability Office (GAO), November 2009, GAO-10-121R.
[22] *Federal Register Vol. 74, No. 9*, January 14, 2009.

The Proposed Rule suggests that the following information could be provided by a real-time traffic information system:

- Location – the location or portion of a route segment where a reported item is occurring, related to mileposts, interchange(s) and/or common landmark(s).
- Direction of Travel – the direction of travel where a reported item is occurring.
- General Description and Impact – a brief account and impact of the reported item.
- Days/Hours and/or Duration – the period in which the reported item is "active" and possibly affecting travel.
- Travel Time or Delay – the duration of traveling from point A to point B, a segment or a trip expressed in time (or delay a traveler will experience).
- Detours/Restrictions/Routing Advice – as appropriate, summaries of required detours, suggested alternate routes or modes and restrictions associated with a reported item.
- Forecasted Weather and Road Surface Conditions – Near-term forecasted weather and pavement conditions along the route segment.
- Current Observed Weather and Road Surface Conditions – conditions know to be in existence that impact travel along the route segment.

The provision of an archive of the above types of information could be used for a variety planning and analysis purposes related to congestion management, including:

- Developing transportation policies and programs.
- Performing needs studies/assessments.
- Ranking and prioritizing transportation improvement projects for funding.
- Evaluation of project-specific transportation improvement strategies.
- Congestion management system performance measurement.
- Establishing and monitoring congestion trends (extent, intensity, duration, reliability).
- Identification of congestion locations and bottlenecks.
- Measuring the effectiveness and benefits of improvements.
- Communicating information about transportation problems and solutions.

The development of the real-time traffic information system for the Tucson area should attempt to integrate system data collection and analysis capabilities into the system, which could then be used to support the congestion management process, and other regional transportation planning and improvement needs.

**PRIMARY ROADWAY SYSTEM PERFORMANCE MEASURES**

The candidate roadway system performance measures from Exhibit 13 were reviewed and considered based on several criteria, including subjective elements like the descriptive relevance of the measure and whether it is generally understood, and objective elements like the data requirements and availability of the data to provide the measure. Based on this general assessment each candidate measure was assigned a primary or secondary role in the CMP process, and in one case a measure was rejected and indicated as not reported (NR). The primary measures are those considered to provide the best general assessments of the characteristics of the roadway system and are recommended to be updated and reported more frequently to monitor system performance. The secondary measures are considered to provide additional supplementary information that can be used to provide a more detailed performance assessment. These recommendations are provided in Exhibit 17. In addition, Exhibit 17 provides a preliminary assessment of how often these measures should be updated using new data.

An illustrative example of how two of the primary roadway system performance measures could be displayed is provided in Exhibits 18 and 19. These exhibits provide the AM and PM peak-

hour congestion estimates from the regional Synchro traffic operations model for signalized intersections and roadway segments. The estimates of congestion level for signalized intersections are based on the Synchro estimates of total intersection delay per entering vehicle. This is the same metric used in the 2000 *Highway Capacity Manual* to define intersection level of service. For the roadway segments the congestion categories are based on the cumulative intersection delay per vehicle for through traffic only along the corridor in both directions divided by the total number of approaches (delay per vehicle per approach). The use of the delay estimate for through traffic only along the roadway segments was selected for use here because it illustrates the potential need for additional through traffic lanes along a corridor. The intersection delay includes the delay to turn movements. The range of values for each metric associated with each congestion level is provided in Exhibit 20.

Exhibits 18 and 19 also provide an illustration of the peak-hour traffic volume entering each of the intersections that have moderate or worse levels of congestion. This provides additional information on system use.

Exhibits 18 and 19 provide an overview of the most congested intersections of the region and an indication of the direction of travel (east-west versus north-south) of the most congested arterial roadways. This type of information can be used to help guide application of congestion management strategies and describe the effectiveness of transportation system improvements to address regional congestion.

## Exhibit 17
## RECOMMENDED PRIMARY AND SECONDARY ROADWAY PERFORMANCE MEASURES

| Measure | Primary / Secondary Application | Recommended Update Frequency |
|---|---|---|
| **System Size / Extent** | | |
| • Lane miles by facility type/functional class | Primary | Annually |
| • Lane miles per capita by facility type/functional class | Secondary | Every 5 years with population update |
| • Number of signalized intersections and locations (with map) | Primary | Annually |
| • Number of HAWK/ other pedestrian / bike signals (with map) | Primary | Annually |
| • New lane miles per year on CMP network and location (with map) | Primary | Annually |
| • Number of intersection turn lane / safety improvements | Primary | Annually |
| • Number of new facilities providing intermodal connections | Primary | Annually |
| **Level of Use** | | |
| • Daily vehicle miles traveled and per capita (VMT and VMT/P) | Secondary | Every 5 years with population update |
| • Average daily traffic – sample of roadways | Secondary | Every 3 years with new traffic counts |
| • Peak-hour volume – sample of roadways | Secondary | Every 3 years with new traffic counts |
| • Intersection daily entering volume – sample of intersections | Secondary | Every 3 years with new traffic counts |
| • Intersection peak-hour entering volume – sample of intersections | Secondary | Every 3 years with new traffic counts |
| • Vehicle or person through-put (at established screenlines) | | |
| - Daily through-put (vehicles or persons per day) | Secondary | Every 3 years with new traffic counts / ridership |
| - Peak-hour through-put (vehicles or persons per hour) | Secondary | Every 3 years with new traffic counts / ridership |
| **System Performance** | | |
| • Roadway Peak Hour congestion category (with map) | Primary | Every 3 years with new traffic counts |
| • Intersection Peak Hour congestion level (with map) | Primary | Every 3 years with new traffic counts |
| • Lane (or centerline) miles by congestion category | NR[1] | |
| • Lane (or centerline) miles by congestion category during peak hours | Primary | Every 3 years with new traffic counts |
| • Number of Intersections by congestion category during peak hours | Primary | Every 3 years with new traffic counts |
| • Roadway delay as a percentage of total travel time (peak hours) | Secondary | Every 3 years with new traffic counts |
| • Most congested locations – roadways / intersections (top 10 – 20) | Secondary | As needed or requested by jurisdictions |
| • Locations where signal timing improvements may be beneficial | Secondary | As needed to improve signal timing |
| • Additional traffic delay due to railroad crossings | Secondary | Every 5 years |
| • Recurring delay estimates (peak-hour ) (hours of intersection delay) | Primary | Every 3 years with new traffic counts |
| • Non-recurring congestion: | | |
| - Average incident clearance time (minutes) | Primary | Every 3-5 years |
| - Incident locations (map) | Primary | Every 3-5 years |
| • Travel time or speed estimates (peak hour) | Secondary | Every 5 years for Synchro calibration |
| • Regional travel time index | Secondary | Every 3-5 years |
| • Customer satisfaction (regional assessment) | Secondary | Every 3-5 years |
| • Lane miles of roadway impacted by roadway construction | Secondary | Annually |
| • Daily vehicle hours traveled and per capita (VHT and VHT/P) | Secondary | Every 3-5 years |
| Safety: | | |
| • Number of crashes / year (vehicle, pedestrian, bike, railroad crossings, etc.) | Primary | Annually |
| • Number of fatal crashes / year | Primary | Annually |
| • Number of injury crashes / year | Primary | Annually |
| • Annual crash rate (crashes per million vehicle miles or entering) | Secondary | Every 3-5 years |
| • Annual fatality rate (fatal crashes per million vehicle miles or entering) | Secondary | Every 3-5 years |
| System Integration: | | |
| • CO (tailpipe), NOx, and VOC levels with and without TIP projects | Secondary | Every 3-5 years |
| • Number of employers in Travel Reduction Program | Secondary | Annually |
| • Number of registered carpool, vanpool, and alternate mode commuters | Secondary | Annually |

1. NR = Not Reported

**Exhibit 18**
**AM PEAK-HOUR REGIONAL ROADWAY CONGESTION**

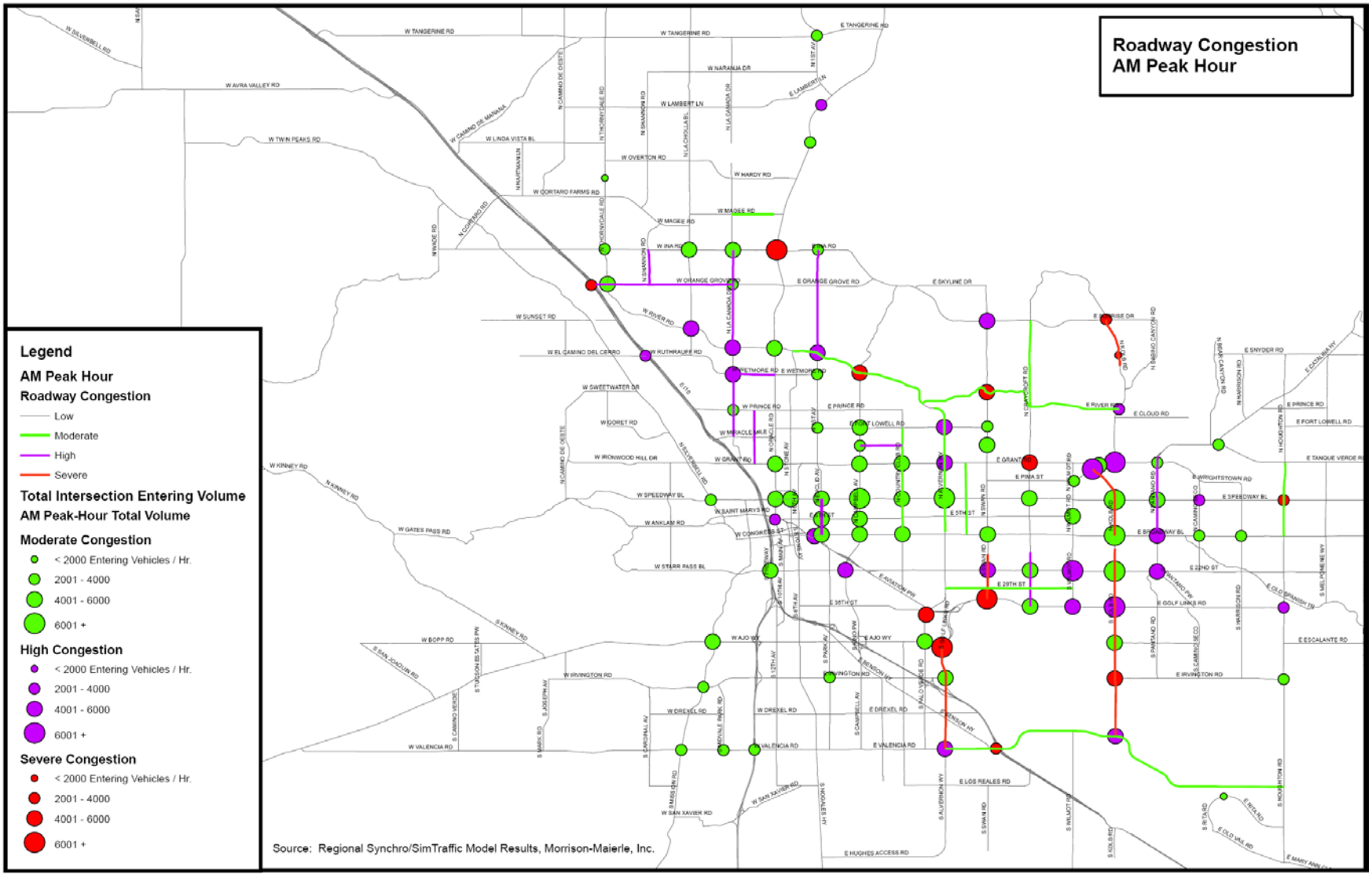





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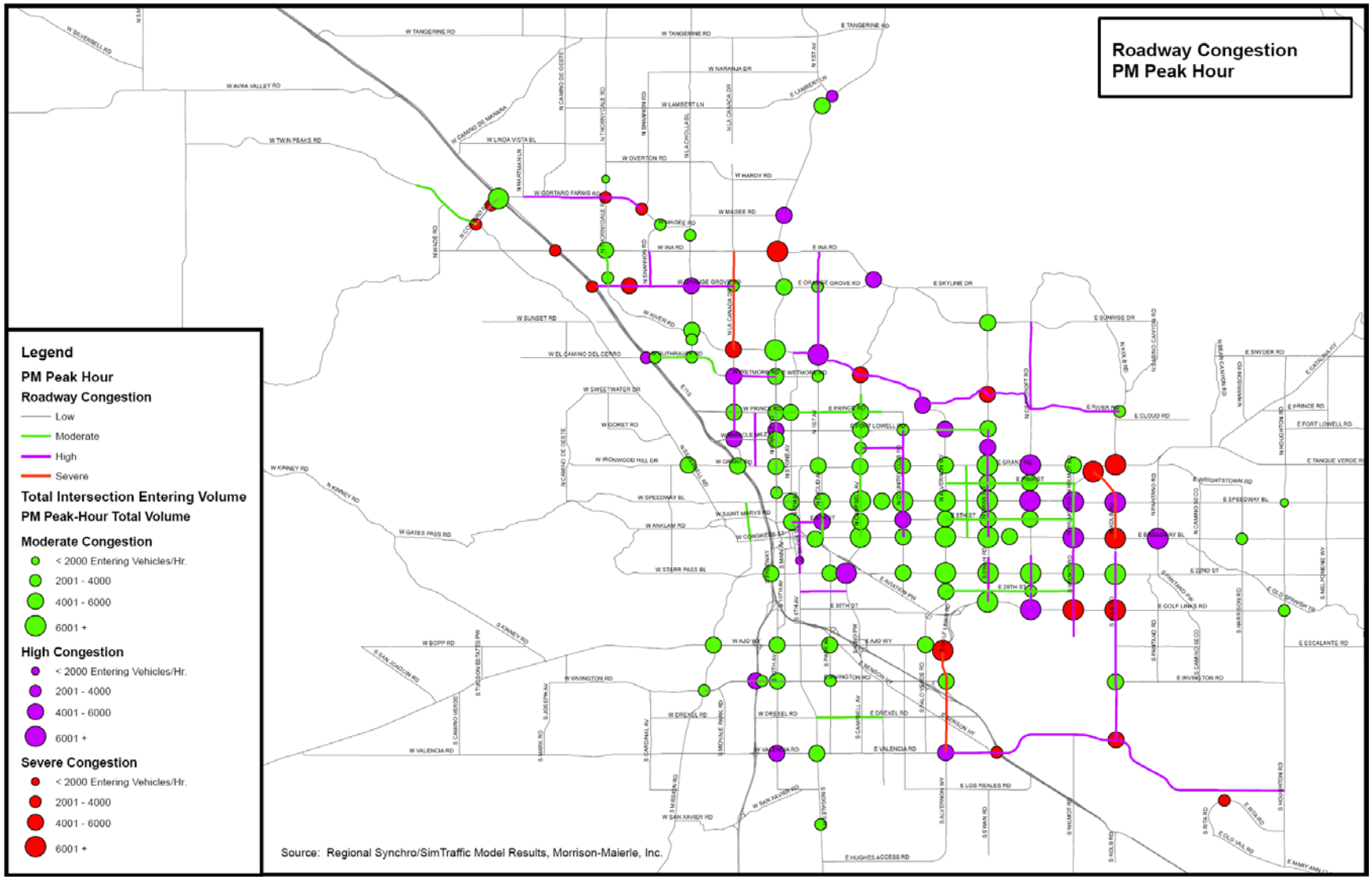
**Exhibit 19**
**PM PEAK-HOUR REGIONAL ROADWAY CONGESTION**






MORRISON MAIERLE, INC.
An Employee-Owned Company

**Exhibit 20**
**INTERSECTION AND ROADWAY CONGESTION METRICS**

| Congestion Level | Intersection Metric (total delay per vehicle in seconds) | Roadway Metric (delay per vehicle per approach for through traffic only in seconds) |
|---|---|---|
| • Low | Delay < 35 | Delay < 30 |
| • Moderate | 35.0 < Delay ≤ 55.0 | 30 < Delay ≤ 35.0 |
| • High | 55.0 < Delay ≤ 80.0 | 35.0 < Delay ≤ 55.0 |
| • Severe | Delay > 80.0 | Delay > 55.0 |

An additional roadway system performance measure developed from the data produced by the regional Synchro model is the percentage of total travel time along roadway segments that is comprised of intersection delay to the through movement. Exhibits 21 and 22 demonstrate the use of this metric for existing traffic conditions. Two categories of this metric are displayed in these exhibits:

1. Delay to 40-45% of total travel time averaged for both directions of travel.
2. Delay greater than 45% of total travel time averaged for both directions of travel.

The application of the primary and secondary performance measures will provide valuable information on system performance. This information can be used to aid decision making on the type, location, and intensity of deployment of strategies to manage congestion. They can also be used to monitor the effectiveness of implemented congestion management strategies to determine whether certain applications should be intensified, reduced, or terminated.

**Exhibit 21**
**AM PEAK-HOUR DELAY AS PERCENT OF TOTAL TRAVEL TIME**

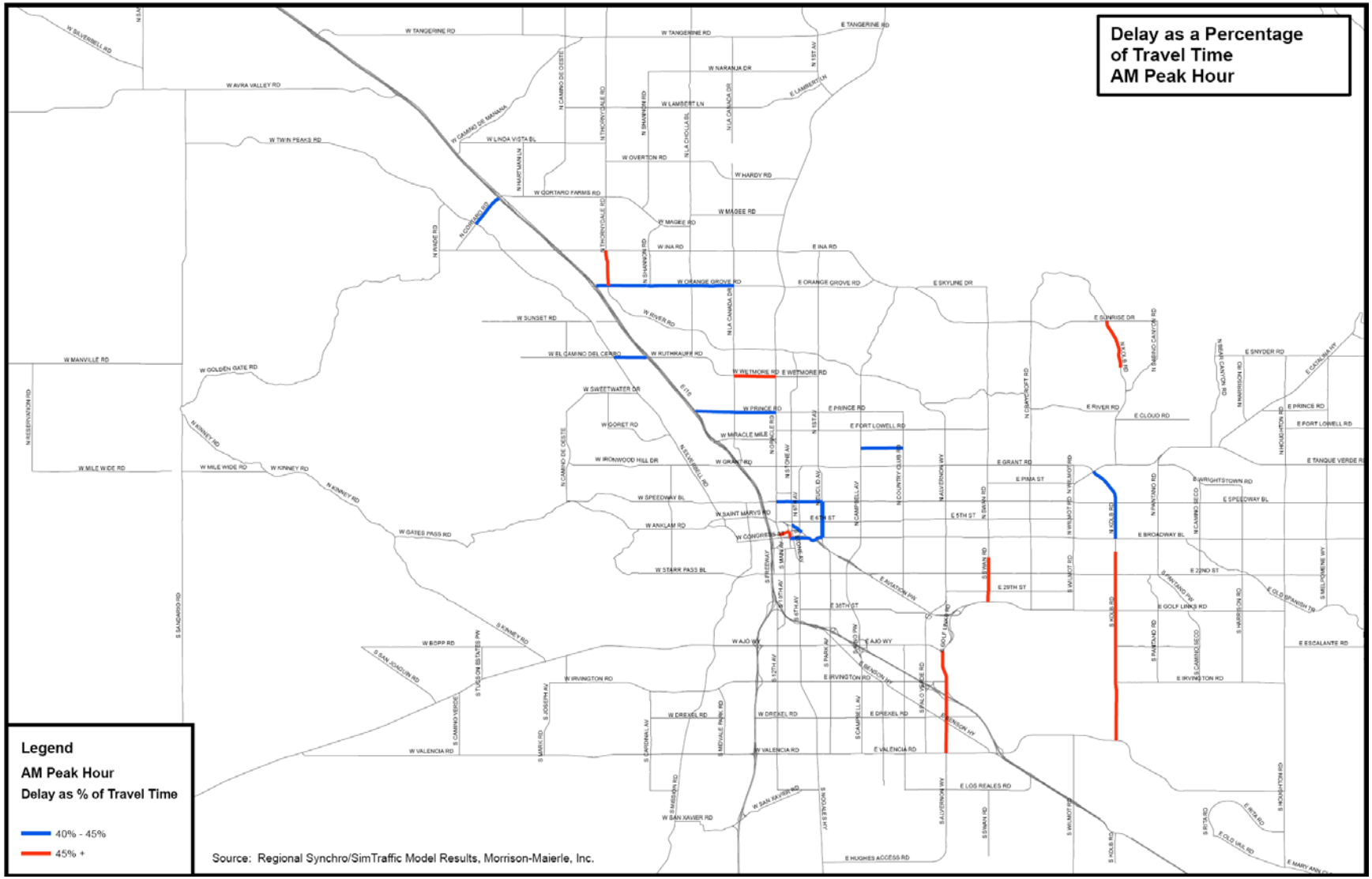





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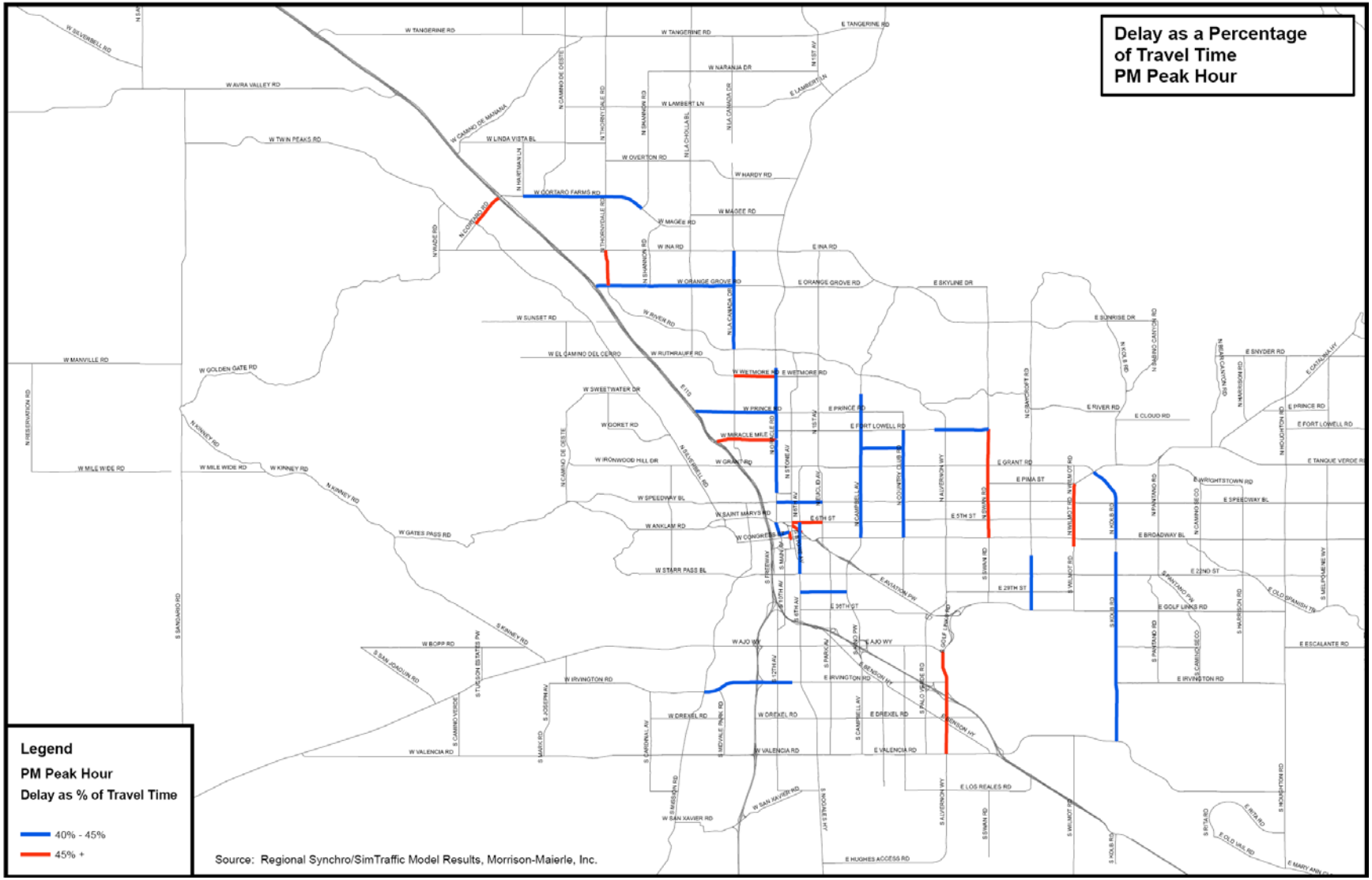
**Exhibit 22**
**PM PEAK-HOUR DELAY AS PERCENT OF TOTAL TRAVEL TIME**



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## TRANSIT AND MULTIMODAL PERFORMANCE MEASURES

This section presents a synthesis of information about transit level of service and transit mobility performance measures in regard to incorporation of the measures into the PAG Congestion Management Process. Information is also presented on multimodal performance measures and mobility strategies to improve transit and multimodal levels of service and overall transit and multimodal mobility. The discussion of mobility performance measures includes measures collected by Sun Tran and relates these measures to measures discussed in the literature.

The Transportation Cooperative Research Program (TCRP), *A Guidebook for Developing a Transit Performance-Measurement System,* recommends the following categories of performance measures for transit[23]:

- **Availability** – where and when service is provided, and having sufficient capacity available for passengers to take trips at their desired time (customer point of view).
- **Service delivery** – including reliability, customer service, passenger loading, and agency goal accomplishment (customer).
- **Safety and security** – reflecting the likelihood that one will be involved in an accident (*safety*) or become the victim of a crime (*security*) while using transit (customer).
- **Maintenance and construction** – evaluating the effectiveness of an agency's maintenance program, and the impacts of construction projects on customers (customer and agency).
- **Economic** – transit performance evaluated from a business perspective, including use, efficiency, effectiveness, and administrative measures (agency and community).
- **Community** – measures of transit's impact on individuals and on the community as a whole (community, agency, and driver/vehicle).
- **Capacity** – the ability of transit facilities to move both vehicles and people (community and driver/vehicle).
- **Travel time** – how long it takes to make a trip by transit (a) by itself, (b) in comparison with another mode, or (c) in comparison with an ideal value (driver/vehicle and customer).

According to the report, secondary categories that overlap the primary categories listed above include *paratransit* measures designed specifically for demand-responsive service and *comfort* measures.

The categories of availability, service delivery, capacity, and travel time are directly related to mobility and level of service measures.

The guidebook further recommends core measures to be collected for the following:

- Service availability
- Service delivery
- Safety and security
- Community impact
- Maintenance
- Financial performance

[23] Transit Cooperative Research Program, *A Guidebook for Developing a Transit Performance-Measurement System,* Report 88, 2003.

- Agency administration

Exhibit 23 presents core service availability and service delivery measures for fixed route service. These core measures directly reflect mobility and level of service.

**EXHIBIT 23**
**RECOMMENDED CORE FIXED-ROUTE SERVICE MEASURES**

| **Core Fixed-Route Service Availability Measures** | |
|---|---|
| • Service Coverage<br>• Hours of Service<br>• Route Coverage | • Frequency<br>• Stop Accessibility |
| **Core Fixed-Route Service Delivery Measures** | |
| • Missed Trips<br>• Route Directness<br>• Customer Response Time<br>• Reliability Factor<br>• Number of Fare Media Sales Outlets<br>• Headway Regularity<br>• Customer Loyalty | • Complaint Rate<br>• On-time Performance<br>• Passenger Load<br>• Transit-Auto Travel Time<br>• Customer Satisfaction<br>• Passenger Environment |

Source: TCRP Report 88, 2003.

Recommended core demand-responsive for demand responsive measures that relate to mobility and level of service are listed below.

- Availability measures
  - Service coverage
  - Span of service
  - Service hours
  - Revenue hours
  - Service denials
- Service monitoring measures
  - On-time performance
  - Missed trips
  - Complaint rate
  - Percentage of missed phone calls (for systems serving more than 100 trips per day), and response time to customer inquiries.
- Travel time measures
  - Travel time and
  - System speed.
- Economic measures
  - Ridership

**Sun Tran Performance Measures**

The City of Tucson operates the Sun Tran transit system in the metropolitan Tucson area. The following are some key facts of the service:[24]

- Sun Tran has 226 buses in its fleet – each bus is wheel chair accessible.
- Sun Tran buses travel more than 27,000 miles each day.

[24] http://www.suntran.com/about_trivia.php

- Sun Tran has more than 2,200 bus stops.
- Every bus is equipped with a bike rack that can carry up to two bicycles.
- Sun Tran's ridership was approximately 19.5 million passenger trips in FY 07-08

Sun Tran collects an array of performance measures for the agency's fixed-route system, Sun Van (formerly Van Tran, City ADA Paratransit Service), Pima County Rural Transit. Specific performance measures as well as standards are listed below are collected for the following categories:

- Convenience
- Reliability
- Comfort
- Productivity

The complete performance measures collected by Sun Transit are listed below for fixed route service, Sun Van services, and the Pima County Rural Transit service. Exhibit 24 summarizes measures that describe the mobility and level of service related measures collected by Sun Tran. Exhibit 25 relates the mobility and level of service performance measures collected by Sun Tran to the Florida DOT performance measures. Exhibit 26 relates the Sun Tran mobility and level of service measures to the measures in quality of service framework put forth in the TCQS manual. Exhibit 27 provides the service measures and standards for Sun Tran fixed route service.

**EXHIBIT 24**
**MOBILITY AND LEVEL OF SERVICE RELATED MEASURES COLLECTED BY SUN TRAN**

| Category | Fixed Route | Sun Van | Rural Transit |
|---|---|---|---|
| **Convenience** | Headway, minutes<br>Stop Spacing<br>Accessibility, Vehicle-revenue hours | Hours of service | |
| **Reliability** | % trips to be on time | % pass trips to be on time | % trips between 0 and 5 min late |
| **Comfort** | Pass to seats at maximum load | Transport time from pickup to drop-off | |
| **Productivity** | Pass per revenue mile | | Pass per vehicle revenue mile |

Source: Sun Tran **http://www.suntran.com/**

**Exhibit 25**
**RELATIONSHIP OF FLORIDA MOBILITY PERFORMANCE MEASURES TO SUN TRAN MEASURES FOR FIXED ROUTE SERVICE**

| Florida | | | Sun Tran | |
|---|---|---|---|---|
| **Performance Category** | **Mobility Performance Measure** | **Definition** | **Category** | **Measure** |
| **Quantity of Travel** | Ridership | Total passenger trips | **Productivity** | Pass per revenue mile |
| **Quality of Travel** | Auto/Transit travel time ratio | Door-to-door trip time | **Reliability** | % trips to be on time |
| | Reliability | On-time performance | | |
| **Accessibility** | Coverage | % person minutes served | | |
| | Frequency | Buses per hour | **Convenience** | Headway, min. Stop Spacing Accessibility, |
| | Span | Hours of service per day | | Vehicle revenue hours |
| **Utilization** | Load Factor | % seats occupied | **Comfort** | Pass to seats at maximum load |

Source: Service Measures and Standards For Sun Transit (Fixed Route Service) **-** *Tucson Metropolitan Short Range Transit Plan, FY 1997-1998 through 2001-2002.*

**Exhibit 26**
**RELATIONSHIP OF QUALITY OF SERVICE FRAMEWORK TO SUN TRAN MEASURES**

| TCQS | | | | Sun Tran | |
|---|---|---|---|---|---|
| **Category** | **Level** | **Performance Measure** | | **Category** | **Performance Measure** |
| **Fixed Route Service** | | | | | |
| **Availability** | Transit Stop | Frequency | | **Convenience** | Headway |
| | Route Segment | Hours of Service | | | Vehicle revenue hours |
| | System | Service coverage | | | |
| **Comfort & Convenience** | Transit Stop | Passenger load | | **Comfort** | Pass to seats at max load |
| | Route Segment | Reliability | | **Reliability** | % trips to be on time |
| | System | Transit vs. automobile time | | | |
| **Demand Responsive Service** | | | | | |
| **Availability** | Transit Stop | Response time | | **Reliability** | % pass trips to be on time |
| | Route Segment | Span of service | | **Convenience** | Hours of service |
| | System | | | | |
| **Comfort & Convenience** | Transit Stop | On time performance | | **Reliability** | |
| | Route Segment | Trips not served | | | |
| | System | Demand responsive transit vs. automobile travel time | | | |

Source: Service Measures and Standards For Sun Transit (Fixed Route Service) **-** *Tucson Metropolitan Short Range Transit Plan, FY 1997-1998 through 2001-2002.*

**Exhibit 27**
**SERVICE MEASURES AND STANDARDS FOR SUN TRAN (FIXED ROUTE SERVICE)**

| Service Measure | Standard |
|---|---|
| **Convenience:**<br>• Headway (minutes between bus trips).<br>• Stop Spacing (distance between bus stops).<br>• Accessibility (percent of vehicle revenue hours. | • Not greater than 60 minutes.<br>• Transit stops shall be spaced ¼ - mile apart except where demand warrants otherwise.<br>• 100% accessible. |
| **Reliability:**<br>• Vehicle Dependability:<br>a. Percentage of trips that are dispatched and operated.<br>b. Miles between roads calls.<br>• Schedule dependability (percentage of trips expected to be on time). | a. Missed Trips shall be no more than 0.5% of the trips on any route in either diction per day. The last trip of the day shall always be completed.<br>b. 4,599 miles between road calls.<br>• On-time performance is defined as zero minutes ahead of schedule to five minutes late. For each route, trips will be on time at time points, with a 95% on-time performance being the system goal. |
| **Comfort:**<br>• Loading (ratio of passengers to seats at the maximum load point).<br>• Safety (total annual vehicle collision accidents per 100,000 vehicle miles). | • At a maximum load point, load ratio shall not exceed the following: 135% for peak hour, peak direction of travel on radial and connective routes; 100% on express routes and limited stop service; 125% during midday; or 150% on individual trips.<br>• A maximum of four avoidable vehicle collision accidents per 100,000 vehicle miles. |
| **Productivity:**<br>• Service Effectiveness (ratio of passengers per revenue miles, revenue hour or vehicle trip operated on each route for weekdays, Saturdays and Sundays).<br>• Cost Efficiency (system-wide total operating costs per revenue mile and per revenue hour.<br>• Cost Effectiveness (the total operating cost per passenger). | • 75% of system average for radial routes; 60% of system average of connective routes; 50% of system average for feeder routes; 45% of system average for circulator routes; 20 passengers per trip for express routes.<br>• Annual increase averaged over a three year period, shall not exceed rate of inflation.<br>• 133% of the system average for radial routes; 166% of the system average for connective routes; 175% of the system average for feeder routes; 180% of the system average for circulator routes. |

Source: Tucson Metropolitan Short Range Transit Play, FY 1997-1998 through 2001-2002.

## Guidelines for Sun Van (formerly Van Tran, City ADA Paratransit Service) [25]

### Service Reduction

The Americans with Disabilities Act of 1990 mandates jurisdictions with fixed routes provided "complementary and comparable" service to those who are certified ADA eligible. Those who become ADA eligible are granted a civil right – a "kind" of constitutional right" – to that "complementary and comparable" transit service. The ADA mandated service area is ¾ mile on either side of each fixed route. A reduction of ADA paratransit service would accompany a reduction in fixed route transit service and would be addressed concurrently in public notice and hearing.

### Service Reallocation

Actual ADA paratransit service began July 1, 1996. As of that date only those who are certified ADA eligible will be allowed to use this paratransit service. Within the ADA mandate service area and during the service times that are comparable to fixed route service, ADA regulations prohibit implementing rules or operating procedures that limit in any way when, how many times, and for what reasons an ADA eligible person can ride.

### Service Expansion

If a fixed route is extended anywhere in the service area, comparable ADA paratransit service must be provided. It is within the purview of the transit system to provide service beyond the ADA mandate if funds allow.

### Service Measures and Standards

Service measures and standards for Sun Van are provided in Exhibit 28.

[25] *Tucson Metropolitan Short Range Transit Plan, FY 1997-1998 through 2001-2002.*

**Exhibit 28**
**SERVICE MEASURES AND STANDARDS FOR SUN VAN (CITY ADA PARATRANSIT SERVICE)**

| Service Measure | Standard |
|---|---|
| **Convenience:** | |
| • Service Span (hours during which the service is operated). | • Span of service shall parallel fixed route service and may change with time of day. |
| **Reliability:** | |
| • Spare Ratio (percentage of operating vehicles available in the yard for replacement on a day-to-day basis. | • Spare ratio shall not fall below 8% of total fleet. |
| • Schedule dependability (percentage of trips expected to be on time, defined as arriving between 10 minutes before and 15 minutes after scheduled pickup time). | • 80% of all trips shall be on time. |
| • Appointment Compliance (percentage of passenger trips arranged to arrive at destination appointment on time). | • 91% of all passenger trips will be schedule to arrive at destination no later than appointment time. |
| • 30-Minute Late Call Compliance (Percentage of passenger trips that are no more than 30 minutes past scheduled pick-up time) | • 98% Of trips are no more than 30 minutes past scheduled pick-up time. |
| • "Will Call" Pickups (A "will call" is a ride requested for a return or subsequent trip following a schedule trip, but for which the departure time cannot be stated in advance). | • 96% of all "will calls" will be picked up within two (2) hours of the call. |
| **Comfort:** | |
| • Safety (ratio of crashes to miles operated). | • No more than 1.2 crashes per 100,000 vehicle miles. |
| • Trip Length (the time to transport a passenger from pickup to drop-off). | • 80% of all trips shall be made in 90 minutes or less. |

Source: Tucson Metropolitan Short Range Transit Play, FY 1997-1998 through 2001-2002.

### Guidelines for Pima County Rural Transit [26]

#### Service Reduction

Trips, routes or route segments considered for elimination will be those that do not meet performance and productivity standards.

#### Service Reallocation

Efforts will be made to routinely evaluate service and reallocate resources to improve equitable geographic coverage, system productivity, and efficiency.[27]

[26] *Tucson Metropolitan Short Range Transit Plan, FY 1997-1998 through 2001-2002.*
[27] *Tucson Metropolitan Short Range Transit Plan, FY 1997-1998 through 2001-2000, page 3-8.*

### Service Expansion

Service expansion will be considered as demand warrants and funding permits.

### Service Measures and Standards

Service measures and standards for Pima County Rural Transit are provided in Exhibit 29.

**Exhibit 29**
**SERVICE MEASURES AND STANDARDS FOR PIMA COUNTY RURAL TRANSIT**

| Service Measure | Standard |
|---|---|
| **Productivity:** | |
| • Cost Efficiency (total cost per vehicle revenue hour) | • Annual increase o greater than the rate of inflation. |
| • Service Effectiveness (passengers per vehicle revenue mile and per vehicle trip). | • Minimum of 75% of the system average for each route. |
| • Cost Effectiveness (total operating cost per passenger). | • Maximum of 133% of the system average for each route. |
| **Service Quality:** | |
| • Reliability (percent of trips that are between zero minutes early and 5 minutes late). | • 90% of all trips to be on time. |
| • Safety (number of vehicle crashes per 100,000 vehicle miles). | • Maximum of 1 average annually. |

Source: Tucson Metropolitan Short Range Transit Play, FY 1997-1998 through 2001-2002.

## RECOMMENDED CMP TRANSIT AND MULTIMODAL PERFORMANCE MEASURES

One of the overriding goals/objectives for the CMP is to increase the use of alternative modes. Recommendations are presented here for performance measures for transit, paratransit, bike, and pedestrian facilities so that the performance of these modes can be related to how well each mode is helping to reduce congestion. In addition, a recommendation is made to consider the development of a mobility index to indicate the overall performance of alternative modes.

### Performance Measures

Exhibits 30 through 33 present recommendations for collecting data for performance measures according to the following categories:

- System size/extent
- Level of use
- System performance

Exhibits 31 and 32 include an additional category, Accessibility and Constraints. The four tables include the primary source of information for the data needed to support the performance measures listed under each category.

**Exhibit 30**
**RECOMMENDED FIXED-ROUTE TRANSIT PERFORMANCE MEASURES**

| Measure | System | Route | Stops | Primary Information Source |
|---|---|---|---|---|
| **System Size/Extent** | | | | |
| • System Coverage | | | | |
| o Total route mileage | x | | | Sun Tran System map |
| o Population within ¼ mile of route | x | x | | Updated GIS Map |
| o Vehicle-miles traveled (VMT) per capita | x | | | Sun Tran database |
| o Passenger-miles traveled (PMT) per capita | x | | | Sun Tran database |
| • Vehicles in Service | | | | |
| o Number of vehicles in service per day | x | | | Sun Tran database |
| • Park-and –Ride Lots | | | | |
| o Number of Park-and-Ride spaces | x | x | | |
| **Level of Use** | | | | |
| • Span of Service | | | | |
| o Hours of service per day | x | x | | Sun Tran operations data |
| o Vehicles per hour | | x | | Bus schedules |
| • Ridership | | | | |
| o Passengers carried during peak hour and daily | x | x | | Sun Tran database |
| o Passengers per revenue mile of service | x | x | | Sun Tran database |
| o No. of Passengers on/off | x | x | x | |
| • Load Factor | | | | |
| o % design capacity (seats occupied plus standees) for peak hour and average day | x | x | | Sun Tran database |
| • Park-and-Ride usage | | | | |
| o % Park-and-Ride spaces occupied | x | x | x | |
| **System Performance** | | | | |
| • Auto/Transit travel time ratio | | | | |
| o Door-to-door trip time | | x | | Sun Tran database |
| • On-time performance | | | | |
| o % trips on time | x | x | x | Sun Tran database |
| • Level of service | | | | |
| o Headway, min | | x | | Sun Tran database |
| o Vehicles per hour | | x | | Sun Tran database |

**Exhibit 31**
**RECOMMENDED PARATRANSIT PERFORMANCE MEASURES**

| Measure | System | Trip | Primary Information Source |
|---|---|---|---|
| **System Size/Extent** | | | |
| • System Coverage | | | |
| o Total route mileage | x | | Sun Tran database |
| o Population within ¼ mile of route | x | x | Updated GIS Map |
| o Vehicle-miles traveled (VMT) per capita | x | | Sun Tran database |
| o Passenger-miles traveled (PMT) per capita | x | | Sun Tran database |
| • Vehicles in Service | | | |
| o Number of vehicles in service per day | x | | Sun Tran database |
| **Level of Use** | | | |
| • Span of Service | | | |
| o Hours of service per day | x | x | Sun Tran operations data |
| • Ridership | | | |
| o Passengers carried during peak hour and daily | x | x | Sun Tran database |
| o Passengers per revenue mile of service | x | x | Sun Tran database |
| • Load Factor | | | |
| o Passengers carried per trip | x | x | Sun Tran database |
| **System Performance** | | | |
| • Auto/Transit travel time ratio | | | |
| o Door-to-door trip time | x | x | Sun Tran database |
| • Level of service | | | |
| o Response time, min | | x | Sun Tran database |
| • Dependability | | | |
| o % trips arriving between 10 minutes before and 10 minutes after scheduled pickup time | x | x | Sun Tran database |
| • Appointment compliance | | | |
| o % trips arriving at destination on time | x | x | Sun Tran database |
| • Will-call compliance | | | |
| o % will-calls picked up within two hours of call | x | | Sun Tran database |

**Exhibit 32**
**RECOMMENDED BICYCLE FACILITY PERFORMANCE MEASURES**

| Measure | System | Subarea | Primary Information Source |
|---|---|---|---|
| **System Size/Extent** | | | |
| • Bike lanes | x | | |
| o Miles of bike lanes per 100,000 in population | | | Tucson Metro Bike Map |
| • Bike paths | x | | |
| o Miles of bike paths per 100,000 in population | | | Tucson Metro Bike Map |
| • Bicycle-suitable streets | x | | |
| o Miles of bicycle-suitable streets per 100,000 in population | | | Tucson Metro Bike Map |
| • Suitable shoulders | x | | |
| o Miles of suitable shoulders per 100,000 in population | | | Tucson Metro Bike Map |
| **Accessibility and Constraints** | | | |
| • Crossings of Streets and Washes | | | |
| o Crossings of Streets and Washes per mile | x | x | Tucson Metro Bike Map |
| • Accessibility of Facilities | | | |
| o Population within ¼ mile | x | x | Updated GIS Map |
| o Activities within ¼ mile | x | x | Updated GIS Map |
| o Bicycle-miles traveled (VMT) per capita | x | x | PAG data collection |
| **Level of Use** | | | |
| • Bike Facility usage | | | |
| o Bicyclists per peak period | x | x | PAG bicycle count |
| **System Performance** | | | |
| • Facility completeness | | | |
| o % facility completeness | x | x | PAG data collection |
| • Level of Service | | | |
| o Travel speed | x | x | PAG data collection |

**Exhibit 33**
**RECOMMENDED PEDESTRIAN FACILITY PERFORMANCE MEASURES**

| Measure | System | Subarea | Primary Information Source |
|---|---|---|---|
| **System Size/Extent** | | | |
| • Sidewalks | | | |
| o Miles of sidewalks per 100,000 in population | x | | PAG Sidewalk Inventory |
| • Separate paths | | | |
| o Miles of separate paths per 100,000 in population | x | | PAG Facility Map |
| **Accessibility and Constraints** | | | |
| • Crossings of Streets and Washes | | | |
| o Crossings of Streets and Washes per mile | x | x | PAG GIS Map |
| • Accessibility of Facilities | | | |
| o Population within ¼ mile | x | x | Updated GIS Map |
| o Activities within ¼ mile | x | x | Updated GIS Map |
| o Person-miles traveled (PMT) per capita | x | x | PAG |
| **Level of Use** | | | |
| • Number of Pedestrians | | | |
| o Pedestrians per day | x | x | PAG data collection |
| **System Performance** | | | |
| • Facility completeness | | | |
| o % facility completeness | x | x | PAG data collection |
| • Level of Service | | | |
| o Travel speed | x | x | PAG data collection |

**Data Collection Requirements**

Information should be collected for each facility, route, or trip—depending upon the mode being evaluated—and aggregated to the subarea and system levels. For each alternative mode—fixed route transit, paratransit, bicycle, and pedestrian—GIS maps should be prepared annually depicting the current extents of the bus routes, paratransit service areas, and bicycle and pedestrian facilities. Attributes of these maps should include the following:

- Population density per square mile by census block
- Employment density per square mile by census block
- Fixed-route transit routes
- Park-and-ride lot locations and capacities
- Paratransit service areas
- Bike lane network
- Sidewalk network
- Multi-use path network

The vehicle-miles traveled (VMT) as well as the passenger miles traveled (PMT) for both fixed route and paratransit services should be computed annually at both the fixed bus route or paratransit trip levels and the system level. Numbers of bicyclists and pedestrians using specific facilities and the total networks should also be computed annually.

In-service logs should be kept for each vehicle to track the numbers of fixed-route buses in service on each route and systemwide, and the numbers of paratransit vehicles used each

day. Passengers using each fixed route should be counted daily; these counts can be used with vehicle data and mileage to compute revenue passenger miles and load factors. Arrival times at enroute time points and terminals should be recorded to enable computation of on-time performance. Passenger surveys should also be periodically conducted to record perceived levels of service, on-time performance and overall satisfaction.

**Mobility Index**

In addition to compiling the modal performance measures, PAG may want to consider developing a mobility index modeled on the City of Boulder Mobility Index illustrated in Exhibit 34. A mobility index would be developed as a composite of performance indices for the transit, bicycle, and pedestrian modes. Each performance index would indicate the level of performance of the respective mode ranging from low to high performance. For this, each index would rate how well each mode performs in regard to the performance measures listed in Tables 17 through 20. For example, a particular transit corridor with a low transit level of service would be assigned a low transit level of service. A composite mobility index would then be developed to indicate the overall performance of alternative modes within a corridor as well as regionwide. The mobility index would be used to relate the performance of alternative modes to corridor and regionwide congestion.

**Exhibit 34**
**CITY OF BOULDER CITYWIDE MOBILITY INDEX**


Source: City of Boulder

**Implementation Priority and Update Frequency**

Exhibits 35 through 38 provide the recommendations for the implementation priority the performance measures and the frequency for updating these measures. Measures indicated for immediate implementation and annual updates are based on data that is considered to be available from Sun Tran and other local agencies. In general, ridership levels and service levels should be reported annually, while measures based on changes in population or land use (things that do not change rapidly) should be updated less frequently.

**Exhibit 35**
**RECOMMENDED FIXED-ROUTE TRANSIT PERFORMANCE MEASURE PRIORITY**

| Measure | Application Priority | Update Data |
|---|---|---|
| **System Size/Extent** | | |
| • System Coverage | | |
| o Total route mileage | Immediate | Annually |
| o Population within ¼ mile of route | Immediate | Annually |
| o Vehicle-miles traveled (VMT) per capita | Immediate | Annually |
| o Passenger-miles traveled (PMT) per capita | Immediate | Annually |
| • Vehicles in Service | | |
| o Number of vehicles in service per day | Immediate | Annually |
| • Park-and-Ride Lots | | |
| o Number of Park-and-Ride spaces | Immediate | Annually |
| **Level of Use** | | |
| • Span of Service | | |
| o Hours of service per day | Short-term | Annually |
| o Vehicles per hour | Short-term | Annually |
| • Ridership | | |
| o Passengers carried during peak hour and daily | Short-term | Annually |
| o Passengers per revenue mile of service | Short-term | Annually |
| • Load Factor | | |
| o % design capacity (seats occupied plus standees) for peak hour and average day | Short-term | Annually |
| • Park-and-Ride usage | | |
| o % Park-and-Ride spaces occupied | Short-term | Every two years |
| **System Performance** | | |
| • Auto/Transit travel time ratio | | |
| o Door-to-door trip time | Short-term | Every two years |
| • On-time performance | | |
| o % trips on time | Short-term | Every two years |
| • Level of service | | |
| o Headway, min | Short-term | Every two years |
| o Vehicles per hour | Short-term | Every two years |

**Exhibit 36**
**RECOMMENDED PARATRANSIT PERFORMANCE MEASURE PRIORITY**

| Measure | Priority | Update Data |
|---|---|---|
| **System Size/Extent** | | |
| • System Coverage | | |
| o Total route mileage | Immediate | Annually |
| o Population within ¼ mile of route | Immediate | Annually |
| o Vehicle-miles traveled (VMT) per capita | Immediate | Annually |
| o Passenger-miles traveled (PMT) per capita | Immediate | Annually |
| • Vehicles in Service | | |
| o Number of vehicles in service per day | Immediate | Annually |
| **Level of Use** | | |
| • Span of Service | | |
| o Hours of service per day | Short-term | Annually |
| • Ridership | | |
| o Passengers carried during peak hour and daily | Short-term | Annually |
| o Passengers per revenue mile of service | Short-term | Annually |
| • Load Factor | | |
| o Passengers carried per trip | Short-term | Annually |
| **System Performance** | | |
| • Auto/Transit travel time ratio | | |
| o Door-to-door trip time | Short-term | Every two years |
| • Level of service | | |
| o Response time, min | Short-term | Every two years |
| • Dependability | | |
| o % trips arriving between 10 minutes before and 10 minutes after scheduled pickup time | Short-term | Every two years |
| • Appointment compliance | | |
| o % trips arriving at destination on time | Short-term | Every two years |
| • Will-call compliance | | |
| o % will-calls picked up within two hours of call | Short-term | Every two years |

**Exhibit 37**
**RECOMMENDED BICYCLE FACILITY PERFORMANCE MEASURES**

| Measure | Priority | Update Data |
|---|---|---|
| **System Size/Extent** | | |
| • Bike lanes | | |
| o Miles of bike lanes per 100,000 in population | Immediate | Annually |
| • Bike paths | | |
| o Miles of bike paths per 100,000 in population | Immediate | Annually |
| • Bicycle-suitable streets | | |
| o Miles of bicycle-suitable streets per 100,000 in population | Immediate | Annually |
| • Suitable shoulders | | |
| o Miles of suitable shoulders per 100,000 in population | Immediate | Annually |
| **Accessibility and Constraints** | | |
| • Crossings of Streets and Washes | | |
| o Crossings of Streets and Washes per mile | Long-term | Every three years |
| • Accessibility of Facilities | | |
| o Population within ¼ mile | Long-term | Every five years |
| o Activities within ¼ mile | Long-term | Every five years |
| o Vehicle-miles traveled (VMT) per capita | Long-term | Every five years |
| o Person-miles traveled (PMT) per capita | Long-term | Every five years |
| **Level of Use** | | |
| • Bike Facility usage | | |
| o Bicyclists per peak period | Short-term | Every three to five years |
| **System Performance** | | |
| • Facility completeness | | |
| o % facility completeness | Short-term | Every three to five years |
| • Level of Service | | |
| o Travel speed | Short-term | Every three to five years |

**Exhibit 38**
**RECOMMENDED PEDESTRIAN FACILITY PERFORMANCE MEASURES**

| Measure | Priority | Update Data |
|---|---|---|
| **System Size/Extent** | | |
| • Sidewalks | | |
| o Miles of sidewalks per 100,000 in population | Immediate | Annually |
| • Separate paths | | |
| o Miles of separate paths per 100,000 in population | Immediate | Annually |
| **Accessibility and Constraints** | | |
| • Crossings of Streets and Washes | | |
| o Crossings of Streets and Washes per mile | Long-term | Every five years |
| • Accessibility of Facilities | | |
| o Population within ¼ mile | Long-term | Every five years |
| o Activities within ¼ mile | Long-term | Every five years |
| o Person-miles traveled (PMT) per capita | Long-term | Every five years |
| **Level of Use** | | |
| • Number of Pedestrians | | |
| o Pedestrians per day | Short-term | Every three to five years |
| **System Performance** | | |
| • Facility completeness | | |
| o % facility completeness | Short-term | Every three to five years |
| • Level of Service | | |
| o Travel speed | Short-term | Every three to five years |

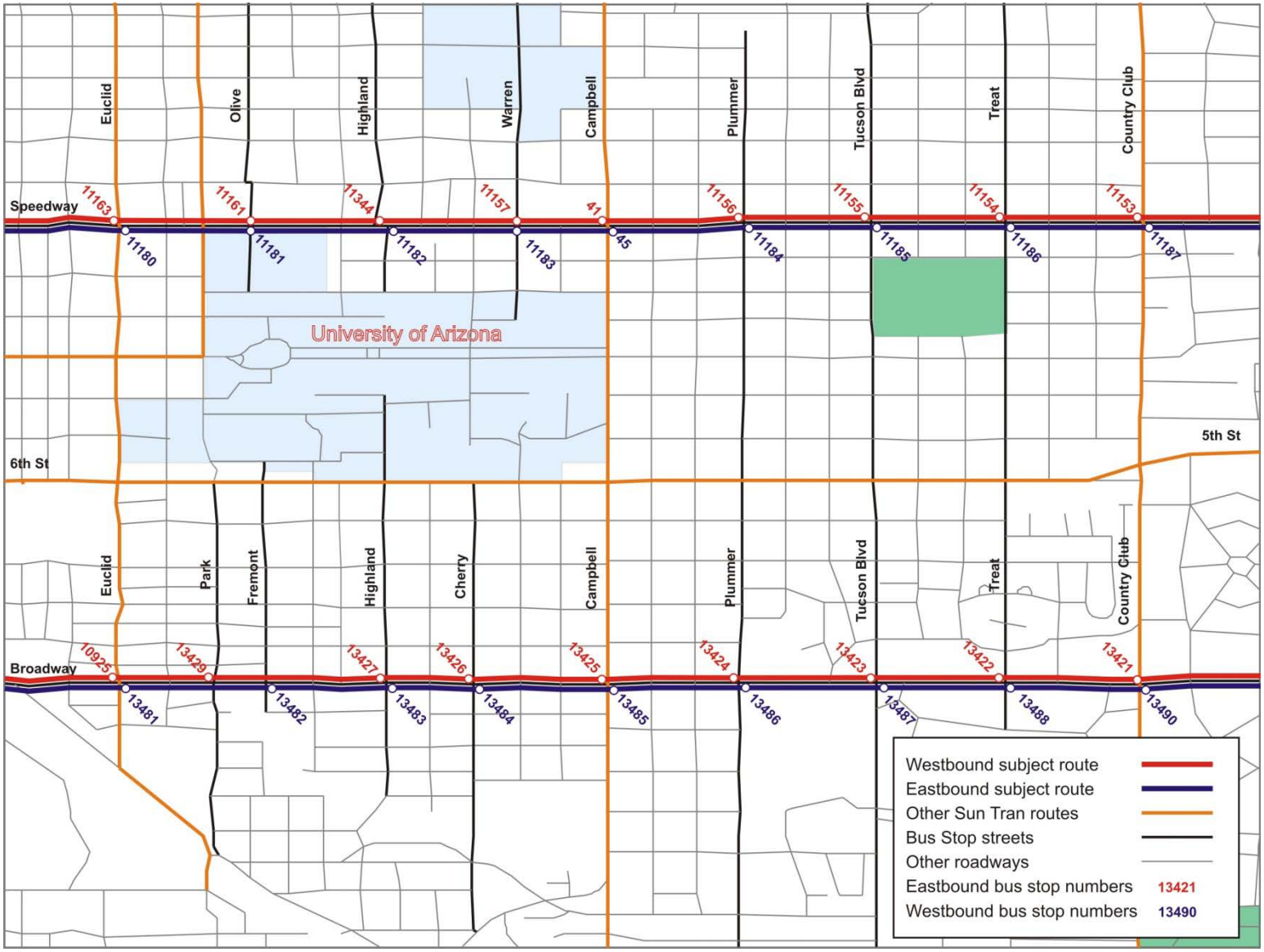
## TECHNIQUES FOR ANALYSIS OF TRANSIT / MULTIMODAL LEVEL OF SERVICE AND PERFORMANCE MEASURES

### Example Study Area and Data

An example study area in central Tucson was identified bounded by Euclid Avenue on the west, Speedway Boulevard on the north, Country Club Avenue on the east, and Broadway Boulevard on the south in order to provide a brief summary of techniques that could be used to demonstrate the use of the recommended transit and multimodal performance measures. Example analysis was provided for the segments of Sun Tran Route 4 – Speedway, and Route 8 – Broadway, operating through the study area. Exhibit 39 depicts the example study area. Note that in order to expedite the completion of this technical example, a GIS analysis of the study area was simulated using a base map of the area developed from TIGER GIS data overlaid with graphics. A system-wide analysis of similar data for all Sun Tran routes would properly be conducted entirely within the GIS application.

As Exhibit 39 shows, each of the bus stops would be a point identified by the bus stop number, and separate GIS layers would be developed for each route, by direction. These steps will facilitate the use of variable data to depict the changes in route performance and the interaction among connecting routes according to the time of day, day of the week, and so forth.

**Exhibit 39**
**SAMPLE STUDY AREA**



The following data were obtained from Sun Tran for Routes 4 and 8:

- Passengers per peak morning and afternoon periods
- Passengers per peak by direction
- Board/alight data by bus stop by route
- Average loads per trip by period

A sample analysis of these data is presented in the following section.

**Sample Area Analysis**

Sun Tran provided data for the following periods: AM Peak, Mid Peak, PM Peak, and Off-Peak. Here, the AM Peak, from 5:30 AM to 8:30 AM, and the PM Peak, from 2:30 PM to 5:30 PM, are analyzed. Data provided were for a weekday trip during November, 2009. Note that data were not obtained from all of the trips for each route during the two peak periods. Exhibit 40 summarizes the data gathering.

**Exhibit 40**
**SUMMARY OF DATA GATHERING FOR AM AND PM PEAK PERIODS**

| | Route 4 East | Route 4 West | Route 8 North | Route 8 South |
|---|---|---|---|---|
| Total AM Peak Trips Operated | 13 | 16 | 16 | 18 |
| Number checked for data provided | 13 | 16 | 10 | 10 |
| Total PM Peak Trips Operated | 18 | 18 | 36 | 36 |
| Number checked for data provided | 16 | 17 | 34 | 34 |

Source: Sun Tran, 2009.

Exhibits 41 and 42 present the performance data from Sun Tran for the AM Peak Period, and Exhibit 43 presents a GIS depiction of AM peak period data.

Exhibits 44 and 45 present the data for the PM peak period, and Exhibit 46 presents a GIS depiction of PM peak period data.

Analysis of this and other data presented graphically would facilitate operating decisions with respect to a number of parameters, including:

- Prioritization of future bus pull-out locations
- Location of shelters and other bus stop furniture
- Schedule adjustment to allow for dwell at heavily-used stops
- Route re-structuring or expanding
- Vehicle assignment based on seating and standee capacity

While this example represents an isolated look at short segments of two routes, a system-wide analysis of a similar nature would have more obvious value. GIS was used effectively to prioritize the locations of future bus bays or pull-outs in both Phoenix and Tempe. Systemwide analyses allow for the inclusion of more global concerns such as an equitable distribution of improvements among Council districts, as well as Title VI concerns that no specific population is inadvertently left underserved—with, for example, fewer bus shelters, overcrowded buses, or longer headways.

As Exhibit 43 shows, use of Route 4 through the study area during the AM Peak Period is much more directional than that of Route 8. Route 4 is much more used westbound than eastbound, whereas eastbound and westbound usage of Route 8 are roughly equivalent. If alightings had

been depicted in Exhibit 43 instead of boardings, the difference in usage of the two directions would be even more clearly defined.

Exhibit 46 shows that boardings in the study area—on both routes—are significantly heavier than boardings in Exhibit 43. The University area is a destination for faculty, staff, and students arriving from all directions in the morning and returning home in the evening. However, the average load per trip through the area is much heavier on Route 8 westbound than eastbound.

## Exhibit 41
## SEGMENT OF ROUTE 4 – SPEEDWAY - AM PEAK

| Stop Number | Speedway Eastbound at | On | Off | Average Load | Cumulative Load |
|---|---|---|---|---|---|
| 11180 | Euclid | 17 | 5 | 11 | 139 |
| 11181 | Olive Underpass | 9 | 8 | 11 | 140 |
| 11182 | Highland Underpass | 2 | 9 | 10 | 133 |
| 11183 | Warren Underpass | 2 | 9 | 10 | 126 |
| 45 | Campbell | 24 | 15 | 10 | 135 |
| 11184 | Plumer | 10 | 6 | 11 | 139 |
| 11185 | Tucson | 6 | 9 | 10 | 136 |
| 11186 | Treat | 3 | 2 | 11 | 137 |
| 11187 | Country Club | 19 | 15 | 11 | 141 |
| **Stop Number** | **Speedway Westbound at** | **On** | **Off** | **Average Load** | **Cumulative Load** |
| 11153 | Country Club | 35 | 33 | 23 | 371 |
| 11154 | Treat | 4 | 4 | 23 | 371 |
| 11155 | Tucson | 6 | 12 | 23 | 365 |
| 11156 | Plumer | 4 | 2 | 23 | 367 |
| 41 | Campbell | 27 | 45 | 22 | 349 |
| 11157 | Warren Underpass | 2 | 24 | 20 | 327 |
| 11344 | Highland Underpass | 1 | 42 | 18 | 286 |
| 11161 | Olive Underpass | 9 | 29 | 17 | 266 |
| 11163 | Euclid | 8 | 22 | 16 | 252 |

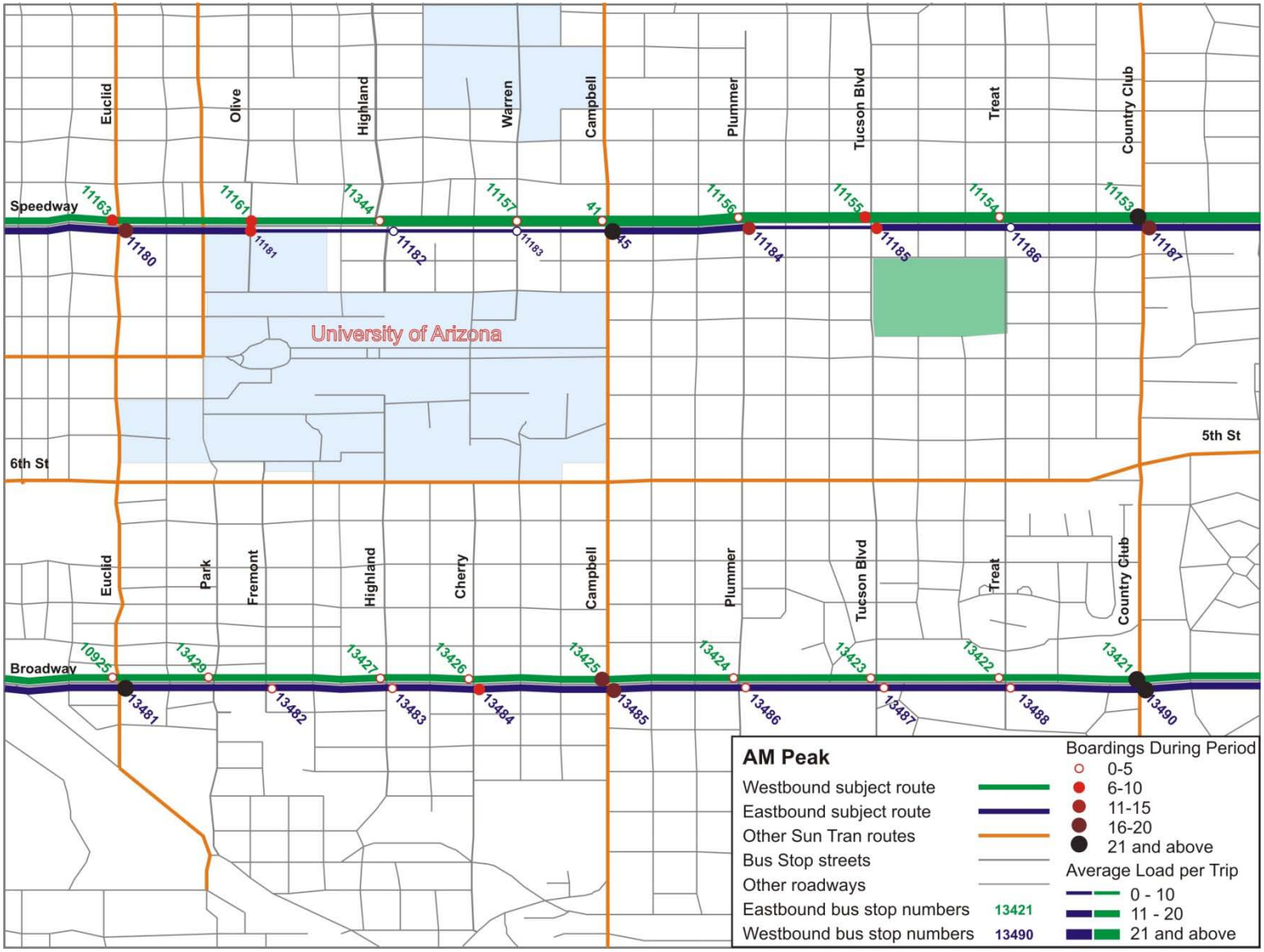
Source: Sun Tran, 2009.

## Exhibit 42
## SEGMENT OF ROUTE 8 – BROADWAY - AM PEAK

| Stop Number | Broadway Eastbound at | On | Off | Average Load | Cumulative Load |
|---|---|---|---|---|---|
| 13481 | Euclid | 25 | 13 | 18 | 182 |
| 13482 | Fremont | 4 | 9 | 18 | 177 |
| 13483 | Highland | 1 | 10 | 17 | 168 |
| 13484 | Cherry | 6 | 5 | 17 | 169 |
| 13485 | Campbell | 19 | 19 | 17 | 169 |
| 13486 | Plumer | 2 | 10 | 16 | 161 |
| 13487 | Tucson | 1 | 21 | 14 | 141 |
| 13488 | Treat | 1 | 9 | 13 | 133 |
| 13490 | Country Club | 24 | 6 | 15 | 151 |
| **Stop Number** | **Broadway Westbound at** | **On** | **Off** | **Average Load** | **Cumulative Load** |
| 13421 | Country Club | 20 | 5 | 18 | 184 |
| 13422 | Treat | 3 | 3 | 18 | 184 |
| 13423 | Tucson | 5 | 12 | 18 | 177 |
| 13424 | Plumer | 2 | 12 | 17 | 167 |
| 13425 | Campbell | 19 | 11 | 18 | 175 |
| 13426 | Cherry | 5 | 8 | 17 | 172 |
| 13427 | Highland | 3 | 4 | 17 | 171 |
| 13428 | Fremont | 1 | 2 | 17 | 170 |
| 13429 | Park Av | 5 | 16 | 16 | 159 |
| 10925 | Euclid | 1 | 22 | 14 | 138 |

Source: Sun Tran, 2009

**Exhibit 43**
**AM PEAK PERIOD ANALYSIS**



## Exhibit 44
## SEGMENT OF ROUTE 4 – SPEEDWAY - PM PEAK

| Stop Number | Speedway Eastbound at | On | Off | Average Load | Cumulative Load |
|---|---|---|---|---|---|
| 11180 | Euclid | 24 | 10 | 17 | 271 |
| 11181 | Olive Underpass | 37 | 1 | 19 | 307 |
| 11182 | Highland Underpass | 51 | 4 | 22 | 354 |
| 11183 | Warren Underpass | 18 | 3 | 23 | 369 |
| 45 | Campbell* | 48 | 25 | 25 | 392 |
| 11184 | Plumer | 5 | 3 | 25 | 394 |
| 11185 | Tucson | 26 | 11 | 26 | 409 |
| 11186 | Treat | 9 | 5 | 26 | 413 |
| 11187 | Country Club | 29 | 38 | 25 | 404 |
| **Stop Number** | **Speedway Westbound at** | **On** | **Off** | **Average Load** | **Cumulative Load** |
| 11153 | Country Club | 19 | 22 | 14 | 239 |
| 11154 | Treat | 6 | 4 | 14 | 241 |
| 11155 | Tucson | 13 | 7 | 15 | 247 |
| 11156 | Plumer | 3 | 2 | 15 | 248 |
| 41 | Campbell* | 25 | 28 | 14 | 245 |
| 11157 | Warren Underpass | 17 | 11 | 15 | 251 |
| 11344 | Highland Underpass | 9 | 14 | 14 | 246 |
| 11161 | Olive Underpass | 5 | 7 | 14 | 244 |
| 11163 | Euclid | 5 | 19 | 14 | 230 |

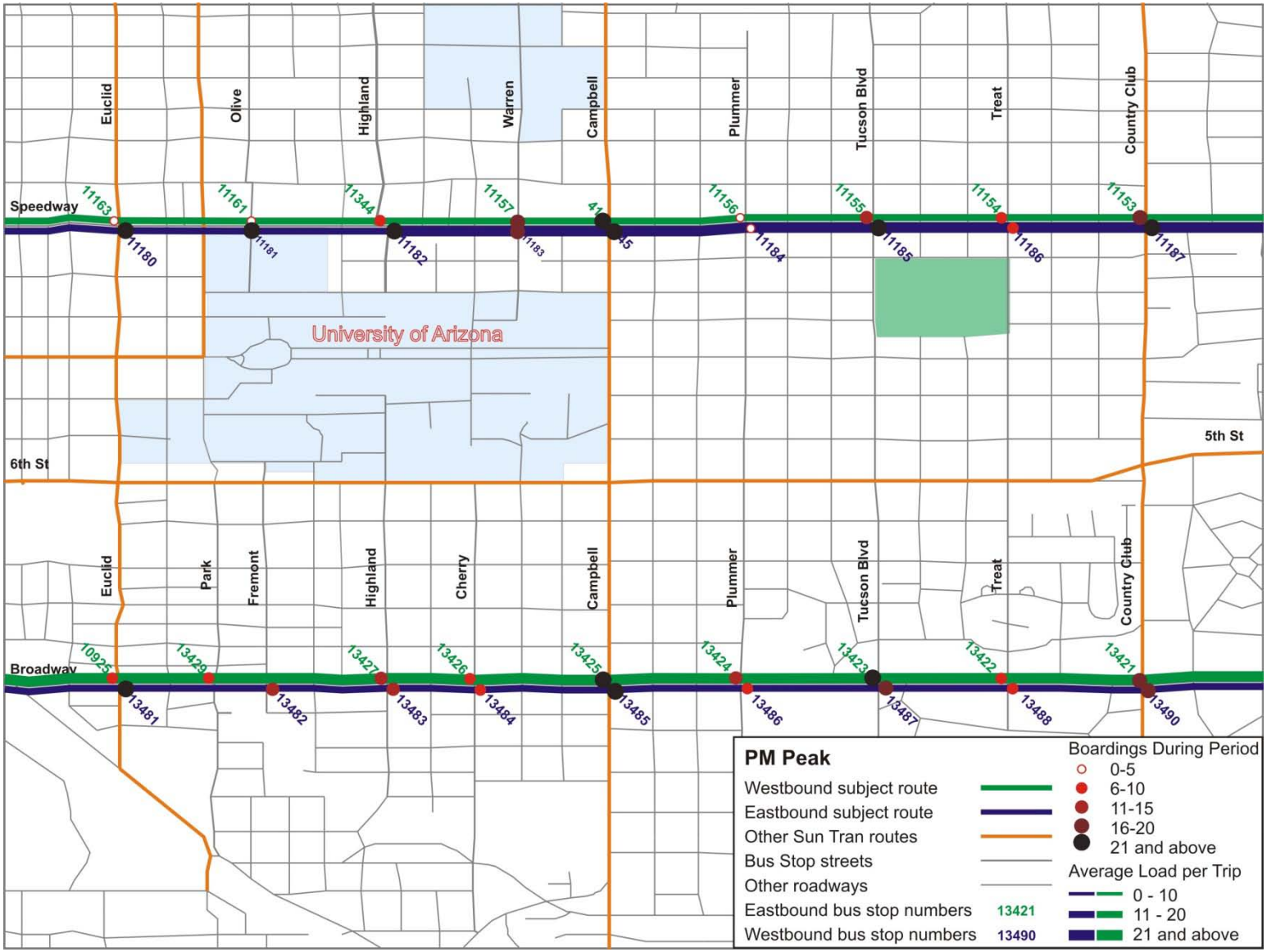
Source: Sun Tran

## Exhibit 45
## SEGMENT OF ROUTE 8 – BROADWAY - PM PEAK

| Stop Number | Broadway Eastbound at | On | Off | Average Load | Cumulative Load |
|---|---|---|---|---|---|
| 13481 | Euclid | 58 | 17 | 17 | 340 |
| 13482 | Fremont | 13 | 7 | 17 | 346 |
| 13483 | Highland | 11 | 10 | 17 | 347 |
| 13484 | Cherry | 9 | 8 | 17 | 348 |
| 13485 | Campbell* | 40 | 37 | 18 | 351 |
| 13486 | Plumer | 8 | 7 | 18 | 352 |
| 13487 | Tucson | 16 | 13 | 18 | 355 |
| 13488 | Treat | 7 | 8 | 18 | 354 |
| 13490 | Country Club | 19 | 27 | 17 | 346 |
| **Stop Number** | **Broadway Westbound** at | **On** | **Off** | **Average Load** | **Cumulative Load** |
| 13421 | Country Club | 16 | 29 | 20 | 375 |
| 13422 | Treat | 10 | 5 | 20 | 380 |
| 13423 | Tucson | 26 | 13 | 21 | 393 |
| 13424 | Plumer | 12 | 18 | 20 | 387 |
| 13425 | Campbell* | 30 | 33 | 20 | 384 |
| 13426 | Cherry | 6 | 6 | 20 | 384 |
| 13427 | Highland | 14 | 3 | 21 | 395 |
| 13428 | Fremont | 5 | 5 | 21 | 395 |
| 13429 | Park Av | 6 | 8 | 21 | 393 |
| 10925 | Euclid | 9 | 22 | 20 | 380 |

Source: Sun Tran

**Exhibit 46**
**PM PEAK PERIOD ANALYSIS**



### Other Opportunities for Graphical Analysis

Exhibit 30 presents the fixed-route transit performance measures. Two of these are "Population within ¼ mile of the route" and "Headway." A map that depicted the population densities with shaded polygons—with darker shading representing more densely-populated corridors—and average route headways—with routes having shorter headways depicted with heavier lines—would show at a glance areas of the metropolitan area that are comparatively underserved.

Similar techniques could be used to determine, for example, whether adequate bike racks are provided on board buses and at key stops, or whether the needs of mobility-limited patrons of a particular route are being adequately addressed. These, however, would require the gathering of additional data.

## PERFORMANCE MEASURES, REGIONAL GOALS, AND CMP OBJECTIVES

Exhibit 47 shows how the recommended performance measures align with the established regional 2040 RTP goals and the stated objectives for the PAG CMP. The recommended performance measures relate directly back to the PAG 2040 RTP goals and will provide a mechanism for measuring the achievement of these goals in the future.

## Exhibit 47
## PERFORMANCE MEASURES, PAG REGIONAL GOALS, AND CMP OBJECTIVES

| 2040 RTP Goals for the System: | CMP Objectives | System Performance Measures |
|---|---|---|
| **Expand Regional Multi-Modal Choices** | Increase the use of alternate transportation modes (walking, bicycling, transit, carpool, and vanpool) to reduce congestion on roadways.<br>• Improve or sustain transit system performance to help reduce congestion.<br>• Improve the quality, quantity, accessibility and use of multi-modal traveler information services.<br>• Provide modal options. | • Auto / Transit travel time ratio.<br>• Transit on time performance.<br>• Transit level of service.<br>• Alternate mode usage total and per capita.<br>• Percent of bicycle facility completeness.<br>• Bicycle travel speed at selected locations.<br>• Percent of pedestrian facility completeness.<br>• Traveler information service improvements.<br>• Trends in traveler mode choice. |
| **Integrate Transportation Choices** | Maximize the efficiency of the interface between transportation modes.<br>• Reduce congestion and improve safety at railroad crossings.<br>• Improve the efficiency of transit boarding.<br>• Improve the efficiency of freight transfer. | • Transit system size/availability.<br>• Additional traffic delay due to railroad crossings.<br>• Crashes per year at railroad crossings.<br>• Commodity flows from, to, within and through the region by mode. |
| **Promote Sustainable Land Use** | Promote programs and land use planning that advance efficient trip-making.<br>• Coordinate corridor and land use strategies.<br>• Coordinate regional transportation systems and land use planning. | • New mixed use and transit oriented development.<br>• Access management activities. |
| **Foster a Vibrant Economic** | Make transportation investment decisions that use public resources effectively and efficiently, using performance based planning. | • Most CMP performance measures. |
| **Enhance Safety** | Improve traveler safety through efficient system operations.<br>• Reduce crashes consistent with the Arizona Strategic Highway Safety Plan reduction goals.<br>• Reduce the regional annual crash rate and fatal crash rate below the national average rates.<br>• Reduce the number of secondary incidents/crashes at incident scenes and work zones.<br>• Reduce the number of crashes involving bicyclists or pedestrians.<br>• Improve safety at railroad crossings. | • Number of crashes / year by crash type.<br>• Number of fatal crashes / year.<br>• Number of injury crashes / year.<br>• Crash rate.<br>• Fatality rate.<br>• Crashes per year at railroad crossings. |
| **Foster Environmental Stewardship** | Make transportation decisions that are compatible with air quality conformity.<br>• Reduce per capita fuel consumption.<br>• Reduce vehicle emissions. | • Number of employers with a trip reduction program.<br>• Number of registered carpool, vanpool, and alternative mode commuters.<br>• Estimated CO (tailpipe) NOx, and VOC levels with and without TIP projects.<br>• CMP initiative level reflected in TIP and RTP.<br>• VMT per capita. |
| **Increase Accessibility** | Address the needs of population groups with special transportation needs.<br>• Reduce congestion for special transportation needs population groups.<br>• Improve paratransit system performance to help reduce congestion. | • Transit System Coverage including paratransit system.<br>• Percent of pedestrian facility completeness.<br>• Accessibility of pedestrian facilities. |
| **Optimize Transportation System Performance** | Provide reasonable and reliable travel time and level of service on transportation systems.<br>• Improve traffic signal timing, coordination and management across all jurisdictional boundaries.<br>• Improve work zone management to reduce event duration and traveler delay.<br>• Improve incident management to reduce incident duration and traveler delay.<br>• Maintain congestion levels for major arterials.<br>• Maintain delay per traveler not to exceed 40 percent of the free flow travel time. | • Recurring delay.<br>• V/C, LOS or congestion category (map).<br>• Lane miles by LOS E or worse.<br>• Delay as a percent of total travel time.<br>• Number of Intersections at LOS E or worse.<br>• Most congested locations (top 10 – 20).<br>• Locations where signal timing improvements may be beneficial.<br>• Travel time or speed estimates.<br>• Average incident clearance time.<br>• Person throughput.<br>• Daily VHT per capita.<br>• Number of traffic signals retimed.<br>• Auto / Transit travel time ratio. |

# 4. PERFORMANCE MONITORING AND INFORMATION DISSEMINATION

## PERFORMANCE MONITORING ACTIVITIES

An important element of the Congestion Management Process is the analysis and reporting of the transportation system performance. This analysis and reporting represents the culmination of the periodic system monitoring based on the selected performance measures and provides the mechanism to disseminate information on system performance to decision makers and the public. The analysis and reporting helps to facilitate decisions on the direction the region should be taking to manage congestion by providing basic information on the extent and magnitude of congestion and by providing information on the effectiveness of previously implemented congestion management strategies.

The measures used to monitor system performance have been grouped into several categories for both roadway and transit/alternative mode application. These general categories are the following:

- Roadway System and Transit/Alternative Modes
  - System size/extent measures (measure of system supply and availability).
  - Level of use measures (demand measures)
  - System performance measures
    - Roadway congestion measures
    - Safety and crash data measures
    - System integration measures (air quality, and rideshare measures)
- Transit/Alternative Modes
  - Accessibility and constraints (factors affecting the use of the systems)

System performance and change should be monitored on a regular basis. For practical reasons some measures should be monitored annually, while others may only need to be evaluated and reported perhaps every five years. In general, the measures relating to system size and extent should be monitored on an annual basis as these measures indicate where transportation system improvements or changes in service have been made. It is much easier to track and document the accomplishments of the past year, rather than trying to accumulate these data for a longer period. Field data collection, such as traffic counts, can be proportioned over several years so that over time all of the data are updated, but the data collection during any single year is manageable and affordable.

Transportation system performance and level of use measures should be completely updated and compared about every five years as it generally takes some time for system use and performance to change in response to population and traffic growth. For the specific locations where system improvements have been implemented (e.g., new general purpose lanes added, new turn lanes at signalized intersections, transit service extensions, etc.) the system performance and level of use measures should be updated during the year when the data needed for the assessment becomes available, which should then be included in the annual update.

The activity flow diagrams provided in Exhibits 48 and 49 provide general guidelines on the activities to be conducted annually and every five years to monitor system performance and report the results of this process. Exhibit 48 presents the activity flow for the roadway system assessment, and Exhibit 49 presents the activity flow for the transit and alternative mode assessment.

**Exhibit 48**
**CMP ROADWAY SYSTEM PERFORMANCE ASSESSMENT ACTIVITIES**

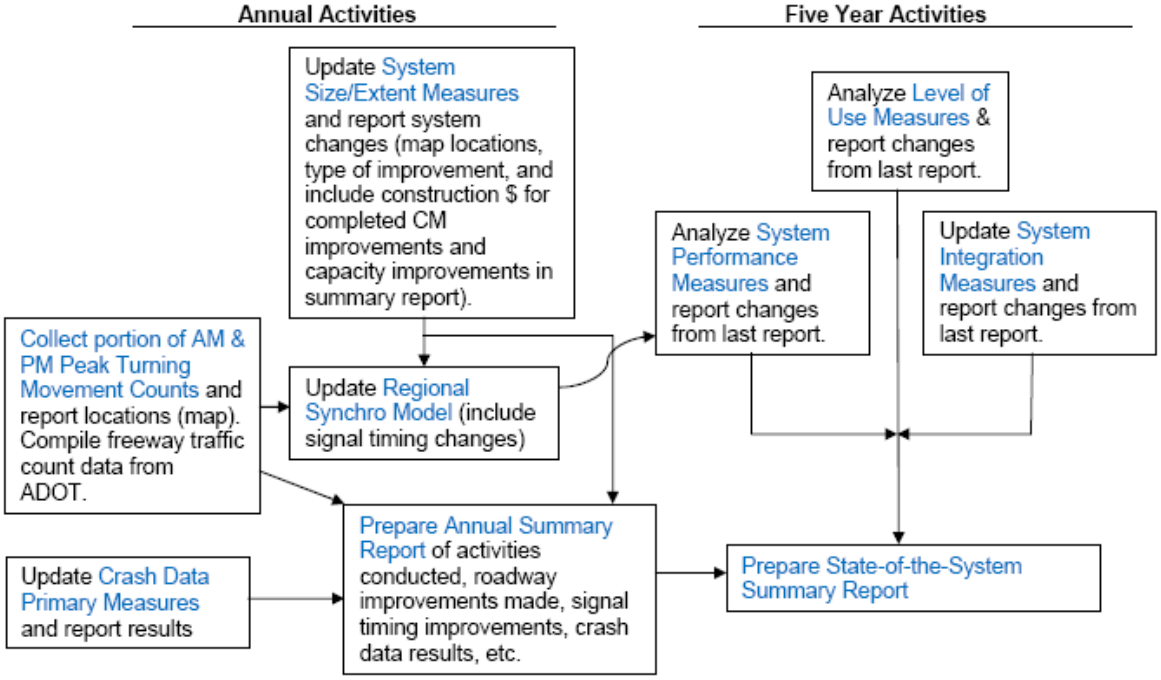
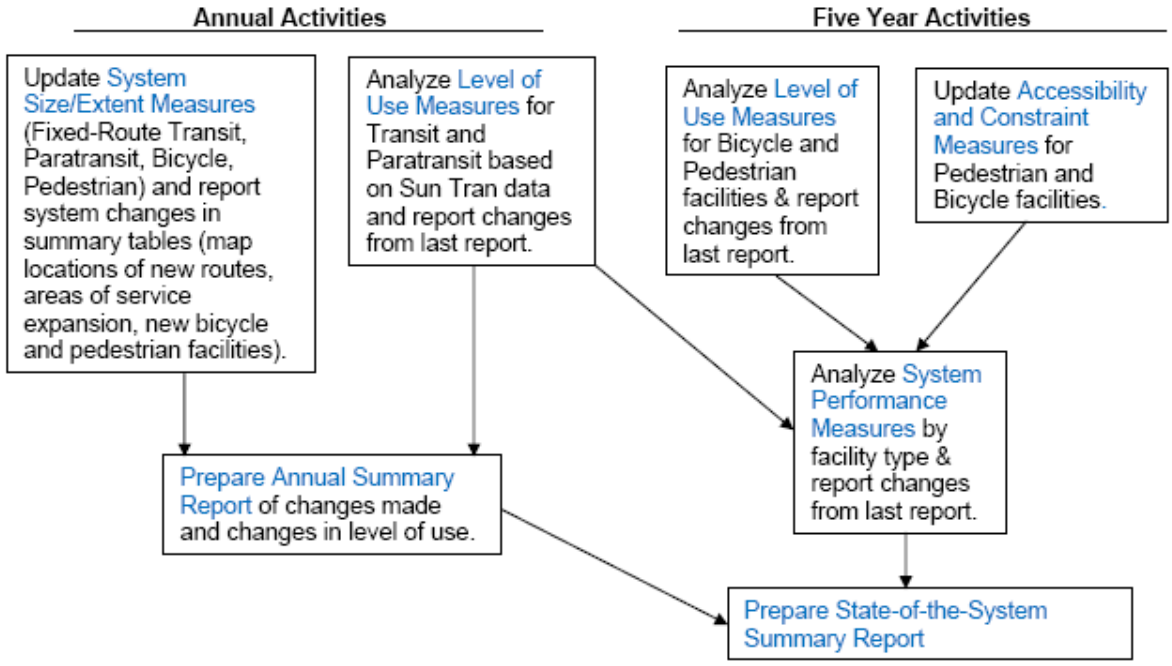



**Exhibit 49**
**CMP TRANSIT/ALTERNATIVE MODE PERFORMANCE ASSESSMENT ACTIVITIES**



The concept is to conduct some data collection, monitoring, and reporting on an annual basis so that the requirements for any single year are manageable. The product from the annual activities is envisioned as a brief summary report identifying what has changed about the transportation system over the last year, a report of what the region has accomplished and how much has been spent to do it.

The information collected and reported from the annual activities are then aggregated and reported in a five year assessment of transportation system performance, a "State-of-the-System Report". The State-of-the-System report would document transportation system changes and improvements, changes in level of usage, performance and improvement cost for the past five-year period. This information would then be compared to the prior five-year periods to provide an indication of how the system performance is changing over time, and measure how well system improvements and congestion management measures are performing. It is envisioned that this product of the CMP would be used to assist in decision making regarding future directions for transportation system improvements and congestion management strategies.

Additional detail on the steps required to perform the activities summarized in Exhibits 48 and 49 is provided in Exhibits 50, 51, 52, and 53. Exhibits 50 and 51 provide the steps required for the roadway system performance assessment, and Exhibits 52 and 53 provide the steps required for the transit/alternative mode assessment.

**It should be noted that the activities summarized in Exhibits 50, 51, 52, and 53 represent guidelines for the congestion management process assessment and reporting. These guidelines should be modified as needed to more accurately reflect how these activities actually take place once PAG has implemented the basic process, collected data, and prepared the annual summary reports and the five-year State-of-the-System Report**.

Over time, this assessment process will undoubtedly change as new technologies emerge that replace the recommended data collection and analysis procedures, and the performance measures are modified to reflect the availability of new data. The lists of activities contained in these exhibits should be periodically updated by PAG to reflect the changes in the process and to maintain consistency in the procedures in the future as new staff take over the continuation of the process.

Exhibits 50 through 53 also provide an estimate of the PAG staff hours needed to implement and maintain the congestion management assessment process annually and for the five-year summary and reporting. This process will require that a single PAG staff member be assigned the lead responsibility for implementation. It is estimated that this could be at least a half-time responsibility for this lead staff member for the first year when the activity procedures will need to be fully developed for the first time and documented so they can be systematically repeated in subsequent years. The initial development of the State-of-the-System report will take additional time for the lead staff member during year five. The lead staff person will also need technical support from PAG staff for GIS mapping, data collection, and data analysis.

In addition to PAG staff requirements, it is also estimated that approximately $88,000 to $103,000 may be required for data collection and other assistance to get the process up and running. Approximately $41,000 to $56,000 of this is estimated to be required annually for traffic data collection and maintaining the regional Synchro model for congestion analysis.

**Exhibit 50**
**ANNUAL ROADWAY SYSTEM PERFORMANCE ASSESSMENT ACTIVITIES**

| Annual Activities | Responsibility | Annual Hours or Cost to Complete |
|---|---|---|
| **Activities to Evaluate System Size / Extent** | | |
| • **System Data Collection** | | |
| Compute lane miles by facility type/functional class (freeway, major arterial, minor arterial) | PAG Staff | 20 hours |
| Inventory signalized intersections with GIS map (completed for 2009 as part of the Regional Synchro Model Development). Update new traffic signals as they are added. Update signal locations map each year. | PAG Staff | 20 hours |
| Inventory HAWK / other pedestrian / bike signals (completed for 2009 as part of the Regional Synchro Model Development). Update new installations as they are added. Update locations map each year. | PAG Staff | 20 hours |
| Update lane- miles of roadway as new facilities are added. Map network additions each year. | PAG Staff | 20 hours |
| Inventory facilities providing intermodal connections with map. Update as new facilities are added (park-and-ride lots, transit centers, shuttle system/fixed route connections). | PAG Staff | 20 hours |
| Acquire data from jurisdictions on actual construction cost of completed roadway system improvements. Inventory these data and prepare summary of dollars spent by improvement type (intersection improvements, safety, improvements, capacity improvements, etc.). | PAG Staff | 40 hours |
| **Activities to Measure Level of Use** | | |
| • **Traffic Data Collection** | | |
| Establish standardized traffic data format for AM and PM peak-period traffic counts (one time activity). | PAG Staff | 20 hours |
| Identify locations for turning movement counts (20-30% of total signalized intersections). | PAG Staff | 8 hours |
| Identify locations for 24-hour traffic counts (freeway segments). Coordinate with ADOT to determine whether these counts might be provided through existing permanent count stations or other ITS installations along I-10 and I-19 within the PAG region. | PAG Staff | 4 hours |
| Conduct traffic counts (consultant services required). | Consultant | $30 – 40K |
| Inventory and quality control traffic count data. | PAG Staff | 20 hours |
| Organize and store traffic count data. | PAG Staff | 20 hours |
| Establish agreements with local jurisdictions to provide turning movements counts collected at signalized intersections as part of traffic impact studies for new development (one time activity). | PAG Staff | 40 hours |
| Inventory and quality control traffic count data provided by local jurisdictions. | PAG Staff | 20 hours |
| **System Performance Assessment Activities** | | |
| • **Crash Data Inventory Safety Assessment** | | |
| Establish standardized format for local jurisdiction reporting crash data (one time activity). The use of data from the state ALISS system may be an option, if these data are current and easily accessible. | PAG Staff | 40 hours |
| Establish agreements with local jurisdictions and procedures for data acquisition (one time activity). | PAG Staff | 40 hours |
| Inventory and quality control crash data provided by local jurisdictions. | PAG Staff | 40 hours |
| Prepare summary tables and exhibits displaying regional crash data. | PAG Staff | 80 hours |

**Exhibit 50 (continued)**
**ANNUAL ROADWAY SYSTEM PERFORMANCE ASSESSMENT ACTIVITIES**

| Annual Activities | Responsibility | Annual Hours or Cost to Complete |
|---|---|---|
| • **Update Regional Synchro Model** | | |
| Contact local jurisdictions for the following information:<br>- Roadway/intersection geometry changes.<br>- Traffic signal timing and/or phasing changes for AM and PM peak-hours.<br>- Location of new traffic signals, with roadway/intersection geometry, and signal timing/phasing information for AM and PM peak-hours. | Consultant | $2 - 3K |
| Enter new intersection turning movement counts for AM and PM peak-hours. | Consultant | $3 - 4K |
| Execute Synchro with new data to insure proper execution of the model. | Consultant | $2 - 3K |
| Prepare updates of summary reports and maps for locations and extent of intersection and arterial roadway congestion using new data. | Consultant | $4 – 6K |
| • **System Integration** | | |
| Estimate the number of employees in the Travel Reduction Program | PAG Staff | 2 hours |
| Estimate the number of registered carpool, vanpool, and alternate mode commuters. | PAG Staff | 2 hours |
| **Prepare Annual Summary Report** | | |
| Summarize the data collected and activities completed from the Annual Activities in the form of tables, charts, and maps and report this information in a brief Annual Report documenting the work completed and the results. This report could contain the following information:<br>• Total lane miles of roadway by facility type within the region on the CMP network.<br>• New lane miles of roadway added during the year and location on a map.<br>• Number of new traffic signals added and locations on a map.<br>• New intermodal facilities added and locations on a map.<br>• Construction dollars spent on the roadway system and intermodal facility improvements cited.<br>• Locations where new turning movement count and 24-hour count data were collected.<br>• Trends in traffic volume based on the traffic count data collected via a comparison of new data to previous data.<br>• Summary of crash data in tabular format with comparison to previous year and analysis of crash trends.<br>• Summary regional congestion measures and reports from Synchro model with updated map is desired (this may not change much from one year to the next, so the mapping may only need to be conducting every 3 to 5 years instead). | PAG Staff | 160 - 200 hours |
| **Total PAG Staff Hours for Annual CMP Activities** | PAG Staff | 636 – 676 hours |
| **Total Consultant Fees for Annual CMP Activities** | Consultant | $41 – 56K |
| | | |

**Exhibit 51**
**FIVE-YEAR ROADWAY SYSTEM PERFORMANCE ASSESSMENT ACTIVITIES**

| Five Year Activities (note that these activities are in addition to the Annual Activities) | Responsibility | Hours or Cost to Complete |
|---|---|---|
| **Activities to Evaluate System Size / Extent** | | |
| Estimate lanes miles per capita of CMP network by facility type (freeway, major arterial, minor arterial). This would be conducted after the update of the regional population database. | PAG Staff | 4 hours |
| Summarize and compare data from annual activities for the past five years. Provide a 5-year summary of system growth and change. | PAG Staff | 20 hours |
| **Activities to Measure Level of Use** | | |
| Estimate daily VMT and daily VMT/person based on regional traffic model estimate of daily VMT. | PAG Staff | 1 hour |
| Define a representative sample of CMP roadway segments for traffic volume comparisons (one time activity). | PAG Staff | 1 hour |
| Report average daily traffic counts and peak-hour volume counts for the sample of CMP roadway segments. | PAG Staff | 10 hours |
| Define a representative sample of signalized intersections on the CMP network for traffic volume comparisons (one time activity). | PAG Staff | 1 hour |
| Compute intersection daily entering volumes for sample of CMP intersections based on traffic count data. Provide comparison to estimates from previous years to assess traffic growth. | PAG Staff | 10 hours |
| Compute intersection AM and PM peak-hour entering traffic for sample of CMP intersections based on traffic data. Provide comparison to estimates from previous years to assess traffic growth. | PAG Staff | 2 hours |
| Define regional screenlines for use in comparing regional traffic and person through-put (one time activity). | PAG Staff | 1 hour |
| Compute typical daily through-put of traffic and persons crossing the screenlines (1.2 X Average Daily Traffic + transit ridership). This would include estimates of daily transit riders crossing the screen lines. Provide comparison to estimates from previous years to assess traffic growth. | PAG Staff | 20 hours |
| Compute AM and PM peak-hour through-put of traffic and persons crossing the screenlines. This would include estimates of peak-hour transit riders crossing the screen lines. Provide comparison to estimates from previous years to assess traffic growth. | PAG Staff | 4 hours |
| Summarize and compare data from annual activities for the past five years. Provide a 5-year summary of growth and change in system use. | PAG Staff | 40 hours |
| **System Performance Assessment Activities** | | |
| Update AM and PM peak-hour congestion category map (roadways and intersections) based on Synchro model output. | PAG Staff | 20 hours |
| Compute lane-miles or centerline miles of roadway by congestion category during AM and PM peak-hours based on Synchro model output. | Consultant | $2K |
| Update the number of signalized intersections by congestion category during the AM and PM peak-hours based on Synchro model output. | Consultant | $1K |
| Update roadway delay as percentage of travel time map for the AM and PM peak-hours using Synchro model output. | Consultant | $2K |
| Compute total hours of signalized intersection delay for the AM and PM peak-hours from the Synchro model output. | Consultant | $2K |
| Compare changes in system performance over the past 5-year period. | PAG Staff | 20 hours |
| Use TransView and Southern Traffic Operations Center capabilities to map annual traffic incident locations and compute average incident clearance time for non-recurring congestion. | PAG Staff | 40 hours |

**Exhibit 51 (continued)**
**FIVE-YEAR ROADWAY SYSTEM PERFORMANCE ASSESSMENT ACTIVITIES**

| Five Year Activities (note that these activities are in addition to the Annual Activities) | Responsibility | Hours or Cost to Complete |
|---|---|---|
| Evaluate other system performance measures as needed or desired. | PAG Staff | 40 hours |
| Compare regional crash trends and crash rates for the last 5-year period. | PAG Staff | 8 hours |
| Compare System Integration trends over the last 5-year period including air quality trends. | PAG Staff | 8 hours |
| **Prepare 5-Year State of the System Summary Report (this report replaces the Annual Summary in year 5)** | | |
| This report would provide summary tables and graphics indicating the existing conditions and how conditions have changed over the past 5-year period. This would include:<br>• System Size / Extent<br>• Level of Use<br>• System Performance | PAG Staff | 80 hours |
| **Total PAG Staff Hours for 5-Year CMP Activities** | PAG Staff | 330 hours |
| **Total Consultant Fees for 5-Year CMP Activities** | Consultant | $7K |
| | | |

**Exhibit 52**
**ANNUAL TRANSIT/ALTERNATIVE MODE SYSTEMS PERFORMANCE ASSESSMENT ACTIVITIES**

| Annual Activities | Responsibility | Annual Hours or Cost to Complete |
|---|---|---|
| **Activities to Evaluate System Size / Extent** | | |
| • **Fixed Route Transit & Paratransit Services (separately)** | | |
| Identify changes in route mileage over the past year. | PAG Staff | 10 hours |
| Update GIS map of route structure | PAG Staff | 12 hours |
| Estimate population with ¼-mile of a route (from GIS map) | PAG Staff | 20 hours |
| Update annual vehicles-miles traveled per capita | PAG Staff | 4 hours |
| Update annual passenger-miles traveled per capita | PAG Staff | 4 hours |
| Update number of vehicles in service per day (weekdays) | PAG Staff | 4 hours |
| Span of Service: Update hours of service and vehicles per hour | PAG Staff | 4 hours |
| • **Bicycle and Pedestrian Facilities** | | |
| Update the miles of bike-lanes, bike paths, bike suitable streets, and suitable shoulders available. | PAG Staff | 8 hours |
| Update the miles of sidewalks and separate paths available. | PAG Staff | 8 hours |
| **Activities to Measure Level of Use** | | |
| • **Fixed Route Transit & Paratransit Services (separately)** | | |
| Ridership: Update daily and peak-hour passengers carried. Update passengers per revenue mile of service. | PAG Staff | 8 hours |
| Load Factor: Update average/typical load factors | PAG Staff | 8 hours |
| **Prepare Annual Summary Report** | | |
| Summarize the data collected and activities completed from the Annual Activities in the form of tables, charts, and maps and report this information is a brief Annual Report documenting the work completed and the results. This report could contain the following information:<br>• Location of new transit routes or extension of existing routes or areas of service.<br>• Changes in the number of vehicles in service on a typical day.<br>• Changes in the daily vehicle hours of service.<br>• Changes in the level of population served.<br>• Changes in peak-period number of vehicles in service by route.<br>• New miles of bike and pedestrian facilities. | PAG Staff | 80 hours |
| **Total PAG Staff Hours for Annual CMP Activities** | PAG Staff | 112 hours |
| | | |

**Exhibit 53**
**FIVE-YEAR TRANSIT/ALTERNATIVE MODE SYSTEM PERFORMANCE ASSESSMENT ACTIVITIES**

| Five Year Activities (note that these activities are in addition to the Annual Activities) | Responsibility | Hours or Cost to Complete |
|---|---|---|
| **Activities to Assess System Size and Extent** | | |
| Prepare five-year summary and comparison of transit system size and extent measures based on annual data collection. | PAG Staff | 20 hours |
| Prepare five-year summary and comparison of bicycle system size and extent measures based on annual data collection. | PAG Staff | 20 hours |
| Prepare five-year summary and comparison of pedestrian system size and extent measures based on annual data collection. | PAG Staff | 20 hours |
| **Activities to Measure Level of Use** | | |
| Identify sample of locations for bicycle counts and conduct counts. Update counts every five years and compare to prior counts. | Consultant | $10K |
| Identify sample of locations for pedestrian counts and conduct counts. Update counts every five years and compare to prior counts. | Consultant | $10K |
| Prepare five- year summary and comparison of transit system level of use based on annual data collection and summary. | PAG Staff | 20 hours |
| **Activities to Assess Accessibility and Constraints** | PAG Staff | |
| Identify constraints to bicycle use: crossings of streets and washes per mile. | PAG Staff | 20 hours |
| Evaluate accessibility of bicycle facilities:<br>• Population within ¼ mile.<br>• Activities with ¼ mile.<br>• VMT per capita<br>• PMT per capita | PAG Staff | 40 hours |
| Identify constraints to walking: crossings of streets and washes per mile, ADA compliance (e.g., lack of corner curb cuts, lack of sidewalks, blockage of sidewalks from utilities, street furniture, etc.) for a sample of locations in the region. | Consultant | $20K |
| Evaluate accessibility of pedestrian facilities:<br>• Population within ¼ mile.<br>• Activities with ¼ mile.<br>• PMT per capita | PAG Staff | 20 hours |
| Summarize and compare data from annual activities for the past five years. Provide a 5-year summary of growth and change in system use. | PAG Staff | 40 hours |
| **System Performance Assessment Activities** | | |
| Transit System Performance Assessment:<br>• Auto/Transit travel time ratio (door to door trip time) for sample O-D pairs.<br>• Percent of trips on time.<br>• Service headways for sample of routes.<br>• Frequency of service (vehicles per hour) for sample of routes. | PAG Staff | 40 hours |
| Paratransit System Performance Assessment:<br>• Auto/Transit travel time ratio (door to door trip time) for sample O-D pairs.<br>• Average response time in minutes.<br>• Percent of trips arriving between 10 minutes before or 10 minutes after scheduled pick up.<br>• Percent of trips arriving at destination on time.<br>• Percent of trips picked up within two hours of call. | PAG Staff | 40 hours |
| Bicycle System Performance Assessment:<br>• Percent of facility completeness.<br>• Typical travel speeds on a sample of routes. | PAG Staff | 20 hours |

**Exhibit 53 (continued)**
**FIVE-YEAR TRANSIT/ALTERNATIVE MODE SYSTEM PERFORMANCE ASSESSMENT ACTIVITIES**

| Five Year Activities (note that these activities are in addition to the Annual Activities) | Responsibility | Hours or Cost to Complete |
|---|---|---|
| Pedestrian System Performance Assessment<br>• Percent of facility completeness.<br>• Level of system constraints to use. | PAG Staff | 20 hours |
| **Prepare 5-Year State of the System Summary Report (this report replaces the Annual Summary in year 5)** | | |
| This report would provide summary tables and graphics indicating the existing conditions and how conditions have changed over the past 5-year period. This would include:<br>• System Size / Extent<br>• Level of Use<br>• System Performance | PAG Staff | 80 hours |
| **Total PAG Staff Hours for Annual CMP Activities** | PAG Staff | 420 hours |
| **Total Consultant Data Collection Costs** | Consultant | $40K |
| | | |

PAG STAFF REQUIREMENTS

Based on the information provided in Exhibits 50 through 53, it is estimated that PAG CMP activities will require an annual level of effort of approximately 0.5 to 0.75 full time equivalent (FTE) employees. The system performance monitoring process for the CMP has been developed with consideration of the staff and data requirements needed to sustain the process in an effort to keep resource requirements at a manageable and affordable level.

Information was available for comparison of the PAG CMP cost estimates to program costs from other MPOs. A "best practices" review of CMPs from six agencies was conducted as part of the first phase in the Maricopa Association of Governments (MAG) Congestion Management Update Project.[28] The following information was reported on programs costs:

- Ongoing efforts to support the North Central Texas Council of Government's CMP typically require 1.5 staff persons and ½ of a manager's time.
- The Hampton Roads Planning District Commission budgets $120,000 annually for CMP efforts, using all in-house staff.
- The Puget Sound Regional Commission indicated a staff commitment of one full-time person and part of a supervisor's time, plus some additional staff effort for CMP activities.
- The Denver Regional Council of Governments currently provides 1.5 to 2 full-time staff equivalents to support ongoing CMP efforts, not including support staff used to support related travel demand management and transportation operations activities.

## EVALUATION OF IMPLEMENTED STRATEGIES

The Federal guidance indicates that the CMP should also evaluate the performance of implemented congestion management strategies to estimate strategy effectiveness. This information should be disseminated to decision makers to aid in future decisions regarding strategy application in the region. The evaluation of strategy effectiveness should be conducted using the adopted CMP performance measures, if these measures are suitable for application to the evaluation.

[28] Maricopa Association of Governments, *Performance Measurement Framework and Congestion Management Update – Review of Best Practices,* prepared by PBS&J, December 2008.

It is not necessary that every implemented congestion management strategy be evaluated. The effectiveness of many strategies is already well documented or can be evaluated prior to implementation using existing analysis tools and data. For example, the effectiveness of the addition of turn lanes at a congested intersection is commonly evaluated during the planning stage using widely accepted traffic operations analysis tools and techniques. The value of this process for the region will come from the evaluation of new policies, programs, or approaches to congestion management that have not been implemented locally before, or where the effectiveness of the strategy has not been well documented.

Two basic approaches to the implementation of strategy evaluation were considered as part of the development of the CMP:

1. Identify the strategies to be evaluated as part of the Transportation Improvement Program (TIP) project development process and designate that a portion of the project funding be set aside for the evaluation of the project. The approach, scope, and budget for the evaluation would be established collaboratively by PAG and the jurisdiction sponsoring the project.
2. Establish a funding source within the PAG TIP for project evaluation, setting aside a specific level of funding each year. Allow local jurisdictions to submit applications for funding of evaluations that they find of particular interest or need. The scope and funding requirements for the project would be developed by the sponsoring jurisdiction and submitted to PAG for review. PAG staff and the PAG TIP Subcommittee would review the applications, select and recommend evaluation projects for funding. The recommendation would follow the PAG approval process through the Transportation Planning Committee (TPC) and the Regional Council.

Of these two, the second general approach is recommended for consideration by PAG for implementation. Initial funding for evaluations should be between $50,000 and $100,000 per year to provide sufficient funding for one or more evaluation projects. However, funding could be established on an as-needed basis, as it seems unlikely that the number of evaluations identified would warrant annual funding of the program.

# 5. CONGESTION MANAGEMENT STRATEGIES

## TOOLBOX OF STRATEGIES

A draft "toolbox" of congestion mitigation strategies was developed with input from the previous PAG Mobility Management Plan projects, a review of the literature, and from a review of Congestion Management Processes and Congestion Management Systems of other jurisdictions. Appendix C contains the initial toolbox of strategies for consideration and application in the CMP.

The toolbox includes a broad range of measures involving all modes of transportation as well as measures that encourage more efficient land use and development practices. Synthesizing recommendations from the literature and the approaches used by several reviewed jurisdictions, the strategy "toolbox" is divided into five overarching strategy categories. The categories are arranged beginning with the most cost effective and efficient strategies and ending with the most cost prohibitive and intrusive (i.e. road widening for capacity improvement). The general categories for the "toolbox" are:

1. Eliminate Person Trips or Reduce VMT During Peak Hour
2. Shift Trips from Automobile to Other Modes
3. Shift Trips from SOV to HOV Auto/Van
4. Improve Roadway Operations
5. Add Capacity

The five categories are each divided into "strategy classifications" with each classification containing several representative mitigation strategies. A brief description is provided for each representative strategy as well as an indication of an implementation timeframe. Finally, for each strategy classification, a listing of benefits is provided. These benefits can be used to tie the mitigation strategy to regional goals and objectives.

The following resources were consulted in the preparation of this draft toolbox:

Literature Review:

- Institute of Transportation Engineers, A Toolbox for Alleviating Traffic Congestion and Enhancing Mobility, Prepared by Michael D. Meyer, Ph.D., P.E., 1997.
- Congestion Management Process (CMP) Innovations: A Menu of Options, Prepared for New York State Association of Metropolitan Planning Organizations (NYSMPOs), Prepared by ICF Consulting, February 2006.
- An Interim Guidebook on the Congestion Management Process in Metropolitan Transportation Planning, USDOT, FHWA, FTA.
- "Congestion Management Systems: A Federal Perspective," Brian Betlyon, FHWA Resource Center, Presented at Transportation Engineering and Safety Conference December 7-9, 2005.

Other CMPs and CMSs:

- Pima Association of Governments Metropolitan Mobility Plan 1993.
- Pima Association of Governments Metropolitan Mobility Plan Update 2000.
- El Paso Metropolitan Planning Organization, Congestion Management Process, November 2008.
- North Central Texas Council of Governments, Congestion Management Process, April 2007.

- Mountainland Association of Governments Congestion Management Process, CMP Toolbox Technical Memorandum, Updated March 2007.
- Genesee County Metropolitan Alliance 2030 Long Range Transportation Plan. Compliance Update, Chapter 14 the Congestion Management Process, August 2007.
- Central Midlands Council of Governments 2035 Long Range Transportation Plan, Chapter 8 Congestion Management, December, 2008.
- Richmond Area MPO Congestion Management System Technical Report for the 2031 Long-range Transportation Plan and Congestion Management System Update, July, 2008.
- Mid-Atlantic Regional Council (MARC) Enhanced Congestion Management System CMS Toolbox, Technical Memorandum, December 2001.

## CURRENT REGIONAL CONGESTION MANAGEMENT PROGRAMS AND PLANS

PAG and its member jurisdictions currently implement a variety of congestion management strategies through ongoing programs, systems and projects. Several of these programs have been ongoing for many years, but have simply not been documented in the context of a congestion management process. The following are notable ongoing programs, systems and projects within the PAG region identified in the Transportation Improvement Program and the Draft 2040 Regional Transportation Plan (RTP) that are considered congestion management strategies. **Note that the level of funding in the 2040 RTP anticipated for these projects and programs was taken from the draft materials that were available at the time this evaluation was conducted and are subject to change in the Final 2040 RTP.**

A review of the Draft 2040 RTP (December 2009) project listing was conducted to estimate the level effort within the Plan that can be attributed to congestion management projects and programs. This review was conducted based on the project categories and project descriptions contained with the Draft 2040 RTP Excel spreadsheet of projects provided by PAG. The format used for this review is such that these materials can be updated relatively easily to provide similar information from future regional plan updates.

### Travel Demand Management Measures

#### PAG Rideshare and Vanpool Programs

The RideShare Program was established in 1974 and is administered by PAG. In 2007, the RideShare Program was expanded to serve all employers and commuters in Pima County, and the number of registrants more than doubled, growing from 224 to 483. In 2008, Rideshare installed a new interactive carpool matching system that allows commuters to find carpool partners, vanpool routes, bike buddies, convenient park-and-ride lots, transit routes and schedules at one Web site. Area commuters are able to find a carpool, vanpool, transit, walking or biking partner through PAG's matching system, and qualify for PAG's Guaranteed Ride Home program. At the end of 2008 there were 2,836 active commuters in the database, reflecting the addition of 1,290 new commuters. Over 3,000 match runs were conducted to assist these commuters in selecting travel options.[29]

Vanpool participation also grew in 2008 with the introduction of a new provider, greater vehicle selection and better customer service. Seven new vanpools were added, an increase of 50 percent.[30]

[29] Pima Association of Governments, *2010-2014 Transportation Improvement Program,* adopted May 28, 2009.
[30] Pima Association of Governments, *2010-2014 Transportation Improvement Program,* adopted May 28, 2009.

### PAG Travel Reduction Program

Travel Reduction Ordinances (TROs), creating the regional Travel Reduction Program (TRP), are in place for each of the following jurisdictions: Pima County, the cities of Tucson and South Tucson, and the towns of Oro Valley, Marana and Sahuarita. The goals of the Ordinances are to reduce traffic congestion and improve air quality. The TRP is implemented through PAG, working with major employers, defined as an employer with 100 or more full-time equivalent employees at a single or contiguous site. Employers with less than 100 employees can also voluntarily participate in the TRP. Employers in the TRP encourage their employees to reduce the vehicle miles traveled in the home to work commute trip through the use of alternate modes or adjusted work schedules such as compressed workweeks or telecommuting. In 2007, 285 sites submitted a TRP plan documenting their commitment to encourage approximately 121,000 employees to use alternate modes for the home to work trip at least one day a week. For the last two years employers averaged 20 activities per site from a list of 44 travel demand strategies.

In the most recent survey year of 2007 TRP employees using alternate modes or special programs, such as compressed work weeks, reported 98.4 million driving miles saved. This translates to an annual savings of 4.9 million gallons of gasoline, millions of dollars in fuel costs and 1,950 metric tons of pollution.[31] In 2009 PAG proposed revisions to the TRO which are under consideration by ADEQ, EPA and the local governments. These revisions are designed to expand the reach of the program throughout the community and streamline the current process requirements.

### Park & Ride Lots

Park and Ride lots assist travelers in making connections to transit or carpools. Sun Tran serves 26 free Park and Ride lots across the region.[32] The 2040 RTP plan includes the addition of park and ride facilities in Sahuarita, Oro Valley, Marana, Rita Ranch, and Green Valley.[33]

## Transportation System Management Measures

### ITS Traffic Signal Systems

On behalf of the region, the City of Tucson currently monitors and controls over 500 traffic signals from the City of Tucson Transportation Control Center. The City of Tucson, Arizona Department of Transportation, Pima County, Marana, Oro Valley, Sahuarita, the City of South Tucson, the Pascua Yaqui Tribe and the Tohono O'odham Nation are in partnership to provide a "seamless" traffic signal operation across jurisdictional boundaries. This has resulted in the interconnection of traffic signals, in and adjacent to the City of Tucson, into a centrally coordinated operation.[34]

### ITS Freeway Management Systems

ITS Freeway Management System Deployment of Phase I of the Tucson metro area Freeway Management System (FMS) has been completed. The initial phase of the FMS uses 13 CCTV cameras with the ability to tilt, zoom and pan 359 degrees for use in monitoring traffic flow and detecting incidents. The cameras have been strategically placed along the mainline so that they

[31] Pima Association of Governments, *2010-2014 Transportation Improvement Program,* adopted May 28, 2009.
[32] Pima Association of Governments, *2010-2014 Transportation Improvement Program,* adopted May 28, 2009.
[33] Pima Association of Governments, Draft *2040 Regional Transportation Plan,* April 2010.
[34] Pima Association of Governments, *2009-2013 Transportation Improvement Program,* adopted June 26, 2008.

can be used to observe traffic on the approaching arterials as well as Interstates 10 and 19. Eight Variable Message Signs (VMS) are also used to provide real-time information for drivers. The FMS components served as important tools to help manage the work zone for the Interstate 10 – Prince Road to 29th Street construction project. ADOT has recognized the importance of active corridor management and has installed a Traffic Operations Center (TOC) that served as the primary freeway operations headquarters during the Interstate 10 reconstruction.

The TOC actively monitors and operates FMS cameras and message boards. The TOC coordinates closely with a number of other centers throughout the region including the City of Tucson Transportation Control Center (TTCC), the TOC in Phoenix, the City of Tucson 911 Center, the State Department of Public Safety and the ADOT Maintenance Facility. These centers are essential to maintaining efficient response and clearance times of incidents along the mainline. To enhance this service during I-10 construction, ADOT has established a tow truck service patrol to assist motorists and clearance activities during construction of the I-10 corridor.[35]

The 2040 RTP contains an additional $67 million for the operation and expansion of the freeway management system. In addition, the Plan contains provisions for the addition of high occupancy vehicle (HOV) lanes to the freeway system for the metro area.

### ITS Transit and Traveler Information Systems

The City of Tucson and Sun Tran are currently implementing a transit priority program in conjunction with regular traffic signal operations. The region also provides the latest traveler information to residents and travelers through commercial radio, television and the Internet via the www.TransView.org Web site. In 1998 the City of Tucson established a partnership with METRO Networks-Tucson, a private traveler information provider, to implement a regional ITS Traveler Information System program. METRO Networks-Tucson provides funding for the operation and upgrading of the region's transportation control center, flight time for staff to monitor roadway conditions, broadcasting of peak-hour transportation announcements, and a potential revenue stream for the city to use on related ITS projects. In addition, Arizona's 511 phone-based travel information system is providing benefits to the traveling public by making accessible and current information on system conditions and transit information readily available to the public. This system has been launched throughout Arizona and is being expanded to include more information about local roadway conditions.[36]

### Other Congestion Management Related Programs in the 2040 RTP

Exhibit 1 contains a summary of other congestion management related programs contained in the Draft 2040 RTP. The Draft 2040 RTP contains numerous congestion management related programs among the project list. These programs address bottlenecks, improve traffic safety, and provide for alternative modes of travel that will reduce roadway congestion. These programs account for nearly $1 billion in funding for congestion management over the period of the Plan, and account for nearly 50 percent of all of the program expenditures in the Plan. In general, these programs are considered to have a high potential to manage congestion for the region. The congestion management potential indicated in Exhibit 54 is a subjective rating of the potential for these projects to reduce motor vehicle congestion on the roadway.

[35] Pima Association of Governments, *2009-2013 Transportation Improvement Program,* adopted June 26, 2008.
[36] Pima Association of Governments, *2009-2013 Transportation Improvement Program,* adopted June 26, 2008.

**Exhibit 54**
**REGIONAL CONGESTION MANAGEMENT PROGRAMS**

| | 2040 RTP Congestion Management Related Programs | |
|---|---|---|
| **Category** | **RTP Funds (in 000s)** | **Congestion Management Potential** |
| Intersection Improvements | $38,926 | High |
| Emergency & Incident Management System | $28,896 | High |
| Freeway Management System | $67,117 | High |
| New Bus Pullouts | $6,697 | Medium |
| Nogales Spur RR Grade Crossings and Separations | $311,385 | High |
| Safety Programs | $303,554 | Medium |
| Commuter Incentives for alternative transportation | $4,150 | Medium |
| Park & Ride Facilities | $25,254 | High |
| Travel Demand Management Programs | $34,000 | High |
| University of Arizona Car Sharing Program | $200 | Low |
| Alternate Modes Program | $3,267 | Medium |
| Freeway HOV Lanes | $166,000 | High |
| **Total** | **$989,446** | |
| **Programs Total** | **$2,034,208** | |
| **CMP Related as Percent of Programs Total** | **48.6%** | |

Source: PAG Draft 2040 RTP, December 2009.

**Transit**

Planned improvements to the PAG region's transit system as identified in the Draft 2040 Regional Transportation Plan approved are shown in Exhibit 55. The existing transit system is described below.

**Sun Tran**

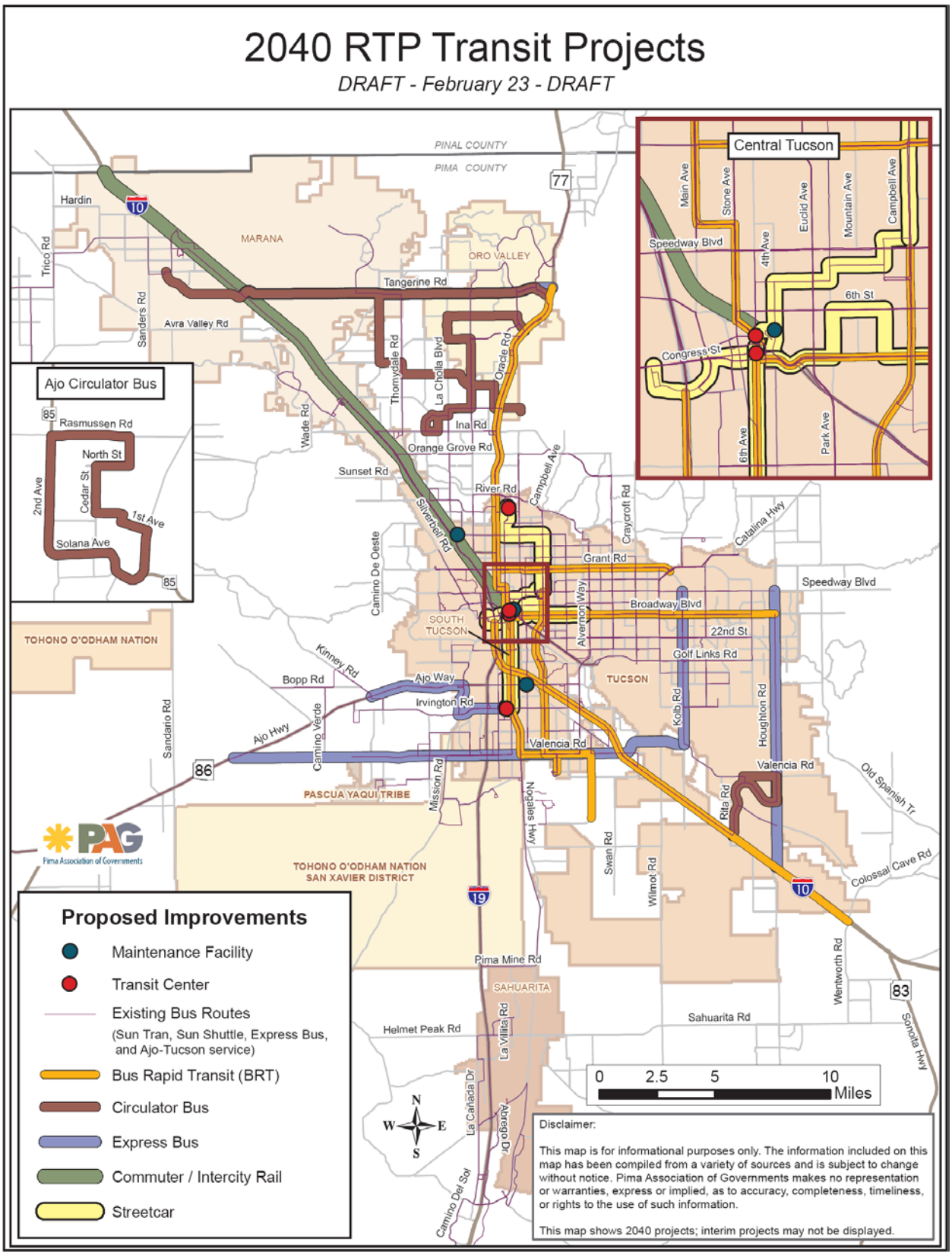
With a fleet of 226 buses, Sun Tran provides fixed route transit service within the City of Tucson, and through intergovernmental agreements, delivers service into Pima County, the City of South Tucson, the Town of Marana, the Town of Oro Valley, the Tohono O'Odham Nation and the Pascua Yaqui Tribe. The system's 40 fixed routes cover a 296-square-mile area.

Ridership on Sun Tran is growing for a seventh consecutive year. Fiscal year-to-date through December 2008, ridership has grown 16.2 percent versus the same period of the previous fiscal year. The system experienced an 8.8 percent ridership increase in FY 2007-2008 when compared to the previous fiscal year.[37]

Six new Bus Rapid Transit (BRT) corridors were selected and included in the 2040 RTP: Broadway Boulevard, 6th Ave/Nogales, Oracle Road, Grant Road, Campbell Ave South / Kino Parkway and Vail. The 2040 RTP plan calls for additional express routes to further enhance commuter options. Potential new corridors include Ajo Way, Kolb Road and Tangerine Road.[38]

[37] Pima Association of Governments, *2010-2014 Transportation Improvement Program,* adopted May 28, 2009.
[38] Pima Association of Governments, Draft *2040 Regional Transportation Plan,* April 2010.

**Exhibit 55**
PLANNED TRANSIT IMPROVEMENTS IN 2040 RTP




Source: Pima Association of Governments, April 2010.

### Sun Van (formerly Van Tran)

With more than 230 employees and a fleet of 119 vans, Sun Van provides paratransit service to the Tucson Metropolitan area and portions of Pima County. Sun Van's service area includes points within three-quarters of a mile along each Sun Tran fixed route, excluding express routes, during the days and times that Sun Tran operates. Sun Van's ridership has grown steadily over the past several years, demonstrating a 25.9 percent increase from FY 03-04 through FY 07-08. In FY 07-08, Sun Van provided 450,487 rides, a 2.4 percent increase over the previous year.[39]

### Pima County Rural Transit and Pima Transit Special Needs

Pima County Rural Transit provides fixed-route transit service to residents living in rural areas of Pima County. The system transports residents to jobs, major shopping centers, and medical facilities within the Tucson metro area by connecting with the Sun Tran system at major transfer centers. Pima Transit Special Needs is a door-to-door paratransit service provided for persons with disabilities living outside the Tucson city limits, but within the Tucson metro area.[40]

### Local Circulators – Downtown Loop, Cat Tran, Oro Valley's Coyote Run, and Sun Shuttle

The Downtown Loop, Cat Tran, Coyote Run, and Sun Van are examples of local circulators that supplement the fixed-route Sun Tran and Pima County Rural Transit systems. The Downtown Loop is a service of the City of Tucson Department of Transportation that operates in the downtown area providing free transit service to community services, government offices, courts, educational facilities and area businesses. The route contains 12 stops with 30 minute headways five days a week.

University of Arizona's Cat Tran is the fixed-route circulator shuttle system serving the University of Arizona Main Campus and the University Medical Center. The *free* system transports students, faculty, staff and visitors to the campus core from nearby parking garages, surface lots and off-campus offices along seven fixed routes Monday through Friday.[41]

Oro Valley's Coyote Run provides door-to-door paratransit service for elderly and disabled residents of the Town. Coyote Run provides about 17,000 trips a year to over 1,200 eligible riders.[42]

Sun Shuttle is a new neighborhood transit service (May 2009) in Marana, Oro Valley, Catalina, Sahuarita, and Green Valley that provides rides within neighborhoods and also connects passengers to other Sun Tran routes, providing transit access to the entire Tucson metropolitan area.[43]

### Modern Streetcar

Funding is already in place for Tucson's first streetcar. This four-mile line is expected to open in 2012 and will connect the Arizona Health Sciences Center, The University of Arizona, Main Gate Square, 4th Ave Avenue Shopping District, Congress Shopping and Entertainment District, and the Mercado District on downtown's west side. The RTP recommends building upon the

[39] Pima Association of Governments, *2010-2014 Transportation Improvement Program,* adopted May 28, 2009.
[40] Pima Association of Governments, Draft *2040 Regional Transportation Plan,* April 2010.
[41] Pima Association of Governments, Draft *2040 Regional Transportation Plan,* April 2010.
[42] Pima Association of Governments, Draft *2040 Regional Transportation Plan,* April 2010.
[43] Pima Association of Governments, Draft *2040 Regional Transportation Plan,* April 2010.

first streetcar by having extension lines along: Campbell Ave (UMC to Tucson Mall), Broadway (Downtown to El Con Mall) and 6th Avenue (Downtown to Laos Transit Center).[44]

Exhibit 56 summarizes the transit system improvements in the Draft 2040 RTP that improve or expand transit service, thus contributing to congestion management. These projects are summarized by the categories included in the Draft 2040 RTP project list. These projects make up approximately $5 billion in RTP expenditures over the plan period.

**Exhibit 56**
**TRANSIT IMPROVEMENTS**

| | 2040 RTP Transit System Improvements, Operations, and Maintenance | | |
|---|---|---|---|
| **Category** | **RTP Funds (in 000's)** | **Length (miles)** | **Congestion Management Potential** |
| Bus Rapid Transit and Express Bus Service Expansion | $633,575 | 75 | High |
| Bus Service Expansion | $586,373 | NA | High |
| Transit System Maintenance and Operations | $2,142,087 | NA | Medium |
| Regional Commuter Rail Service | $466,988 | 27 | High |
| Other Alternative Mode Projects | $83,807 | NA | Low |
| Paratransit Service, Mainenance and Operations | $456,184 | NA | Low |
| Streetcar Service Expansion, Operations, Maintenance | $688,373 | 17.4 | Medium |
| **Total** | **$5,057,387** | | |
| **Transit System Total** | **$5,078,887** | | |
| **CMP Related as Percent of Transit Total** | **99.6%** | | |
| Projects exclude planning and feasibility studies, and design. | | | |

Source: PAG Draft 2040 RTP, December 2009.

### Bicycle and Pedestrian Improvements

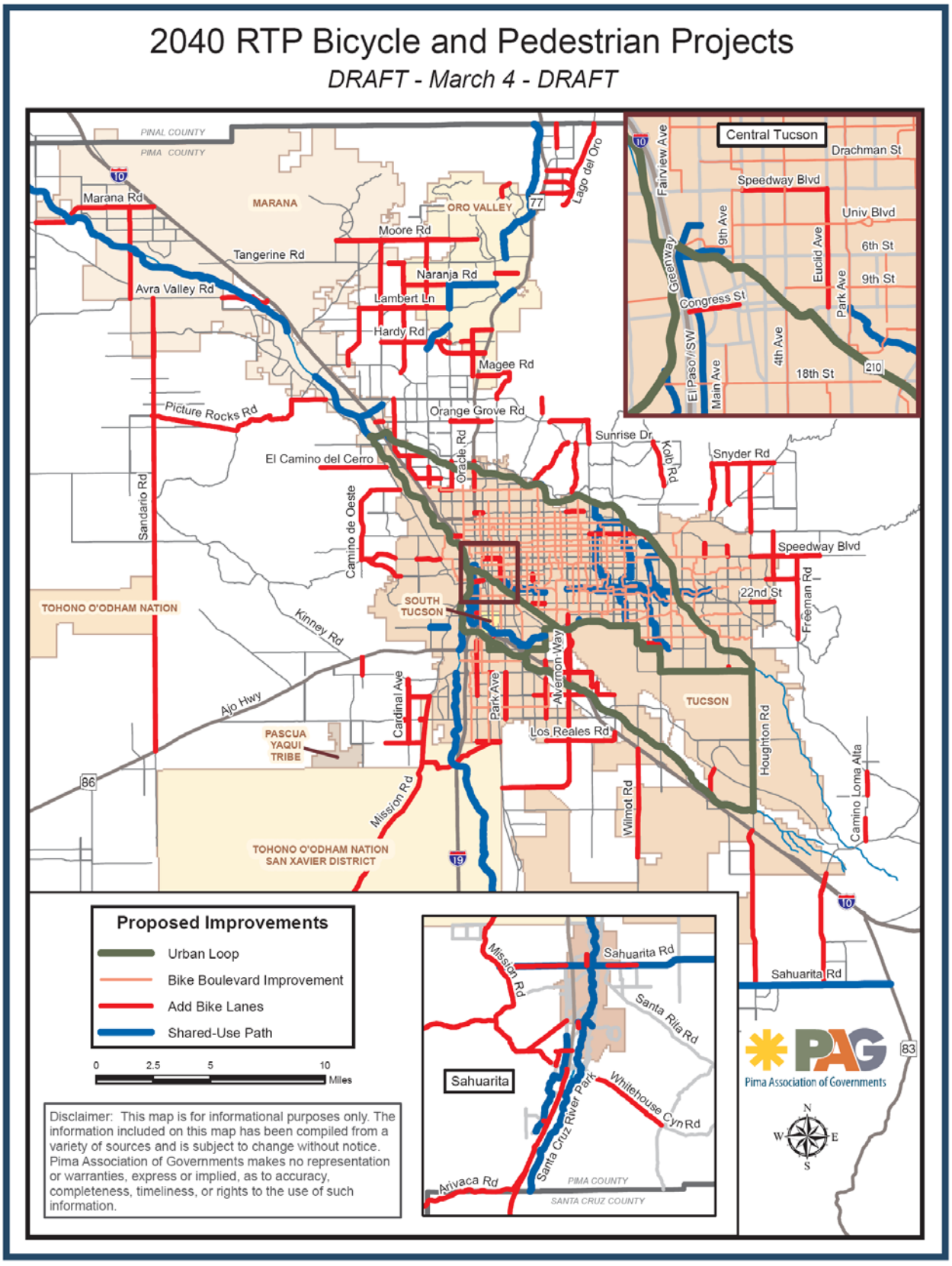
There are several categories of bicycle and pedestrian projects in the 2040 RTP to improve the region's multimodal transportation network for current and future generations. Currently, there are over 817 miles of bikeway facilities in the region which includes bike lanes, shared-use paths and residential bike routes. The 2040 RTP would add nearly 700 additional miles of these facilities.

The 2040 RTP includes additional bicycle facilities totaling approximately $273 million (excluding costs of concurrently developing bicycle lanes as part of roadway projects).[45] The 2040 RTP includes sidewalk improvements to help fill the gaps in the sidewalk network and make the system easier to navigate for those with a disability to travel. The total allocation for pedestrian facilities and programs in the 2040 RTP is approximately $220 million.[46]

Bicycle and pedestrian facility improvements proposed as part of the 2040 RTP are shown in Exhibit 57.

[44] Pima Association of Governments, Draft *2040 Regional Transportation Plan,* April 2010.
[45] Pima Association of Governments, Draft *2040 Regional Transportation Plan,* April 2010.
[46] Pima Association of Governments, Draft *2040 Regional Transportation Plan,* April 2010.

**Exhibit 57**
PLANNED BICYCLE AND PEDESTRIAN IMPROVEMENTS IN 2040 RTP




Source: Pima Association of Governments, April 2010.

Bicycle and pedestrian improvements are contained in two separate elements of the 2040 RTP project listing:

- Improvements contained within larger roadway improvement projects that add bicycle lanes and sidewalks as an integral part of the project.
- Separate, stand alone bicycle and pedestrian improvement projects.

Exhibit 58 provides a summary of the miles of roadway improvements that include the addition of bicycle lanes and sidewalks. The separate cost of the bicycle lanes and sidewalks is not available in the description of projects of these roadway projects.

**Exhibit 58**
**MILES OF ROADWAY IMPROVEMENTS WITH BICYCLE AND SIDEWALK FEATURES**

| 2040 RTP Miles of Roadway Improvements With | | |
|---|---|---|
| **Bike Lanes and Sidewalks** | **Bike Lanes Only** | **Sidewalks Only** |
| 121 | 30 | 29 |
| Total Cost of above is unknown | | |

Source: PAG Draft 2040 RTP, December 2009.

Exhibit 59 summarizes the stand alone bicycle and pedestrian system improvements contained in the Draft 2040 RTP by improvement category. Total estimated cost of these improvements is $493 million. These improvements are considered to be 100 percent congestion management related.

**Exhibit 59**
**BICYCLE AND PEDESTRIAN IMPROVEMENT PROJECTS**

| 2040 RTP Bicycle and Pedestrian Improvement Projects | | | |
|---|---|---|---|
| **Improvement Category** | **Length (miles)** | **RTP Funds (in 000s)** | **Congestion Management Potential** |
| Bike Boulevard Improvements | 166 | $24,864 | Medium |
| Construct/restripe bike lanes | 219 | $103,019 | Medium |
| Other Bike Programs and Improvements | NA | $145,639 | Medium |
| Pedestrian Facility Improvements and Programs | 57 | $219,781 | Low |
| **Totals** | **442** | **$493,303** | |
| Ped-Bike Plan Total | | **$493,303** | |
| Ped-Bike CMP as Percent of Plan | | 100.0% | |

Source: PAG Draft 2040 RTP, December 2009.

## Summary of Congestion Management Funding in the 2040 RTP

Exhibit 60 provides a brief summary of the total funding in the Draft 2040 RTP that is associated with congestion management projects and programs. Approximately $6 billion of projects and programs is contained in the Draft RTP that is directly related to congestion management efforts. This amounts to an estimated 37 percent of the entire funding for the 2040 RTP.

**Exhibit 60**
**SUMMARY OF CONGESTION MANAGEMENT FUNDING IN THE 2040 RTP**

| 2040 RTP Summary Table | |
|---|---|
| | **RTP Funds (000s)** |
| **RTP Total Cost** | $17,641,407 |
| **CMP Related Features** | $6,540,136 |
| **CMP as Percent of Total Plan** | 37.1% |
| | |
| Excludes cost of pedestrian and bicycle features associated with roadway widening projects as these are not available as separate cost items. | |

Source: PAG Draft 2040 RTP, December 2009.

# 6. INCORPORATING THE CMP INTO THE TIP PROCESS FOR PROJECT DEVELOPMENT

## TRANSPORTATION IMPROVEMENT PROGRAM (TIP) AND THE CMP

In recognition of the Federal requirements for the CMP, particularly as they relate to Transportation Management Areas that are in nonattainment for either carbon monoxide or ozone, a procedure was developed through this study to link the TIP project development process to the CMP. In that the PAG planning area is not currently classified as nonattainment, PAG is taking a proactive approach to ensuring that all "significant" single-occupant vehicle (SOV) capacity projects are developed as part of a CMP.

The procedure developed to review all "significant" SOV projects is designed to help:

- Ensure that significant SOV projects consider, and when applicable include congestion management strategies as part of the project development process.
- Document the congestion management strategies to be included with the significant SOV project.

PAG's Congestion Management Process defines a "significant" SOV project as: any project of one (1) mile or more that adds new general purpose travel lanes to an existing or new roadway. A "significant" SOV project is expected to result in a noteworthy increase in the carrying capacity for SOVs and have impacts on air quality. These projects are required to be addressed through a congestion management process.

This requirement of the CMP will be linked to the TIP project development process through the project data provided by a local jurisdiction to support a major project's funding application. The application form already used by PAG (see Appendix D for the complete new form), and filled out by the local jurisdiction, will contain a few additional CMP-related questions:

- Is the project considered to be a "significant" project according to PAG's Congestion Management Process (CMP)?
- Are Federal funds being used or requested to support the project?
- Is the project a significant increase in single occupant vehicle (SOV) capacity?
- Does the project address a congestion issue as identified by PAG's transportation system reporting or other source?
- Does the project incorporate congestion management strategies as identified in the PAG CMP Strategies Toolbox or otherwise?
- Please identify the congestion management strategies included as part of the project using the "PAG CMP Strategies Toolbox Worksheet."

The PAG Congestion Management Strategies Toolbox Worksheet is a checklist of congestion management strategies that are considered appropriate and applicable to the region. This checklist is designed to easily facilitate the documentation of strategies to be included with the significant SOV project, but it is not necessarily all inclusive of the strategies that may be used. Local agencies have complete flexibility and latitude to include any additional congestion management strategies into their project, and this is encouraged by PAG. The PAG checklist, provided in Exhibit 61, provides the opportunity for local jurisdictions to identify additional congestion management strategies that will be included with the project.

## Exhibit 61
## PAG CONGESTION MANAGEMENT STRATIGIES TOOLBOX WORKSHEET

### CONGESTION MANAGEMENT STRATEGIES WORKSHEET

**Indicate whether the project includes or directly encourages any of the following by checking the applicable boxes (check all that apply):**

**Strategy 1: Policies to Eliminate Person Trips or Reduce VMT During Peak Hour**

- ☐ **Policy Management / Activity Centers** (e.g., density cluster, mixed use development, transit oriented development, pedestrian oriented development, incentives to encourage employees to live closer to work, etc.).
- ☐ **Travel Demand Management** (e.g., telecommuting, preferential parking, stagger/flexible work hours, carpool/vanpool programs, intermodal transit systems, vehicle use limitations, etc.)
- ☐ **Congestion Pricing** (e.g., road user fees, toll roads, parking management, peak period parking surcharges, fuel tax increase, transit fare reductions, increased property tax for private parking lots, etc.).

**Strategy 2: Shift Trips from Automobile to Other Modes**

**A. Public Transit Capital Improvements**

- ☐ Exclusive right-of-way (new rail service or bus lanes/bypass ramps)
- ☐ Fleet expansion
- ☐ Improved intermodal connections
- ☐ Improved / increased park-n-ride facilities
- ☐ Rapid transit system
- ☐ Paratransit service
- ☐ Special event or activity center shuttle service
- ☐ More / better amenities
- ☐ Other:_____

**B. Public Transit Operational Improvements**

- ☐ Service expansion
- ☐ Express routes
- ☐ Traffic signal preemption
- ☐ Transit information systems
- ☐ Transit schedule coordination (e.g., timed transfers)
- ☐ Transit promotion / marketing
- ☐ Service revision focusing on congestion relief
- ☐ Other:_____

**C. Advanced Public Transportation Systems**

- ☐ Intelligent Bus Stops
- ☐ Other:_____

**D. Non-Motorized Modes**

- ☐ Bikeway construction
- ☐ Bicycle / transit connection
- ☐ Improved/expanded pedestrian network
- ☐ Auto restricted zones
- ☐ Grade separation for bicycles / pedestrians
- ☐ Bicycle / pedestrian amenities
- ☐ Other:_____

**Strategy 3: Shift Trips from SOV to HOV Auto / Van**

**A. HOV Measures**

- ☐ High occupancy vehicle lanes
- ☐ Employer trip programs
- ☐ Preferential parking or free parking for HOVs
- ☐ Other:_____

**Strategy 4: Improve Roadway Operations**

**A. Access Management**

- ☐ Driveway consolidation
- ☐ Median opening closure
- ☐ Ramp metering
- ☐ Restricted access
- ☐ Left-turn restrictions
- ☐ Other:_____

**B. Incident Management**

- ☐ Special event management
- ☐ Incident detection and response
- ☐ Other:_____

**C. Traffic Operational Improvements**

- ☐ Loading zone restrictions
- ☐ Railroad crossing improvements
- ☐ Arterial grade separation
- ☐ On/off ramp construction
- ☐ Arterial capacity improvements (< 1 mile)
- ☐ Intersection Improvements (new turn lanes, improved geometry, grade separation, etc.)
- ☐ Turn-around lanes
- ☐ Interstate access reduction
- ☐ Signal optimization
- ☐ Bridge construction / widening
- ☐ Freight movement management
- ☐ Intersection/roadway safety improvements
- ☐ Other:_____

**D. Intelligent Transportation Systems**

- ☐ Freeway information / motorist assistance
- ☐ Freeway management
- ☐ Traffic signal control
- ☐ Advanced traveler information
- ☐ Incident information / routing
- ☐ Fleet management
- ☐ Transit priority systems
- ☐ Other:_____

**Strategy 5: Add Capacity (major project ≥ 1 mile)**

- ☐ Freeway capacity (new general purpose lanes)
- ☐ Frontage road capacity (new lanes)
- ☐ Arterial capacity (new lanes)
- ☐ Other:_____

# APPENDIX A

# NATIONAL TRANSPORTATION OPERATIONS COALITION (NTOC) PERFORMANCE MEASUREMENT INITIATIVE DETAILED PERFORMANCE MEASURES DEFINITIONS

## Appendix A

### National Transportation Operations Coalition (NTOC) Performance Measurement Initiative Detailed Performance Measures Definitions

**Performance Measure:** Customer Satisfaction

**Definition:** A qualitative measure of customers' opinions related to the roadway management and operations services provided in a specified region. (See Note 1) A baseline set of questions is provided here as a resource for customer satisfaction surveys related to management and operations. Agencies may select questions from the following list, which can then be supplemented as dictated by local conditions and concerns.

- How satisfied are you with the information available from various sources (radio, TV, 511, websites, etc.) that inform you about the status of alternate routes and transportation modes before you begin a trip?
- How satisfied are you with the information available from various sources (radio, TV, 511, websites, etc.) that enable you to estimate the amount of additional time that must be added to your normal travel time to account for unexpected delays due to traffic accidents and other unusual occurrences?
- How satisfied are you with information available from various sources (radio, 511, dynamic message signs, highway advisory radio, etc.) that inform you about the status of alternate routes and transportation modes while you are traveling to your destination?
- How satisfied are you with the traffic signal operations in your region? In other words, do you feel that the number of stops and delays experienced at traffic signals are reasonable, considering the traffic conditions that exist when you are traveling?
- How satisfied are you that authorities respond and clear roadway emergencies promptly?
- How satisfied are you with the extent of traffic delays caused by work zones in your region?
- How satisfied are you with the time it takes you to commute to work?
- How satisfied are you with the time it takes you to make routine local trips?
- How satisfied are you with the time it takes you to make long-distance trips (greater than 50 miles) within your state/county/region?

**Includes:** Customer satisfaction with operations on freeways, arterials, corridors and regions.

**Excludes:** Many agencies regularly conduct customer satisfaction surveys asking questions about the entire range of services they offer. The questions in this survey are specifically restricted to highway management and operations.

**Units of Measurement:** Respondents should either be provided with the following multiple-choice answers to the questions being asked:

Very satisfied
Somewhat Satisfied
Neutral
Somewhat Dissatisfied
Very Dissatisfied
Don't know/Not Applicable

Or alternatively, the questions contained in this performance measure can be reformatted to elicit Agree/Disagree responses

**Processing** (or how to measure): It is recommended that responses be processed to provide both the distribution of answers (i.e. percent answering very satisfied, somewhat satisfied, etc.) as well as the average response. Survey results should also be analyzed by travel location and type of customer.

**Typical Applications:** Agency management and evaluation of the quality of service being provided to its customers. This measure can also be used for outreach to senior agency management and government officials.

**Example:** Given the inability of financial and personnel resources to accomplish all of the various operations tasks desired by the public, the agency wants to know the relative levels of satisfaction that exist with each of their programs (e.g. traffic incident response, dynamic sign messages, traffic signal operations, etc.)

**Notes:**

(1) Customers include all transportation system stakeholders (motorists, commercial vehicle operator as well as members of the public affected by transportation services (shippers, fleet operators, first responders, etc.))

**Performance Measure:** Extent of Congestion – Spatial (See Note 1)

**Definition:** Miles of roadway within a predefined area and time period, for which average travel times are 30% longer than unconstrained travel times. (See Note 2)

**Includes:** Individual roadways (arterials or freeways), corridors or regions.

**Excludes:** N/A

**Units of Measurement:** Units may be either:
Lane miles or centerline miles of congested conditions
Percent of congested roadways. Calculated as a ratio = 100% x (Congested Lane or Centerline Miles)/(Total Lane or Centerline Miles)

**Processing** (How to measure)**:**

1. Segment the roadways included in the measurement into sections. (See Note 3)
2. Select the time period during which congestion is to be calculated. This must be a time period during which the unconstrained travel times remain constant.
3. Calculate the unconstrained travel time for the section using one of the definitions provided as Note 2.
4. Determine the average travel times for the time period of interest for each section. (See Note 4)
5. Measure the length of each section for which this calculation is made
6. Congested conditions are then equal to the sum of the lengths of the roadway sections for which the travel times are 30% greater than the unconstrained travel time.
7. The ratio is the sum of the congested roadway sections calculated in step (5) divided by the total lengths of all roadway sections included in the analysis.

**Typical Applications: P**lanning and outreach

**Example:** Communication with the public of changes in roadway transportation system quality of service.

**Notes:**

(1) Two types of congestion have been defined, spatial (how widespread is the congestion) and temporal (how long does it last). It is possible to combine these two into a composite measure of congestion defined as lane-mile-hours of congestion with units of congested mile-hours.

(2) One of two alternative forms of unconstrained travel time may optionally be used - see definitions.

(3) A roadway section is a length of roadway being analyzed for which conditions including volume/capacity ratio, signal spacing (if applicable), land use characteristics, etc. are relatively homogenous. .

(4) Travel times may be measured either using floating car runs, or calculated based on the length of the section divided by the average speeds for that section.

**Performance Measure:** Extent of Congestion – Temporal (See Note 1)

**Definition:** The time duration during which more than 20% of the roadway sections in a predefined area are congested as defined by the "Extent of Congestion – Spatial" performance measure.

**Includes:** Individual roadways (arterials or freeways), corridors or regions.

**Excludes:** N/A

**Units of Measurement:** Hours of congestion

**Processing** (How to measure)**:**

1. Select the time period to be used for calculating hours of congestion. (The period may be 24 hours.)
2. Divide the time period into five-minute intervals.
3. Execute processing steps one through five of the "Extent of Congestion – Spatial" performance measure.
4. Identify congested sections as those for which the actual travel times are more than 30% greater than the unconstrained travel times. (See Notes 2 and 3)
5. Count the number of time periods for which more than 20% of the sections are identified as having been congested.
6. Calculate the hours of congestion as the total number of congested time periods times 5 (min./measurement) divided by 60 min./hr.

**Typical Applications:** Planning and outreach

**Example:** Communication with the public related to changes in roadway transportation system quality of service.

**Notes:**

(1) Two types of congestion have been defined, spatial (how widespread is the congestion) and temporal (how long does it last). It is possible to combine these two into a composite measure of congestion defined as lane-mile-hours of congestion with units of congested mile-hours.

(2) One of two alternative forms of unconstrained travel time may optionally be used - see definitions

(3) A roadway section is a length of roadway being analyzed for which conditions including volume/capacity ratio, signal spacing (if applicable), land use characteristics, etc. are relatively homogenous.

**Performance Measure:** Incident Duration

**Definition:** The time elapsed from the notification of an incident until all evidence of the incident has been removed or until response vehicles have left the the incident scene. (See Notes 1 and 2)

**Includes:** Localized incidents occurring on any roadway (freeways and arterials) such as crashes, disabled vehicles, and medical emergencies.

**Excludes:** Non-traffic incidents such as building fires, law enforcement actions. Also excludes planned events (parades, sporting events, etc.) and regional weather incidents.

**Units of Measurement:** Median minutes per incident

**Processing** (How to measure)**:** Calculating the time difference between incident notification and incident removal. Average incident durations may be calculated for specific roadway types as the numerical average of incidents occurring at the locations and the times of interest for the analysis period.

**Typical Applications:** Operations management

**Example:** Evaluating the effectiveness of service patrol routes, and actions of emergency responsers on incident duration.

**Notes:**

(1) Incident notification includes receipt of the fact that an incident has occurred by any public agency personnel (dispatcher, field vehicle, traffic operations center operator, etc.)

(2) Evidence of the incident includes service vehicles, emergency vehicles, vehicles and individuals involved with the incident and debris resulting from the incident.

**Performance Measure:** Non-Recurring Delay

**Definition:** Vehicle delays in excess of recurring delay for the current time-of-day, day-of-week, and day-type. (See Notes 1 and 2).

**Includes:** Roadway segments, roadways, selected routes, corridors, and regions.

**Excludes:** Not applicable

**Units of Measurement:** Vehicle-hours

**Processing:**

1. Select roadways on which delay is to be measured
2. Select time period during which delay is to be measured
3. Determine the vehicle demand on the roadway during the selected time period (See Note 3)
4. Measure the delay during the selected time period
5. Calculate the product of the delay and the demand.
6. Calculate the difference between the delay for the measurement period and the recurring delay for the same roadway segment, time-of-day, and day-type.

**Typical Applications:** Planning, engineering and operations

**Example:** Calculate the delays caused by incidents and other causes of non-recurring delay, to perform benefit cost analysis of work zone staging, special events traffic management, freeway service patrols and other traffic incident management techniques, etc..

**Notes:**

(1) Delay is defined as the difference between the travel time actually required to traverse a roadway segment, and the unconstrained travel time. See definitions.

(2) Day type is used to differentiate between the traffic conditions that exist during normal working days, weekends, holidays (major and minor), shopping/sale days, summer season, etc.

(3) Vehicle demand includes sum of the volume of vehicles traveling through the roadway being evaluated and vehicle queue lengths awaiting passage along the roadway. Queues may exist on freeway entrance ramps, and on mainlines during incidents. Queues at signalized intersections entering the roadway being analyzed must also be included in measurement of vehicle delay for arterials.

**Performance Measure:** Recurring Delay

**Definition:** Vehicle delays that are repeatable for the current time-of-day, day-of-week, and day-type. (See Notes 1, 2 and 3).

**Includes:** Roadway segments, roadways, selected routes, corridors, and regions.

**Excludes:** Not applicable

**Units of Measurement:** Vehicle-hours

**Processing** (How to measure):

1. Select roadways on which delay is to be measured
2. Select time period during which delay is to be measured
3. Determine the demand on the roadway during the selected time period. (See Note 3) [no need to repeat Note 3 here]
4. Measure the delay during the selected time period during normal conditions (i.e. when there are no incident or special events)
5. Calculate the product of the delay and the demand.

**Typical Applications:** Planning, engineering and operations. Also serves as the baseline delay for estimating non-recurring delay.

**Example:** Determine the reduction in delay resulting from traffic signal retiming.

**Notes:**

(1) Delay is repeatable when it can be forecasted when the day-of-week, time-of-day, and day-type are known.

(2) Delay is defined as the difference between the travel time actually required to traverse a roadway segment, and the unconstrained travel time. See definitions.

(3) Day type is used to differentiate between the traffic conditions that exist during normal working days, weekends, holidays (major and minor), shopping/sale days, summer season, etc.

(4) Vehicle demand includes sum of the volume of vehicles traveling through the roadway being evaluated and vehicle queue lengths awaiting passage along the roadway. Queues may exist on freeway entrance ramps, and on mainlines during incidents. Queues at signalized intersections entering the roadway being analyzed must also be included in measurement of vehicle delay for arterials.

**Performance Measure:** Speed (See Note 1)

**Definition:** The average speed of vehicles measured in a single lane, for a single direction of flow, at a specific location on a roadway (See Note 2)

**Includes:** Traffic flow on all roadway types, under both recurring and non-recurring traffic conditions.

**Units of Measurement:** Miles per hour, feet per second or kilometers per hour

**Processing** (How to measure)**:** The average speed is the summation of the speeds of individual vehicles divided by the number of vehicles whose speeds have been measured during a defined time period.

**Typical Applications:** Used by agencies for internal applications associated with the planning, engineering and real-time operations for specific segments of roadway. Used to inform the public of existing traffic conditions on websites.

**Example:** Measurement of speed on an arterial section for calculating traffic signal offsets.

**Notes:**

(1) This performance measure is designated speed. It is actually the "point mean speed". It is anticipated that this measure will be replaced by space mean speed at the time when the measurement of the latter becomes economical.

(2) The roadway location selected should be representative of speeds existing throughout the roadway. Usually the length is equal to the detection zone of a vehicle detector (single loop, multiple loop speed trap, radar, vision system, etc.)

**Performance Measure:** Throughput - Person

**Definition:** Number of persons including vehicle occupants, pedestrians and bicyclists crossing a roadway screen line in one direction per unit time. (See Note 1). May also be the number of persons traversing a screen line in one direction per unit time. (See Note 2)

**Includes:** People flow on all roadway types under both recurring and non-recurring traffic conditions.

**Excludes:** Not applicable

**Units of Measurement:** Persons per hour

**Processing** (How to measure): Sum of persons carried on all modes traversing the roadway or screen line measured for the period of an hour

**Typical Applications:** Used by agencies to evaluate the transportation effectiveness of roadways, and to evaluate their person-carrying capacity for planning and operations purposes including evacuation planning.

**Example:** Person throughput can be used to compare the movement of persons on high occupancy vehicle lanes with the movement of persons on unrestricted lanes.

**Notes:**

(1) A roadway section is defined as a roadway of any length accommodating the flow of vehicles, pedestrians and/or bicycles, along which there are no entrances or exits that will affect the measurement of throughput.

(2) A screen line is a planning term that defines an imaginary line crossing one or more roadways, across which person flow or traffic flow is measured.

**Performance Measure:** Throughput - Vehicle

**Definition:** Number of vehicles traversing a roadway section in one direction per unit time. (See Note 1). May also be the number of vehicles traversing a screen line in one direction per unit time. (See Note 2)

**Includes:** Traffic flow on all roadway types under both recurring and non-recurring traffic conditions.

**Excludes:** Not applicable

**Units of Measurement:** Vehicles per hour

**Processing** (How to measure)**:** Sum of all types of vehicles traversing the roadway or screen line measured for the period of an hour. Each vehicle of any type both with and without trailers, receives an equal count.

**Typical Applications:** Used by agencies to evaluate the transportation effectiveness of roadways for planning and operations purposes.

**Example:** Evaluate the ability of a roadway or corridor to serve the vehicular demand between major transportation origins and destinations, such as two nearby urban regions.

**Notes:**

(1) A roadway section is defined as a roadway of any length accommodating the flow of all types of vehicles, along which there are no entrances or exits that will affect the measurement of throughput.

(2) A screen line is a planning term that defines an imaginary line crossing one or more roadways, across which person flow or traffic flow is measured.

**Performance Measure:** Travel Time - Link

**Definition:** The average time required to traverse a section of roadway in a single direction. (See Note 1)

**Includes:** Travel times on all roadway types under both recurring and non-recurring traffic conditions.

**Excludes:** Link travel times are applicable to a single mode and a single facility type. See Travel Time – Trip for multi-modal or multi-facility travel.

**Units of Measurement:** Minutes per trip

**Processing** (How to measure) **:** Travel time is collected for multiple of trips, during which the section of roadway is traversed using floating cars or equivalent measurement techniques. The average time is calculated as the sum of the travel times divided by the number of trips. Care must be taken to ensure that prevailing traffic and roadway conditions remain unchanged during the measurement period.

**Typical Applications:** Planning and operations.

**Example:** Comparing the travel time on an arterial section before and after the installation of new signal timing. Evaluating the impact of an incident on the travel time of a freeway section.

**Notes:**

(1) A section of roadway is defined by the individual or organization performing the travel time measurements. It will typically be a section of roadway between two signalized intersections or between two freeway interchanges, but it can be any desired section of roadway.

**Performance Measure:** Travel Time – Reliability (Buffer Time)

**Definition:** The buffer time describes the additional time that must be added to a trip (measured as defined by Travel Time – Trip), to ensure that travelers making the trip will arrive at their destination at, or before, the intended time, 95% of the time.

**Includes:** Travel times on all roadway and mode types under both recurring and non-recurring traffic conditions.

**Excludes:** Statistical variations in travel time that might occur due to the fact that travelers are traveling at different times of day when differing levels of traffic demand occur. This measure is intended to apply to a specific time of day, during which repeatable traffic and roadway conditions typically exist.

**Units of Measurement:** Minutes. This measure may also be expressed as a percent of total trip time or as an index.

**Processing** (How to measure)**:**

1. Multiple measurements of travel time are made for a given time of day and day of week, for which repeatable traffic and roadway conditions exist.
2. The travel times recorded during step 1 are arranged in ascending order.
3. The average of the distribution is calculated as the sum of the trip durations divided by the number of trips.
4. The top (longest) 5% of the trips is eliminated, leaving a truncated travel time list.
5. The buffer time is calculated as the difference in time between the average travel time, and the longest travel time of the truncated distribution.
6. If it is desired to express the buffer time as a percent, the calculation is made by dividing the buffer index from step (5) by the average calculated in step (3).

**Typical Applications:** Traveler information, outreach, evaluating the effectiveness of incident management programs.

**Example:** Buffer time is displayed on a traveler information website, for travelers to evaluate the time required for a rush hour commute, to ensure on-time arrivals.

**Performance Measure:** Travel Time - Trip

**Definition:** The average time required to travel from an origin to a destination on a trip that might include multiple modes of travel. (See Note 1)

**Includes:** Travel times on all roadway and mode types under both recurring and non-recurring traffic conditions.

**Units of Measurement:** Minutes per trip

**Processing (**How to measure)**:** Travel time is collected for multiple of trips from origin to destination. Travel time is computed as the sum of the travel time required for each mode used during the trip, including walking times and waiting times from origin to destination. The average time is calculated as the sum of the travel times divided by the number of trips. Care must be taken to ensure that prevailing traffic and roadway conditions remain unchanged during the measurement period.

**Typical Applications:** Traveler information and outreach.

**Example:** The total time required to drive to a transit stop, waiting time for a transit vehicle, transit travel time, and walking time to a destination is included in a travel time computation to enable travelers to compare their time from origin destination on alternate travel modes.

**Notes:**

(1) Trip time is the total elapsed time from origin destination including all modes of transportation included in the trip.

## Definitions to Support Performance Measure Descriptions

**Floating Car Runs:** A data collection technique used to determine representative speeds and/or travel times for a section of roadway. During a floating car run, the driver attempts to drive at a representative speed by passing as many vehicles as have passed the floating car. Speeds and travel times are recorded as required for the performance measure being evaluated.

**Unconstrained Speed:** Two different definitions of unconstrained speed may optionally be used as the basis for the appropriate performance measures:

- Free-flow speed is the speed that occurs during good weather conditions, and with traffic densities low enough that motorist's speed is unaffected by interactions with other vehicles.
- Target speed occurs when vehicles are traveling at speeds established by operations personnel as the desired speed for a given roadway under prevailing roadway and traffic conditions

**Unconstrained Travel Time:** Two different definitions of unconstrained travel time may optionally be used as the basis for the appropriate performance measures:

- Free-flow travel time is defined as the time it takes motorists to traverse a roadway section when they are traveling at a speed representative of good weather conditions, and with traffic densities low enough that their speed is not affected by interactions with other vehicles.
- Target travel time is defined as the time it takes motorists to traverse a roadway section when they are traveling at speeds established by operations personnel as the desired speed for a given roadway under prevailing roadway and traffic conditions

# APPENDIX B

## RECOMMENDED CORE FREEWAY PERFORMANCE MEASURES
## NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM (NCHRP)
## *GUIDE TO EFFECTIVE FREEWAY PERFORMANCE MEASUREMENT*
## FEBRUARY 2007

**TABLE 9** Recommended Core Freeway Performance Measures

| Performance Metric | Definition | Units | Geographic Scale | Time Scale | Relationship to National Transportation Operations Coalition (NTOC) Measures |
|---|---|---|---|---|---|
| *Average (Typical) Congestion Conditions (Quality of Service)* | | | | | |
| Travel Time | The average time consumed by vehicles traversing a fixed distance of freeway | Minutes | Specific points on a section or a representative trip only; separately for GP and HOV lanes | Peak hour, a.m./p.m. peak periods, midday, daily | Direct correspondence to NTOC measure, but distinction between "link" and "trip" travel time is not used |
| Travel Time Index | The ratio of the actual travel rate to the ideal travel rate[a] | None; minimum value = 1.000 | Section and areawide as a minimum; separately for GP and HOV lanes | Peak hour, a.m./p.m. peak periods, midday, daily | Not recommended by NTOC |
| Total Delay, Vehicles | The excess travel time used on a trip, facility, or freeway segment beyond what would occur under ideal conditions[b] | Vehicle-hour | Section and areawide as a minimum; separately for GP and HOV lanes | Peak hour, a.m./p.m. peak periods, midday, daily | NTOC distinguishes between recurring and nonrecurring delay; delay by source recommended by *Guidebook* as supplements |
| Total Delay, Persons | The excess travel time used on a trip, facility, or freeway segment beyond what would occur under ideal conditions[c] | Person-hours | Section and areawide as a minimum; separately for GP and HOV lanes | Peak hour, a.m./p.m. peak periods, midday, daily | NTOC distinguishes between recurring and nonrecurring delay; delay by source recommended by *Guidebook* as supplements |
| Delay per Vehicle | Total freeway delay divided by the number of vehicles using the freeway | Hours (vehicle-hours per vehicle) | Section and areawide | Peak hour, a.m./p.m. peak periods; daily | Not recommended by NTOC |
| Spatial Extent of Congestion No. 1 | Percent of Freeway VMT with Average Section Speeds <50 mph[d] | Percent | Section and areawide | Peak hour, a.m./p.m. peak periods | NTOC uses a single measure with different thresholds, but the concept is fundamentally the same |
| Spatial Extent of Congestion No. 2 | Percent of Freeway VMT with Average Section Speeds <30 mph | Percent | Section and areawide | Peak hour, a.m./p.m. peak periods | |
| Temporal Extent of Congestion No. 1 | Percent of Day with Average Freeway Section Speeds <50 mph | Percent | Section and areawide | Daily | NTOC uses a single measure with different thresholds, but the concept is fundamentally the same |
| Temporal Extent of Congestion No. 2 | Percent of Day with Average Freeway Section Speeds <30 mph | Percent | Section and areawide | Daily | |
| Density | Number of vehicles occupying a length of freeway | Vehicles per lane-mile | Section | Peak hour/periods for weekday/weekend | Not recommended by NTOC |

(*continued on next page*)

**TABLE 9** (Continued)

| Performance Metric | Definition | Units | Geographic Scale | Time Scale | Relationship to National Transportation Operations Coalition (NTOC) Measures |
|---|---|---|---|---|---|
| *Reliability (Quality of Service)* | | | | | |
| Buffer Index | The difference between the 95th percentile travel time and the average travel time, normalized by the average travel time | Percent | Section and areawide | Peak hour, a.m./p.m. peak periods, midday, daily | NTOC recommends a "buffer time" which is the difference between the 95th percentile travel time and the average; conceptually the same as the *Guidebook* |
| Planning Time Index | The 95th Percentile Travel Time Index | None; minimum value = 1.000 | Section and areawide | Peak hour, a.m./p.m. peak periods, midday, daily | |
| *Capacity Bottlenecks (Activity-Based)* | | | | | |
| Geometric Deficiencies Related to Traffic Flow (Potential Bottlenecks) | Count of potential bottleneck locations by type[e] | Number | Section and areawide | N/A | Not recommended by NTOC |
| Major Traffic-Influencing Bottlenecks | Count of locations that are the primary cause of traffic flow breakdown on a highway section, by type | Number | Section and areawide | N/A | Not recommended by NTOC |
| *Throughout (Quality of Service)* | | | | | |
| Throughout—Vehicle | Number of vehicles traversing a freeway in vehicles | Vehicles per unit time | Section and areawide | Peak hour, a.m./p.m. peak periods, midday, daily | Direct correspondence to NTOC measure |
| Throughout—Persons | Number of persons traversing a freeway | Persons per unit time | Section and areawide | Peak hour, a.m./p.m. peak periods, midday, daily | Direct correspondence to NTOC measure |
| Vehicle-Miles of Travel | The product of the number of vehicles traveling over a length of freeway times the length of the freeway | Vehicle-miles | Section and areawide | Peak hour, a.m./p.m. peak periods, midday, daily | Not recommended by NTOC |
| Truck Vehicle-Miles of Travel | The product of the number of trucks traveling over a length of freeway[f] times the length of the freeway | Vehicle-miles | Section and areawide | Peak hour, a.m./p.m. peak periods, midday, daily | Not recommended by NTOC |
| Lost Highway Productivity | Lost capacity due to flow breakdown—the difference between measured volumes on a freeway segment under congested flow versus the maximum capacity for that segment | Vehicles per hour | Section and areawide | Peak hour, a.m./p.m. peak periods, midday, daily | Not recommended by NTOC |
| *Customer Satisfaction (Quality of Service)* | | | | | |
| Worst Aspect of Freeway Congestion | (Defined by question) | (1) happens every work day; (2) incidents that are not cleared in time; and (3) encountering work zones | Areawide or statewide | Annually; tied to survey frequency | Not recommended by NTOC |

| | | | | | |
|---|---|---|---|---|---|
| Satisfaction with Time to Make Long-Distance Trips Using Freeways | (Defined by question) | (1) very satisfied; (2) somewhat satisfied; (3) neutral; (4) somewhat dissatisfied; (5) very dissatisfied; and (6) do not know | Areawide or statewide | Annually; tied to survey frequency | Direct correspondence to NTOC measure |
| *Safety (Quality of Service)* | | | | | |
| Total Crashes | Freeway crashes as defined by the State, i.e., those for which a police accident report form is generated | Number | All safety measures computed areawide; section level may be computed if multiple years are used | All safety measures computed annually | Not recommended by NTOC |
| Fatal Crashes | Freeway crashes as defined by the State, i.e., those for which a police accident report form is generated, where at least one fatality occurred | Number | | | Not recommended by NTOC |
| Overall Crash Rate | Total freeway crashes divided by freeway VMT for the time period considered | Number per 100 million vehicle-miles | | | Not recommended by NTOC |
| Fatality Crash Rate | Total freeway fatal crashes divided by freeway VMT for the time period considered | Number per 100 million vehicle-miles | | | Not recommended by NTOC |
| Secondary Crashes | A police-reported crash that occurs in the presence of an earlier crash[g] | Number | | | Not recommended by NTOC |
| *Ride Quality (Quality of Service)* | | | | | |
| Present Serviceability Rating (PSR) | The general indicator of ride quality on pavement surfaces[h] | Internal scale | Section and areawide | Annually | Not recommended by NTOC |
| International Roughness Index (IRI) | Cumulative deviation from a smooth surface | Inches per mile | Section and areawide | Annually | Not recommended by NTOC |
| *Environment (Quality of Service)* | | | | | |
| Nitrous Oxides ($NO_x$) Emission Rate | Modeled $NO_x$ attributable to freeways divided by freeway VMT | Number | Section and areawide | Annually | Not recommended by NTOC |
| Volatile Organic Compound (VOC) Emission Rate | Modeled VOC attributable to freeways divided by freeway VMT | Number | Section and areawide | Annually | Not recommended by NTOC |
| Carbon Monoxide (CO) Emission Rate | Modeled CO attributable to freeways divided by freeway VMT | Number | Section and areawide | Annually | Not recommended by NTOC |
| Fuel Consumption per VMT | Modeled gallons of fuel consumed on a freeway divided by freeway VMT | Number | Section and areawide | Annually | Not recommended by NTOC |
| *Incident Characteristics (Activity-Based)* | | | | | |
| No. of Incidents by Type and Extent of Blockage | Self-explanatory | Type: (1) crash; (2) vehicle breakdown; (3) spill; and (4) other. Blockage: Actual number of lanes blocked; separate code for shoulder blockage | Section and areawide | a.m./p.m. peak periods, daily | Not recommended by NTOC |



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**TABLE 9** (Continued)

| Performance Metric | Definition | Units | Geographic Scale | Time Scale | Relationship to National Transportation Operations Coalition (NTOC) Measures |
|---|---|---|---|---|---|
| Incident Duration[i] | The time elapsed from the notification of an incident to when the last responder has left the incident scene | Minutes (median) | Section and areawide | a.m./p.m. peak periods, daily | Direct correspondence to NTOC measure |
| Blockage Duration | The time elapsed from the notification of an incident to when all evidence of the incident (including responders' vehicles) has been removed from the travel lanes | Minutes (median) | Section and areawide | a.m./p.m. peak periods, daily | Not recommended by NTOC |
| Lane-Hours Loss Due to Incidents | The number of whole or partial freeway lanes blocked by the incident and its responders, multiplied by the number of hours the lanes are blocked | Lane-hours | Section and areawide | a.m./p.m. peak periods, daily | Not recommended by NTOC |
| *Work Zones (Activity-Based)* | | | | | |
| No. of Work Zones by Type of Activity | The underlying reason why the work zone was initiated: (1) resurfacing only; (2) RRR; (3) lane addition w/o interchanges; (4) lane additions w/interchanges; (5) minor cross-section; (6) grade flattening; (7) curve flattening; (8) bridge deck; (9) bridge superstructure; (10) bridge replacement; and (11) sign-related | Number | Section and areawide | Daily | Not recommended by NTOC |
| Lane-Hours Lost Due to Work Zones | The number of whole or partial freeway lanes blocked by the work zone, multiplied by the number of hours the lanes are blocked | Lane-hours | Section and areawide | a.m./p.m. peak periods; midday; night; daily | Not recommended by NTOC |
| Average Work Zone Duration by Type of Activity | The elapsed time that work zone activities are in effect | Hours | Section and areawide | Daily | Not recommended by NTOC |
| Lane-Miles Lost Due to Work Zones | The number of whole or partial freeway lanes blocked by the work zone, multiplied by the length of the work zone | Lane-miles | Section and areawide | a.m./p.m. peak periods, daily | Not recommended by NTOC |
| *Weather (Activity-Based)* | | | | | |
| Extent of highways affected by snow or ice | Highway centerline mileage under the influence of uncleared snow or ice multiplied by the length of time of the influence | Centerline-Mile-Hours | Section and areawide | Daily | Not recommended by NTOC |
| Extent of highways affected by rain | Highway centerline mileage under the influence of rain multiplied by the length of time of the influence | Centerline-Mile-Hours | Section and areawide | Daily | Not recommended by NTOC |

| | | | | | |
|---|---|---|---|---|---|
| Extent of highways affected by fog | Highway centerline mileage under the influence of fog multiplied by the length of time of the influence | Centerline-Mile-Hours | Section and areawide | Daily | Not recommended by NTOC |
| *Operational Efficiency (Activity-Based)* | | | | | |
| Percentage of Freeway Directional Miles (with traffic sensors, surveillance cameras, DMS, service patrol coverage) | One measure for each type of equipment deployed in an area | Percentage (xxx.x%) | Section and areawide | Annually | Not recommended by NTOC |
| Percentage of Equipment (DMS, surveillance cameras, traffic sensors, ramp meters, RWIS) in "Good" or Better Condition | | Percentage (xxx.x%) | Section and areawide | Annually | Not recommended by NTOC |
| Percentage of total device-days out-of-service (by type of device) | | Percentage (xxx.x%) | Section and areawide | Annually | Not recommended by NTOC |
| Service patrol assists | Self-explanatory | Number | Section and areawide | Annually | Not recommended by NTOC |

[a]Travel rate is the inverse of speed, measured in minutes per mile. The "ideal travel rate" is the rate that occurs at the free flow speed of a facility, or a fixed value set for all facilities that is meant to indicate ideal conditions or "unconstrained" (see text for discussion of the ideal/unconstrained/free flow speed).

[b]See text above for definition of "ideal."

[c]See text above for definition of "ideal."

[d]A freeway "section" is a length of freeway that represents a relatively homogenous trip by users. Logical breakpoints are major interchanges (especially freeway-to-freeway) and destinations (e.g., Central Business District). The term "section" is sometimes used to describe this, but it usually implies additional parallel freeways and/or transit routes.

[e]Bottleneck types are Types A-C weaving areas (see HCM and Section 7.0); left exits; freeway-to-freeway merge areas; surface street on-ramp merge areas; acceleration lanes at merge areas <300 feet; lane drops; lane width drops >= 1 foot; directional miles with left shoulders <6 feet; directional miles with right shoulders <6 feet; steep grades; substandard horizontal curves. The shoulder categories are included because of the ability of more than 6-foot shoulders to shelter vehicles during traffic incidents.

[f]Trucks are defined as vehicles with at least six tires, i.e., FHWA Classes 5–13 plus any larger vehicles as defined by a state.

[g]See text for discussion.

[h]See: http://www.fhwa.dot.gov/policy/1999cpr/ch_03/cpg03_2.htm.

[i]Since in many cases the actual time the incident occurred is unknown, the notification time is used to indicate the official "start" of the incident. On most urban freeways, through the use of cell phones by the public, the time between when the incident occurs and when it is first reported is very small.

**Table 10** Supplemental Recommended Freeway Performance Measures

| Performance Metric | Definition | Units | Geographic Scale | Time Scale | Relationship to National Transportation Operations Coalition (NTOC) Measures |
|---|---|---|---|---|---|
| *Average Congestion Conditions (Quality of Service)* | | | | | |
| Bottleneck ("Recurring") Delay | Delay that is attributable to bottlenecks[j] | Vehicle-hours | Section and areawide | Peak hour, a.m./p.m. peak periods, midday, daily | NTOC defines two categories: recurring and nonrecurring; see text for discussion |
| Incident Delay | Delay that is attributable to traffic incidents | Vehicle-hours | Section and areawide | Peak hour, a.m./p.m. peak periods, midday, daily | |
| Work Zone Delay | Delay that is attributable to work zones | Vehicle-hours | Section and areawide | Peak hour, a.m./p.m. peak periods, midday, daily | |
| Weather Delay | Delay that is attributable to inclement weather | Vehicle-hours | Section and areawide | Peak hour, a.m./p.m. peak periods, midday, daily | |
| Ramp delay (where ramp metering exists) | Delay that occurs at ramp meters | Vehicle-hours | Individual ramps and section as a minimum | Peak hour, a.m./p.m. peak periods | |
| Abnormal Volume-Related Delay | Delay caused by abnormal high volumes[k] | Vehicle-hours | Section and areawide | Peak hour, a.m./p.m. peak periods, midday, daily | |
| Volume-to-capacity ratio | The ratio of the demand volume attempting to use a short segment of freeway divided by the freeway's capacity, as defined by the *HCM* | None | Bottleneck locations only (freeway interchanges, lane-drops, bridges) | Peak-hour volume/ peak-hour capacity<br>Peak-period volume/ peak-period capacity | Not recommended by NTOC |
| Traffic Demand Indicator | Ratio of actual traffic demand (volume) to average traffic demand[l] | None | Section and areawide | Peak+Shoulder Periods | Not recommended by NTOC |
| Delay per Capita | Total freeway delay divided by the population of the area being studied | Vehicle-hours per person | Areawide and statewide | Peak hour, a.m./p.m. peak periods; daily | Not recommended by NTOC |
| Average speeds by hour of the day (used primarily as an indicator of air quality) | The miles traveled by vehicles over a distance divided by the time it took to travel that distance (space mean speed)[m] | Miles per hour | Section and areawide | Peak hour, a.m./p.m. peak periods; daily | NTOC defines "speed" as the time mean speed |
| *Reliability (Quality of Service)* | | | | | |
| Reliability: Failure Measure No. 1 | Percentage of trips (section or O/D) with space mean speeds <= 50 mph | Percent | Section and areawide | Peak hour, a.m./p.m. peak periods, midday, daily | Not recommended by NTOC |
| Reliability: Failure Measure No. 2 | Percentage of trips (section or O/D) with space mean speeds <= 30 mph | Percent | Section and areawide | Peak hour, a.m./p.m. peak periods, midday, daily | Not recommended by NTOC |
| Planning Time Index | 95th percentile travel time divided by the free flow travel time | N/A | Section and areawide | Peak hour, a.m./p.m. peak periods, midday, daily | Not recommended by NTOC |

| | | | | | |
|---|---|---|---|---|---|
| *Throughput (Quality of Service)* | | | | | |
| VMT per capita | Freeway VMT divided by the population of the study area | N/A | Section and areawide | Peak hour, a.m./p.m. peak periods, midday, daily | Not recommended by NTOC |
| *Customer Satisfaction (Quality of Service)*[n] | All customer satisfaction measures apply areawide or statewide<br>All customer satisfaction measures developed every 1–3 years | | | | |
| Biggest concern about transportation[o] | Defined by survey question | Percent | | | Not recommended by NTOC |
| Most important thing the Department could do to improve congestion[p] | Defined by survey question | Percent | | | Not recommended by NTOC |
| Usage rates and percent of favorable response to broadcast video images | Defined by survey question | Percent | | | Not recommended by NTOC |
| Usage rates and percentage of favorable response to traveler information about (1) congestion and (2) work zones | Defined by survey question | Percent | | | Not recommended by NTOC |
| Usage rates and percentage of favorable response to DMS messages | Defined by survey question | Percent | | | Not recommended by NTOC |
| Usage rates and percentage of favorable response to service patrols | Defined by survey question | Percent | | | Not recommended by NTOC |
| Percentage of favorable response to work zone management | Defined by survey question | Percent | | | Not recommended by NTOC |
| Percentage of favorable response to freeway planning process | Defined by survey question | Percent | | | Not recommended by NTOC |
| Percentage of favorable response with completed projects | Defined by survey question | Percent | | | Not recommended by NTOC |
| Percentage of favorable response with air quality | Defined by survey question | Percent | | | Not recommended by NTOC |
| Percentage of favorable response with long-distance travel | Defined by survey question | Percent | | | Not recommended by NTOC |



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**Table 10** (Continued)

| Performance Metric | Definition | Units | Geographic Scale | Time Scale | Relationship to National Transportation Operations Coalition (NTOC) Measures |
|---|---|---|---|---|---|
| Percentage of favorable response with pavement condition | Defined by survey question | Percent | | | Not recommended by NTOC |
| Percentage of favorable response with highway safety (how safe it is to travel?) | Defined by survey question | Percent | | | Not recommended by NTOC |
| Percentage of favorable response with amount of salt used on main rural highways | Defined by survey question | Percent | | | Not recommended by NTOC |
| Percentage of favorable response with environmental aspects of road construction | Defined by survey question | Percent | | | Not recommended by NTOC |
| Percentage of favorable response with environmental aspects of road planning and design | Defined by survey question | Percent | | | Not recommended by NTOC |
| *Customer Satisfaction (Quality of Service)*[q] | All customer satisfaction measures apply areawide or statewide<br>All customer satisfaction measures developed every 1–3 years | | | | |
| Safety (Quality of Service) | All safety data defined by state police accident report (PAR) | | All safety measures computed areawide; section level may be computed if multiple years are used | All safety measures computed annually | No safety measures recommended by NTOC |
| Number of fatal, injury, and PDO crashes—total and by (1) type of collision; (2) time of day; (3) relation to ramps; and (4) "first harmful event" (fixed object, rollover, etc.) | | Number; distribution percentages within each category | | | |
| High-crash locations[r] | | | Specific locations or short segments of freeway | | |
| Alcohol-involved crashes (fatal, injury, total) | | Number | | | |

| | | | | | |
|---|---|---|---|---|---|
| Commercial vehicle crashes (total and hazmat involved) | | Number | | | |
| Commercial vehicle crash rate | Total number of commercial vehicle crashes divided by commercial vehicle VMT | Rate | | | |
| Crashes where speed was a contributing factor | | Number | | | |
| Total Work Zone Crashes, Injuries, and Fatalities | | Number | | | |
| Total Weather-Related Crashes, Injuries, and Fatalities | | Number | | | |
| *Incident Management (Activity-Based)* | | | | | |
| First Responder Response Time | Time difference between when the incident was first detected by an agency and the on-scene arrival of the first responder | Minutes | Section and areawide | a.m./p.m. peak periods, daily | Not recommended by NTOC |
| Notification Time | Time difference between when the incident was first detected to when the last agency needed to respond to the incident was notified | Minutes | Section and areawide | a.m./p.m. peak periods, daily | Not recommended by NTOC |
| Total Response Time | Time difference between when the incident was first detected by an agency and the on-scene arrival of the last responder | Minutes | Section and areawide | a.m./p.m. peak periods, daily | Not recommended by NTOC |
| Clearance Time | Time difference between when the first responder arrived on the scene and blockage of a travel lane is removed | Minutes | Section and areawide | a.m./p.m. peak periods, daily | Not recommended by NTOC |
| On-Scene Time | Time difference between when the first responder arrives and the last responder leaves an incident scene; also may be computed for individual responders | Minutes | Section and areawide | | Not recommended by NTOC |
| *Customer Satisfaction (Quality of Service)*[s] | All customer satisfaction measures apply areawide or statewide<br>All customer satisfaction measures developed every 1–3 years | | | | |
| Linger Time | Time difference between when the blockage of a travel lane is removed and the last responder leaves the incident scene | Minutes | Section and areawide | | Not recommended by NTOC |
| Traffic Influence Time | Time between when an incident was first detected and the last responder leaves the incident scene | Minutes | Section and areawide | a.m./p.m. peak periods, daily | Not recommended by NTOC |
| Detection Method (citizens, police, other agencies) per month | The method by which incidents are detected or reported | Locally defined | Section and areawide | a.m./p.m. peak periods, daily | Not recommended by NTOC |
| Service patrol assists (total and by incident type) | | | Section and areawide | a.m./p.m. peak periods, daily | Not recommended by NTOC |

(*continued on next page*)

**Table 10** (Continued)

| Performance Metric | Definition | Units | Geographic Scale | Time Scale | Relationship to National Transportation Operations Coalition (NTOC) Measures |
|---|---|---|---|---|---|
| *Work Zones (Activity-Based)* | | | | | |
| Traffic volume passing through work zones | Self-explanatory; AADT estimates may be used in place of actual counts | Vehicles | Section and areawide | Daily | No work measures recommended by NTOC |
| Average Time Between Rehabilitation Activities by Type of Activity | Type of activity: (1) resurfacing only; (2) RRR; (3) lane addition w/o interchanges; (4) lane additions w/interchanges; (5) minor cross-section; (6) grade flattening; (7) curve flattening; (8) bridge deck; (9) bridge superstructure; (10) bridge replacement; and (11) sign-related | Months | Areawide | N/A | |
| Average Number of Days Projects Completed Late | "Late" is any time after the scheduled completion | Days | Areawide | N/A | |
| Ratio of Inactive Days to Active Days | "Active" is when some work zone activity was performed during a day | N/A | Areawide | Annually | |
| Crashes Per Lane-Mile Lost | Work zone crashes divided by the number of lanes lost | N/A | Section, areawide, and statewide | Annually | |
| Average Work Zone Duration by Work Zone Type by Lanes Lost | Time length of work zone activities by their severity in terms of traffic impact; Lanes lost = 0, 1, 2, 3, 4+ | Hours | Areawide | Annually | |
| Average Number of Days That a Contract Work Zone is Active | "Active" is when some work zone activity was performed during a day | Days | Areawide | Annually | |
| *Weather (Activity-Based)* | | | | | |
| Number of incident responses during weather-related events | Self-explanatory | Number | Areawide | Monthly and annually | |
| Lane-miles and freeway miles officially closed due to weather or flooding | Self-explanatory | Lane-miles | Areawide | Monthly and annually | |
| Number of freeways with reduced speed limits by MP3 reductions | Self-explanatory | Number | Areawide | Monthly and annually | |
| Number of freeway ramps closed due to weather by weather event | Self-explanatory | Number | Areawide | Annually | |

| | | | | |
|---|---|---|---|---|
| *Customer Satisfaction (Quality of Service)*[t] | All customer satisfaction measures apply areawide or statewide<br>All customer satisfaction measures developed every 1–3 years | | | |
| Weather (Activity-Based) | | | | |
| Time between 2 inches of snow accumulation and plowing (clearance) | Self-explanatory | Minutes | Areawide (lane-mile weighted) | Annually |
| Lane-miles pretreated with chemical snow/ ice control | Self-explanatory | Lane-miles | Areawide | Annually |
| Lane-miles pretreated with chemical snow/ice control that experienced snow or ice conditions | Self-explanatory | Lane-miles | Areawide | Annually |
| Weather event VMT ratio | VMT during event: VMT for recent same DOW | N/A | Areawide | Annually |
| Weather event delay ratio | Delay during event: Delay for recent same DOW | N/A | Areawide | Annually |
| Delay per lane-mile affected by major weather events | Self-explanatory | Rate | Areawide | Annually |
| Crashes per lane-mile affected by major weather events | Self-explanatory | Rate | Areawide | User-specified |
| *Operational Efficiency (Activity-Based)*[u] | | | | |
| Service patrol vehicles in operation per shift | Self-explanatory | Number | Section and areawide | User-specified |
| Percentage of freeway miles (with electronic data collection, surveil-lance cameras, DMS, service patrol coverage) | Self-explanatory | Percent | Areawide | User-specified |
| Number of messages placed on DMSs | Self-explanatory | Number | Section and areawide | User-specified |
| Individuals receiving traveler information by source (511, other direct means) | Self-explanatory | Number | Section and areawide | User-specified |
| Percentage of equipment (DMS, surveillance cameras, sensors, ramp meters, RWIS) in "good" or better condition | Self-explanatory | Percent | Section and areawide | User-specified |



(*continued on next page*)

**Table 10** (Continued)

| Performance Metric | Definition | Units | Geographic Scale | Time Scale | Relationship to National Transportation Operations Coalition (NTOC) Measures |
|---|---|---|---|---|---|
| Percentage of total device-days out-of-service (by type of device) | Self-explanatory | Percent | Section and areawide | User-specified | |
| Incident detection method | Self-explanatory | Number | Areawide | User-specified | |
| No. devices exceeding design life | Self-explanatory | Number | Section and areawide | User-specified | |
| MTBF for field equipment (by type of device) | Self-explanatory | Days | Section and areawide | User-specified | |
| Number of freeway miles instrumented with traffic data collection devices | Self-explanatory; directional miles | Miles | Areawide | User-specified | |
| Freeway construction projects completed within 30 days of scheduled completion | Self-explanatory | Number | Areawide | | |

[j]Delay is the excess travel time used on a trip, facility, or freeway segment beyond what would occur under ideal conditions; see text for a discussion of "ideal" conditions.
[k]May be due to either special events or normal variation due to daily/seasonal fluctuations in demand.
[l]See text for a more complete explanation.
[m]Although the *Guidebook* calls this space mean speed, depending on how the measurements are taken, it may be a "synthesized" space mean speed. That is, if the basic measurements are from point detectors, theoretically speaking, it is closer to being a time mean speed.
[n]Usually included in statewide surveys of public's attitudes toward transportation and service provided; also may be done at the local level.
[o](1) Congestion, (2) poor road and bridge condition, (3) highway crashes, (4) transit not available.
[p](1) Build more roads, (2) clear incidents faster, (3) reduce time that work zones are needed, (4) more effective snow removal, (5) better inform travelers about congestion they will encounter on their trips.
[q]Usually included in statewide surveys of public's attitudes toward transportation and service provided; also may be done at the local level.
[r]Most states have procedures for identifying high-crash locations. Additional guidance may be available through software packages such as FHWA's *SafetyAnalyst.*
[s]Usually included in statewide surveys of public's attitudes toward transportation and service provided; also may be done at the local level.
[t]Usually included in statewide surveys of public's attitudes toward transportation and service provided; also may be done at the local level.
[u]A multitude of other operational efficiency measures resides in asset management information and performance measurement systems.

# APPENDIX C

# DRAFT TOOLBOX OF CONGESTION MANAGEMENT STRATEGIES

Appendix
Toolbox of Potential Strategies

| Category | Strategy Classification | Representative Strategies | Description | Implementation | Benefits |
|---|---|---|---|---|---|
| **Category 1: Eliminate Person Trips or Reduce VMT During Peak Hour** | Policy Management / Activity Centers | Land Use Policies/Regulations | Along Rapid Transit corridors (1/2 mile band): Zoning Regulations, Access to Jobs- Jobs/Housing Balance, Initiatives to develop in areas of existing infrastructure. | Long Term 10 or more years | Reduce travel need. Reduce travel time. Reduce person hours of travel. Increase mode choices. Reduce person hours of travel. Reduce travel distance. Increase mode choices. Reduce emissions. Reduce fuel consumption. Reduce cost of transportation to the community. |
| | | Development Design Standards | Along Rapid Transit corridors (1/2 mile band): Zoning Regulations, Access to Jobs- Jobs/Housing Balance, Initiatives to develop in areas of existing infrastructure. | Long Term 10 or more years | |
| | | Land Use / Transportation | Strategies integrating land development with multimodal options at the development stage. | Long Term 10 or more years | |
| | | Density Clusters | Create new higher land use densities to reduce travel distances and improve travel options. | Long Term 10 or more years | |
| | | Mixed Use Development | Mix commercial, retail and residential land use enabling areas to become self-sufficient; reduces the need to drive for services. | Long Term 10 or more years | |
| | | Concurrency management; trip budgets for new development | Development regulations stipulating limits on impacts to the transportation system for new development proposals. | Long Term 10 or more years | |
| | | Incentives to encourage employees to live closer to work. | Examples: Waiver of head tax, low-interest home loans, housing subsidy | Long Term 10 or more years | |
| | | Subsidized housing near transit facilities | Provide financial incentives to encourage residential development where residents are more likely to utilize transit. | Long Term 10 or more years | |
| | Travel Demand Management | Telecommuting | Employees work from home or telecommute center instead of traveling to the office. Could be full time or only one or more days per week. | Short Term 1 to 5 years | Reduce travel need. Reduce travel time. Reduce person hours of travel. Increase mode choices. Reduce person hours of travel. Reduce travel distance. Increase mode choices. |
| | | Preferential Parking | Choice parking locations designated for carpools and vanpools. | Short Term 1 to 5 years | |
| | | Staggered work hours/Flexible work hours | Employees are assigned arrival and departure times by their employer outside the usual commute periods. | Short Term 1 to 5 years | |
| | | Compressed work week | Unique work schedule allowing employees to work typical work week hours in only a few days. | Short Term 1 to 5 years | |

| Category | Strategy Classification | Representative Strategies | Description | Implementation | Benefits |
|---|---|---|---|---|---|
| **Category 1: Eliminate Person Trips or Reduce VMT During Peak Hour (cont.)** | Travel Demand Management (cont.) | Carpool Incentives | Incentives for commuters to share rides in carpools and vanpools. | Short Term 1 to 5 years | Reduce emissions. Reduce fuel consumption. Reduce cost of transportation to the community. |
| | | Vanpool Programs | Vanpool operation, marketing and promotion. | Short Term 1 to 5 years | |
| | | Guaranteed Ride Home | Guarantees transportation to carpool/vanpool rides due to unexpected schedule changes. | Short Term 1 to 5 years | |
| | | Transit Oriented Development | Encourage transit ridership by developing residential and commercial centers designed to maximize access by Transit and Nonmotorized transportation. | Long Term 10 or more years | |
| | | Intermodal Transit Systems | Construct intermodal infrastructure and facilities to provide modal connectivity. | Long Term 10 or more years | |
| | | Vehicle Use Limitations | Include various regulatory strategies to limit automobile travel at a particular time and place. | Long Term 10 or more years | |
| | Congestion Pricing | Road User Fees | Assess taxes on VMT or gas consumption. | Long Term 10 or more years | Reduce travel time. Reduce person hours of travel. Reduce person hours of travel. Reduce travel distance. Increase mode choices. Reduce emissions. Reduce fuel consumption. Reduce cost of transportation to the community. |
| | | Toll Roads / HOT | Assessing a fee to each vehicle for the use of a roadway. HOT lanes require single-occupant vehicles to pay a toll that varies based on demand. | Long Term 10 or more years | |
| | | Parking Management | Reduce auto trips by controlling the supply and price of parking | Short Term 1 to 5 years | |
| | | Peak Period Parking Surcharges | Staggered parking rates to encourage travel during off peak hours | Short Term | |
| | | Fuel Tax Increase | Financial disincentive to travel by single occupancy vehicle | Long Term 10 or more years | |
| | | Transit fare reductions / reduced fare zones, times | Provide financial incentives to transit use in congested areas and during peak times. | Short Term 1 to 5 years | |
| | | Increased property tax for private parking lots | Financial disincentive to oversupply of parking encourages alternative modes, and HOV use. | Short Term 1 to 5 years | |

| Category | Strategy Classification | Representative Strategies | Description | Implementation | Benefits |
|---|---|---|---|---|---|
| **Category 2: Shift Trips from Automobile to Other Modes** | Public Transit Capital Improvements | Exclusive Right of Way – New Rail Service | Exclusive right-of-way can be given to heavy rail, commuter rail, and light rail services. This is most appropriately applied in a densely populated area serving a major employment center. | Long Term<br>10 or more years | Reduce travel time.<br>Reduce person hours of travel.<br>Increase mode choices.<br>Reduce emissions.<br>Reduce fuel consumption.<br>Reduce cost of transportation to the community. |
| | | Exclusive Right of Way – Busways, Bus Only Lanes, Bus Bypass Ramps | Exclusive right of way can be given to bus ways, bus only lanes, and bus bypass ramps. This is applied to freeways and expressways with high existing transit ridership rates. | Long Term<br>10 or more years | |
| | | Fleet Expansion | Expansion of existing rail and/or bus capacity will provide increased service. | Short Term<br>1 to 5 years | |
| | | Improved Intermodal Connections | Intermodal facilities can be built or existing ones improved. These are the centers where several modes of transportation are physically and operationally integrated, such as a park-and-ride lot at a commuter rail station. | Long Term<br>10 or more years | |
| | | Improved / Increased Park-n-Ride Facilities | Construct secured parking lots to encourage people to use an adjacent transit line | Short Term<br>1 to 5 years | |
| | | Rapid Transit System | Medium capacity bus system operating on busways and with new technologies that allow buses to be partially or fully guided to improve operating speeds, capacity of busway facilities, and reduce facility right-of-way needs. | Long Term<br>10 or more years | |
| | | Paratransit Service | Add flexible routing or on-demand service | Long term<br>10 or more years | |
| | | Special Event or Activity Center Shuttle Service | Add service for events | Short Term<br>1 to 5 years | |
| | | More / better amenities | Make transit more attractive by providing improved shelters, newer buses, etc. | Short Term<br>1 to 5 years | |

| Category | Strategy Classification | Representative Strategies | Description | Implementation | Benefits |
|---|---|---|---|---|---|
| **Category 2: Shift Trips from Automobile to Other Modes (cont.)** | Public Transit Operational Improvements | Service Expansion | Increase transit system efficiency by redesigning routes to better serve the public, enhancing transit service, additional transit facilities. | Short Term 1 to 5 years | Reduce travel time. Reduce person hours of travel. Increase mode choices. Reduce emissions. Reduce fuel consumption. Reduce cost of transportation to the community. |
| | | Express Routes | Provide express transit line from one area of the city to another (usually located at Park-and-Rides). | Short Term 1 to 5 years | |
| | | Traffic Signal Priority | Reduce transit travel time and attractiveness of using transit by providing signal priority for buses / light rail | Short Term 1 to 5 years | |
| | | Fare Reductions / Reduced Rate of Fare Increase | Provide economic incentive to use transit by reducing fares or limiting rate of fare increase | Short Term 1 to 5 years | |
| | | Transit Information Systems | Increase travelers convenience and promote ridership with a system providing pre-trip planning information via interactive voice response telephone information, kiosks, and the internet. | Medium Term 5 to 10 years | |
| | | Transit Schedule Coordination (e.g., Timed transfers) | Optimize schedules between connecting routes to minimize transfer delay. | Short Term 1 to 5 years | |
| | | Transit Promotion / Marketing | Encourage transit ridership with public information / promotion program. | Short Term 1 to 5 years | |
| | | Service Revision Focusing on Congestion Relief | More service in congested corridors, more freeway express service, shuttle service | Short Term 1 to 5 years | |
| | | Turn Restriction Exemption | Reduces travel time by eliminating detours to avoid turn restrictions | Short Term 1 to 5 years | |
| | | Bus Stop Relocation | Uses existing signal progression to bus's advantage | Short Term 1 to 5 years | |
| | | Bus Stop Consolidation | Reduces the number of stops, thereby improving average bus speeds | Short Term 1 to 5 years | |
| | | Skip-stops | Reduces the number of stops and improves bus speed | Short Term 1 to 5 years | |
| | Advanced Public Transportation Systems | Intelligent Bus Stops | Satellite based communications technology providing passengers at bus stops with information regarding schedules, last bus, next bus, on-time / delay , etc. | Medium Term 5 to 10 years | |

| Category | Strategy Classification | Representative Strategies | Description | Implementation | Benefits |
|---|---|---|---|---|---|
| **Category 2: Shift Trips from Automobile to Other Modes (cont.)** | Non-Motorized Modes | Bikeway Construction | Construction of bikeway infrastructure to encourage bicycling as a mode of transportation (direct paths between popular destinations) | Short Term<br>1 to 5 years | Reduce travel time.<br>Reduce person hours of travel.<br>Increase mode choices.<br>Reduce emissions.<br>Reduce fuel consumption.<br>Reduce cost of transportation to the community. |
| | | Bicycle / Transit Connection | Construction of paths and lockers at transit terminals to connect bike transportation with transit. | Short Term<br>1 to 5 years | |
| | | Improved/Expanded Pedestrian Network | Construction of pedestrian paths to encourage walking as a mode of transportation | Short Term<br>1 to 5 years | |
| | | Auto Restricted Zones | Auto free zones opening access to pedestrians, bikes, and transit | Long Term<br>10 or more years | |
| | | Grade Separation for Bicycles / Pedestrians | Construct pedestrian and bicycle overpasses and underpasses to encourage walking and bicycling as modes of transportation. | Long Term<br>10 or more years | |
| | | Bicycle/pedestrian amenities | Bike racks, lockers/showers, ped lighting, crossings, landscaping | Short Term<br>1 to 5 years | |
| | | Employer Trip Programs | Initiatives and incentives to employees to increase the use of non-motorized transportation alternatives | Long Term<br>10 or more years | |
| **Category 3: Shift Trips from SOV to HOV Auto/Van** | HOV Measures | High Occupancy Vehicle Lanes | Exclusive commuter lanes added to freeways for vehicles with a minimum number of occupants | Long Term<br>10 or more years | Reduce travel time.<br>Reduce person hours of travel.<br>Increase mode choices.<br>Reduce emissions.<br>Reduce fuel consumption.<br>Reduce cost of transportation to the community. |
| | | Preferential Parking or Free Parking for HOVs | Provides incentive for employees to carpool | Short Term<br>1 to 5 years | |
| | | Employer Trip Programs | Incentives to increase the vehicle occupancy rate of employees through carpooling or vanpooling (See Strategy 1 Travel Demand Management) | Short Term<br>1 to 5 years | |

| Category | Strategy Classification | Representative Strategies | Description | Implementation | Benefits |
|---|---|---|---|---|---|
| **Category 4: Improve Roadway Operations** | Access Management | Access Management | Policies and standards that control access to different land uses by limiting curb and median cuts | Short Term<br>1 to 5 years | Reduce travel time.<br>Reduce person hours of travel.<br>Reduce emissions.<br>Reduce fuel consumption.<br>Reduce cost of transportation to the community. |
| | Incident Management | Special Event Management | Coordination of special events outside peak traffic hours | Short Term<br>1 to 5 years | Reduce travel time.<br>Reduce person hours of travel.<br>Reduce emissions.<br>Reduce fuel consumption.<br>Reduce cost of transportation to the community. |
| | | Incident Detection and Response | Real time monitoring and reaction to incidents through high technology (i.e. Freeway Surveillance with Courtesy Patrol) | Medium Term<br>5 to 10 years | |
| | Traffic Operational Improvements | Loading Zone Restrictions | Loading facilities designed so truck deliveries are completed quicker and with less obstruction to traffic. | Short Term<br>1 to 5 years | Reduce travel time.<br>Reduce person hours of travel.<br>Reduce travel distance.<br>Reduce emissions.<br>Reduce fuel consumption.<br>Reduce cost of transportation to the community. |
| | | Railroad Crossing Improvements | Removal of bottlenecks at railroad crossings | Short Term<br>1 to 5 years | |
| | | Arterial Grade Separation | Control traffic flow through limited side street access. | Short Term<br>1 to 5 years | |
| | | “X-Ramp” Construction | Relocate freeway ramps where access occurs prior to the intersection while the exit occurs immediately after the cross street. | Short Term<br>1 to 5 years | |
| | | Turn-around lanes | Remove turn-around traffic from gateway intersections by constructing continuous turn-around lanes prior to the intersection. | Short Term<br>1 to 5 years | |
| | | Interstate Access Reduction | Limit freeway access to longer commutes and redirect shorter trips to urban arterials. | Short Term<br>1 to 5 years | |

| | | | | | |
|---|---|---|---|---|---|
| **Category 4: Improve Roadway Operations (cont.)** | Traffic Operational Improvements (cont.) | Signal Optimization | Improve peak hour traffic flow by timing signals through signalized intersections. | Short Term<br>1 to 5 years | |
| | | Bridge Construction/Widening | Construction / widening of a bridge structure to improve connectivity and traffic flow. | Short Term<br>1 to 5 years | |
| | | Arterial Improvements | Construction of medians, resurfacing or other geometric improvements to improve traffic flow. | Short Term<br>1 to 5 years | |
| | | Intersection Improvements | Improve traffic flow through construction of turn lanes, widening or other geometric improvements | Short Term<br>1 to 5 years | |
| | | Freight Movement Management | The timing of deliveries may be changed by dictating when deliveries are allowed or how long they may take. | Long Term<br>10 or more years | |
| | Intelligent Transportation Systems | Freeway Info./ Motorist Assist. | Technology to mitigate congestion such as surveillance systems or electronic message billboards. | Medium Term<br>5 to 10 years | Reduce travel time.<br>Reduce person hours of travel.<br>Reduce travel distance.<br>Reduce emissions.<br>Reduce fuel consumption.<br>Reduce cost of transportation to the community. |
| | | Freeway Management | Control center monitors roadway conditions in order to coordinate traffic control, emergency response and traveler information. | Medium Term<br>5 to 10 years | |
| | | Traffic Signal Control | Such as advanced signal light synchronization and ramp metering to improve traffic flow. | Short Term<br>1 to 5 years | |
| | | Incident Information/Routing | Highway advisory radio and variable message signs and internet traffic reports that provide real-time information and advice to drivers. | Medium Term<br>5 to 10 years | |
| | | Fleet Management | Allows transit, taxi and truck fleet managers to monitor the locations, condition and performance of vehicles and freight. | Short Term<br>1 to 5 years | |
| | | Transit Priority Systems | Give transit vehicles priority through an intersection. | Medium Term<br>5 to 10 years | |

| Category | Strategy Classification | Representative Strategies | Description | Implementation | Benefits |
|---|---|---|---|---|---|
| **Category 5: Add Capacity** | Capacity Expansion | Freeway Capacity | Addition of travel lanes to increase capacity and improve traffic flow. | Long Term 10 or more years | Reduce travel time. Reduce person hours of travel. Reduce travel distance. Reduce emissions. Reduce fuel consumption. Reduce cost of transportation to the community. |
| | | Frontage Road Capacity | Addition of frontage roads to increase capacity and improve traffic flow. | Long Term 10 or more years | |
| | | Arterial Capacity | Addition of travel lanes to increase capacity and improve traffic flow. | Long Term 10 or more years | |

## APPENDIX D

## REVISED PAG TIP MAJOR PROJECT FUNDING APPLICATION FORM

# TRANSPORTATION IMPROVEMENT PROGRAM
# PROJECT DATA
# TO SUPPORT
# MAJOR PROJECTS
# FUNDING APPLICATION

PROJECT NAME _____ SPONSOR ID _____

TIP ID #_____ | SPONSOR PRIORITY _____

## SAFETY BENEFITS

1. What are the safety problems in the project area? Describe recent accident history, lack of lighting, substandard geometry, etc. (3 year history)

| Scoring: | Level of Safety Problems | Points |
|---|---|---|
| | High | 20 |
| | Medium | 10 |
| | Low | 5 |

2. How does the project propose to address the safety conditions in the project area?

Scoring: Secondary multiplier - Subjective 0 to 1

1. 1 = The project will likely solve all of the safety problems in the project area.
2. .75 = The project will make a major contribution to eliminating the safety problems in the project area.
3. .5 = The project will make a minor contribution to eliminating the safety problems in the project area.
4. 0 = The project will not contribute to eliminating the safety problems in the project area.

Total Safety Score = _____points x _____multiplier = _____ (Max of 20 points)

## SYSTEM PRESERVATION

3. What is the average Pavement Condition Index, Bridge Sufficiency Index, or other infrastructure condition in the project area?

| Roadway Pavements | | Bridges and other structures | |
|---|---|---|---|
| Condition | Points | Condition | Points |
| Good | 1 | Good (80-100) | 1 |
| Fair | 5 | Fair (50-80) | 5 |
| Poor | 10 | Poor (under 50) | 10 |

* Projects that do not address the identified condition problems get zero points.

Total System Preservation Score = _____ (Max of 10 points)

## NUMBER OF USERS WHO WILL BENEFIT

4. What is the average ADT on the most recent PAG traffic volumes maps? If the count is more than one year old, give the year the count was taken.

Existing ADT: Estimated Future ADT (2025):

Scoring: Total score is the sum of both tables below.

| Existing Conditions | | Future Conditions (2025) | |
|---|---|---|---|
| ADT | Points | ADT | Points |
| 70,000 or more | 6 | | |
| 55,000 - 69,999 | 5 | 60,000 or more | 4 |
| 40,000 - 54,999 | 4 | 40,000 – 54,999 | 3 |
| 25,000 - 39,999 | 3 | 25,000 – 39,000 | 2 |
| 10,000 - 24,999 | 2 | 10,000 – 24,999 | 1 |
| less than 10,000 | 1 | less than 10,000 | 0 |

Total User Benefit Score = _____ (Max of 10 points)

## CONGESTION BENEFITS

5. Is the project considered to be a "significant" project according to PAG's Congestion Management Process (CMP)*?

* PAG's Congestion Management Process defines a "significant" project as: <u>any project of one (1) mile or more that adds new general purpose travel lanes to an existing or new roadway</u>.

YES _____ NO _____

If "YES" please answer questions 5(a) through 5(d).
If "NO" proceed to question 6.

* A "significant" project is expected to result in a noteworthy increase in the carrying capacity for single occupant vehicles (SOVs) and have impacts on air quality. These projects are required to be addressed through a congestion management process. Projects meeting this requirement should answer questions 5(a) through 5(d) and identify congestion management strategies that are incorporated as part of the project. The PAG CMP Strategies Toolbox Worksheet (Appendix A) provides a list of congestion management strategies for incorporation as part of general transportation projects.

5(a) Are Federal funds being used or requested to support the project?

YES _____ NO _____

5(b) Is the project a significant increase in single occupant vehicle (SOV) capacity?

YES _____ NO _____

If "NO" please explain:

5(c) Does the project address a congestion issue as identified by PAG's transportation system reporting or other source?

YES _____ NO _____

If "YES" please explain the congestion issue, how it has been identified and how the project will address the issue:

5(d) Does the project incorporate congestion management strategies as identified in the PAG CMP Strategies Toolbox or otherwise?

YES _____ NO _____

Please identify the congestion management strategies included as part of the project. Use Appendix A "PAG CMP Strategies Toolbox Worksheet" to identify strategies.

COMPLETE APPENDIX A

| | | | |
|---|---|---|---|
| 6. | What is the average peak hour LOS in the project area before the project? | Average Daily LOS | Peak hour LOS |
| 7. | What will be the opening day LOS after the project is built? | Average Daily LOS | Peak Hour LOS |
| 8. | What is the estimated LOS for 2025 if the project is not built? | Average Daily LOS | Peak Hour LOS |
| 9. | What is the estimated 2025 LOS if the project is built? | Average Daily LOS | Peak Hour LOS |

Scoring (5-8): Total score is the sum of both tables below.

| Existing LOS | After project LOS | Points | 2025 Ave. LOS w/o the project | 2025 Ave. LOS w/ the project | Points |
|---|---|---|---|---|---|
| E | D or better | 3 | E | D or better | 3 |
| F | D or better | 5 | F | D or better | 5 |
| F | E | 4 | F | E | 4 |

Total Congestion Score = _____ (Max of 10 points)

## ENVIRONMENTAL BENEFITS

10. How does the project support or promote any of the following?
    1. Use of rubberized asphalt
    2. Use of recycled materials or salvage of existing materials
    3. Paving dirt roads
    4. Construction of new bicycle or pedestrian facilities
    5. Reductions in VMT or promotes alternate fuel useage

6. Provision of landscaping
7. Provision of special wildlife accommodations
8. Noise mitigation beyond legal requirements
9. Flood control facilities or removal of dip crossings
10. Specific improvements to control existing erosion problems
11. Adding new curbing and/or paved shoulders

Scoring: Score one point for each of the above items addressed by the project.

Total Environmental Score = _____ (Max 10 points)

## IMPROVED ACCESSIBILITY

11. How does the project improve access to public transit service? Address the following:
    1. New transit service.
    2. New transit amenities (shelters, sidewalk, etc.)
    3. Improved conditions on existing transit routes.

(Subjective up to 10 points)

12. How many lineal feet of new (not replacement) sidewalk or multi-use facility will be built with the project?

1 point for each 1000' of new (not replacement) sidewalk or multi-use facility (Max of 5 points)

Total Accessibility Score = _____ (Max of 15 points)

## IMPROVE SYSTEM CONTINUITY

13. Does the project contribute to the continuity of the system by completing missing links or extending a major corridor? If yes, please describe.

Scoring: Roadway missing links or extensions = 10 points
Sidewalk missing links or extensions = 2 points
Shoulders/bike path missing links or extensions = 2 points

Total Continuity score = _____ (Max of 10 points)

## REGIONAL SIGNIFICANCE

14. To what degree is the project consistent with local and regional land use plans?

Scoring: * Specifically listed in the RTP = 1 point
Specifically listed in sponsor's general plan = 4 points
Specifically listed in multiple jurisdiction's general plans = 9 points

* Reconstruction and major maintenance projects will be considered to be listed in both the RTP and the sponsor's local plans.

15. Does the project facilitate travel to destinations of significant regional importance? (Score 1 point for each of the following destinations served to a maximum of 3. Must be within 2 miles of the destination and directing traffic toward the destination.)

1. Mt. Lemmon
2. TIA
3. Desert Museum
4. Davis Monthan
5. Tucson Mall
6. University of Arizona & Tech Park
7. Park Mall
8. El Con Mall
9. Foothills Mall
10. All Major Hospitals
11. Sahuaro National Monument (East & West)
12. All PCC Campus'
13. Sabino Canyon
14. Tucson Convention Center
15. Pima Air Museum
16. All Casinos
17. La Encantada Shopping Center
18. Town Centers
19. Jewish Community Center
20. Others to be identified

Total Regional Significance score = _____ (Max of 10 points)

| SUMMARY | | | |
|---|---|---|---|
| Item | Points | Item | Points |
| Safety Benefits | | Environmental Benefits | |
| System Preservation | | Improved Accessibility | |
| Benefiting Users | | System Continuity | |
| Congestion Benefits | | Regional Significance | |

Total Score = _____

MORRISON MAIERLE, INC.
An Employee-Owned Company
8710 North Thornydale Road, Suite 140
Tucson, Arizona 85742