Agenda Item #6

MARICOPA ASSOCIATION of GOVERNMENTS
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April 10, 2012

TO: Members of the Transportation Policy Committee

FROM: Bob Hazlett, P.E., Senior Engineering Manager

SUBJECT: SUMMARY OF WHITE PAPER RECOMMENDATIONS – MAG MANAGED LANES NETWORK DEVELOPMENT STRATEGY – PHASE I PROJECT

On November 15, 2010, the MAG Regional Council authorized procurement of consultant services to develop the MAG Managed Lanes Network Development Strategy - Phase I project. This multi-phase effort was in response to consideration for public-private-partnership (P3) opportunities in the Phoenix Metropolitan Area where high occupancy vehicle (HOV) lanes could be operated as high occupancy toll (HOT) lanes as part of an overall managed lanes strategy. Since the last presentation on this project to the Transportation Policy Committee in October 2011, the project consultant has developed eight planning papers on the following topics:

- Project Goals and Objectives
- Legal and Regulatory Issues
- HOV Hours of Operation
- HOV Occupancy
- HOV Separation Treatment
- Pricing and Tolling Methods
- Active Traffic Management and Managed Freeways

A summary of the recommendations from these papers is attached to this memorandum, and the links to the papers themselves can be found on the MAG website at: http://www.azmag.gov/Projects/Project.asp?CMSID=4190.

In addition to the attached information, the consultant has completed a Tier I screening of the MAG Regional Freeway system to identify segments that could be suitable for a priced managed lanes implementation. The Tier I screening considers existing and projected HOV demand, available capacity, and constructability as parameters for the assessment. The overall result of this screening has noted that the most favorable attributes for capacity and operations tend to contribute to least favorable characteristics for constructability. For example, the Tier I screening of SR-51/Piestewa Freeway suggests that existing and future travel demand are very favorable for priced managed lanes, but the ability to construct to full design standards, especially between the Interstate 10/SR-202L Mini-Stack and Northern Avenue would be difficult.

As information from the Tier I Screening is still under study, preliminary data from this effort will be presented to the Transportation Policy Committee in its briefing on Wednesday, April 18, 2012. Questions or comments related to the MAG Managed Lanes Network Development Strategy – Phase I project should be directed to me at 602 254-6300 or bhazlett@azmag.gov.

Managed Lanes Network Development Strategy – Phase I

White Paper
Summary of Recommendations

MARICOPA ASSOCIATION OF GOVERNMENTS

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Revision History

Revision	Date	Description	Submitted by
1.0	04/06/2012	Initial draft for internal review	DJH
1.1	04/09/2012	Draft for client review	DJH

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1.0 BACKGROUND

The Maricopa Association of Governments (MAG) is working in cooperation with the Arizona Department of Transportation (ADOT), Federal Highway Administration (FHWA), and other regional partner agencies to explore the regional managed lanes system, including determining future needs for High-Occupancy Vehicle (HOV) system expansion and the potential for introducing enhanced lane management techniques such as value pricing in the form of High-Occupancy Toll (HOT) lanes, and active traffic management. The outcome of this effort will be a MAG Managed Lanes Network Development Strategy – Phase I Report that will guide future planning and investment in HOV and Managed Lanes facilities in the region.

To support the evaluation of the managed lanes network in the MAG region, a series of technical "white papers" have been developed to examine the relevant issues by drawing upon the substantial and growing research and experience on managed lanes around the nation. These white papers will assess the pros and cons associated with each relevant issue to better enable the regional partners to reach conclusions on the feasibility and specific technical aspects of managed lanes for the Phoenix area. The complete series of white papers will be made available for review on the MAG website. The following is a bulleted summary of the key recommendations of the policy and practice white papers. The subsequent sections provide additional narrative regarding the policy and practice recommendations, in no particular order of priority.

1.1. Regional Managed Lanes Goals and Objectives

Goals	Objectives
Improved Mobility	• Reduce travel times and improve travel time reliability • Manage travel demand and traffic congestion • Improve/maximum existing system infrastructure • Maximize use of technology • Increase capacity • Provide mobility options • Improve transit service options, efficiency and reliability
Revenue Alternatives	• Leverage existing revenue sources • Access new/alternative revenue sources • Accelerate project delivery to complete the system • Support ongoing operations and maintenance • Support transit service provision • Better plan future investments
Public and Political Support	• Support public education and outreach • Identify/foster political champions • Facilitate equitable distribution of costs whereby users pay for what they use
Improved Environmental Quality	• Provide air quality benefits • Enhance quality of life

1.2. Access Treatment

- Utilize near-continuous access design and operations
  - Maintain consistency with the current continuous access for the region's HOV lane system
  - Afford operational, enforcement and toll collection benefits of restricted access in strategic locations
  - Traffic conditions and other design, operational and cost considerations will determine specific segments for limited access

1.3. Lane Separation

- Continue current HOV lane separation techniques in conjunction with managed lanes
  - Primarily utilize a combination of painted line and painted buffer lane separation
  - Barrier separation where elevated segments (including Direct HOV ramps) or contraflow operations are involved.
- Begin modifying existing HOV markings to reflect the Manual of Uniform Traffic Control Devices (MUTCD)

1.4. Hours of Operation

- Expand hours of operation to ensure time savings and reliability throughout more of the day
  - Initially expand peak hours of operation (5:00 AM to 10:00 AM; 2:00 PM to 7:00 PM)
  - Establish performance thresholds for expanding to daytime and weekend hours of operation (e.g., 5:00 AM to 9:00 PM)
  - Any change in hours of operation will require extensive public outreach and analysis to explore potential impacts to traffic.
- Ensure regional consistency to promote familiarity and support for managed lanes

1.5. Occupancy Requirements

- Maintain existing occupancy requirement of two or more persons per vehicle (2+) during initial deployment of HOT
  - Permit eligible carpools to use managed lanes facilities toll-free
- Require all managed lanes users to carry a transponder with switchable settings to declare carpool status
  - Simplify enforcement while ensuring flexibility to adjust over time
- Ensure regional consistency in occupancy requirements
  - Possibly utilize different uniform occupancy requirement for all regional HOV facilities compared to regional HOT facilities

1.6. Pricing Methods

- Utilize variable pricing to manage lanes based on levels of congestion within segments of each facility.
    - Fixed-schedule variable pricing provides predictability for users
    - Dynamic variable pricing can better adjust for real-time demand
- Calculate tolls on a per mile basis but communicate toll rates to customers per-segment
    - Utilize per-facility pricing for full length trips on multi-segmented corridors

1.7. Active Traffic Management and Managed Freeways

- Active Traffic Management utilizes various Intelligent Transportation System technologies to dynamically manage and control traffic using following strategies:
    - Speed Harmonization/Lane Control
    - Queue Warning
    - Hard Shoulder Running
    - Junction Control
    - Dynamic Re-routing
    - Traveler Information
- Managed Freeways implement a comprehensive package of strategies to fully manage access to and demand for a freeway facility
    - Utilize integrated data collection sensors along the roadway and advanced system management tools to monitor and control real time traffic conditions to ensure a more consistent level of freeway performance

2.0 REGIONAL MANAGED LANE GOALS AND OBJECTIVES

Managed lane goals and objectives should be consistent with regional and statewide goals and objectives, and should represent one component of a larger congestion management planning effort, since managed lanes are only one of the many tools available. Although managed lane vision, goals, and objectives for central Arizona will be unique and specific to local needs, examples from other areas provide appropriate guidance as a basis for further consideration and development in a local context.

Building upon the vision and guiding principles for transportation the State of Arizona and MAG region, and goals and objectives for managed lanes in other areas, specific goals and objectives for managed lanes in the MAG region were identified by the Project Planning Partners Advisory Group. These goals and objectives will establish the parameters by which subsequent specific policy elements can be defined and the performance of managed lanes can ultimately be evaluated.

Table 2-1 MAG Region Managed Lanes Goals and Objectives

Goals	Objectives
Improved Mobility	• Reduce travel times and improve travel time reliability • Manage travel demand and traffic congestion • Improve/maximum existing system infrastructure • Maximize use of technology • Increase capacity • Provide mobility options • Improve transit service options, efficiency and reliability
Revenue Alternatives	• Leverage existing revenue sources • Access new/alternative revenue sources • Accelerate project delivery to complete the system • Support ongoing operations and maintenance • Support transit service provision • Better plan future investments
Public and Political Support	• Support public education and outreach • Identify/foster political champions • Facilitate equitable distribution of costs whereby users pay for what they use
Improved Environmental Quality	• Provide air quality benefits • Enhance quality of life

Overall, the Project Partners placed an emphasis on improving mobility over revenue alternatives, with providing travel time reliability being identified and the most important aspect of mobility. In balancing potentially conflicting mobility and revenue goals, the group placed 2/3 emphasis mobility and 1/3 revenue, where the emphasis on revenue should be used to meet the mobility goals. The group felt that utilizing revenue to leverage existing funding should be a priority over generating new revenue. Achieving political support was also viewed as a key goal to advocate and facilitate implementation of a network of managed lanes within the MAG region.

3.0 ACCESS TREATMENT

Arizona's experience with HOV lanes began with construction commencing in 1983, and completion of the first operational facility on I-10 in 1988. The lanes were (and continue to be) constructed with a continuous line and/or buffer separation design, as shown in Figure 3-1.

Figure 3-1 Sample Lane Separation Treatments on Phoenix-area HOV Lanes

There are three types of access to the existing HOV lanes in the Phoenix area, based upon the location within the corridors.

The first pertains to the mainline HOV lanes, where continuous access to the HOV lanes is provided at all points. Vehicles may cross the painted buffer, regardless of the width and appearance of the buffer at that point, provided such a movement otherwise conforms to moving vehicle guidance and safety requirements.

The remaining two conditions pertain to direct-access to the HOV lanes from other facilities. Freeway-to-freeway direct connectors provide dedicated freeway-to-freeway movement between HOV lanes without weaving, thus positively affecting operations across all lanes of travel at these interchanges. Direct access ramps (DAR) provide dedicated connections from intersecting arterial streets to the HOV lanes. In the MAG region, these direct-access provisions are collectively referred to as Direct HOV (DHOV) ramps. In both cases, the construction of these access ramps may be costly, but the operational benefits can be significant at key locations (Figure 3-2).

Figure 3-2 Sample DHOV Ramps in the Phoenix-area

As the requirements of the Phoenix area managed lane network are developed, it is recommended that a regional tolling approach utilizing near-continuous access design and operations be defined to best maintain consistency with the current continuous access system in place for the region's HOV lane system while affording the

operational, enforcement and toll collection benefits of restricted access in strategic locations. Prevailing traffic conditions and other design, operational and cost considerations will need to be evaluated to determine the specific segments or corridors that require the application of limited access to maximize the efficiency and effectiveness of a managed lanes network.

A regional preference for utilizing near-continuous access allows the region to focus subsequent efforts to identify system-based options for resolving various operational and enforcement issues associated with access to managed lanes. Preliminary options include the expanded use of technology and operational treatments that can positively affect compliance. Altogether, developing a near-continuous access managed lane system is possible – and desirable – but these issues must be addressed as planning and design of the managed lanes system proceeds.

Near-continuous access is currently utilized on managed lanes facilities in Salt Lake City, Utah, and Minneapolis, Minnesota, as depicted in Figure 3-3.

Figure 3-3 Sample Near-Continuous Access Managed Lanes

A: I-15 (Salt Lake City) **B: I-35W (Minneapolis)**

4.0 LANE SEPARATION

Three different approaches for separating managed lanes from adjacent general purpose lanes are typically used on facilities in the United States.

- Painted line/buffer separation (as found on HOV lanes throughout California, and priced managed lanes facilities including I-15 in Salt Lake City and SR-167 in Seattle)
- Traffic channelizer separation (as found on SR-91 in Orange County, California, I-10 in Houston, and I-95 in Miami)
- Barrier separation (as found on I-15 in San Diego and I-25 in Denver)

All HOV lanes in Arizona currently exhibit painted line/buffer separation approach of employing pavement markings to communicate the HOV lane(s) next to adjacent

general purpose traffic lanes. Solid single or double white (with chevrons) pavement markings are standard in Arizona. The 2009 Manual on Uniform Traffic Control Devices (MUTCD) updated the pavement markings guidance as they pertain to Line and Buffer Separated managed lanes (including both HOV lanes and priced managed lanes). The guidance is as follows:

- Prohibited access segments consist of double-solid white lines on either side of the buffer and chevron markings if the buffer is wider than 4 feet.
- Discouraged access segments consist of two solid white lines. The MUTCD is silent on the desired width of the discouraged-access segment.
- Permitted (open) access segments should consist of either single or double wide broken lines without buffer.

All three conditions are shown in Figure 4-1 and Figure 4-2 below.

Figure 4-1 Controlled Access Buffer-Separated Lane Markings (2009 FHWA MUTCD)

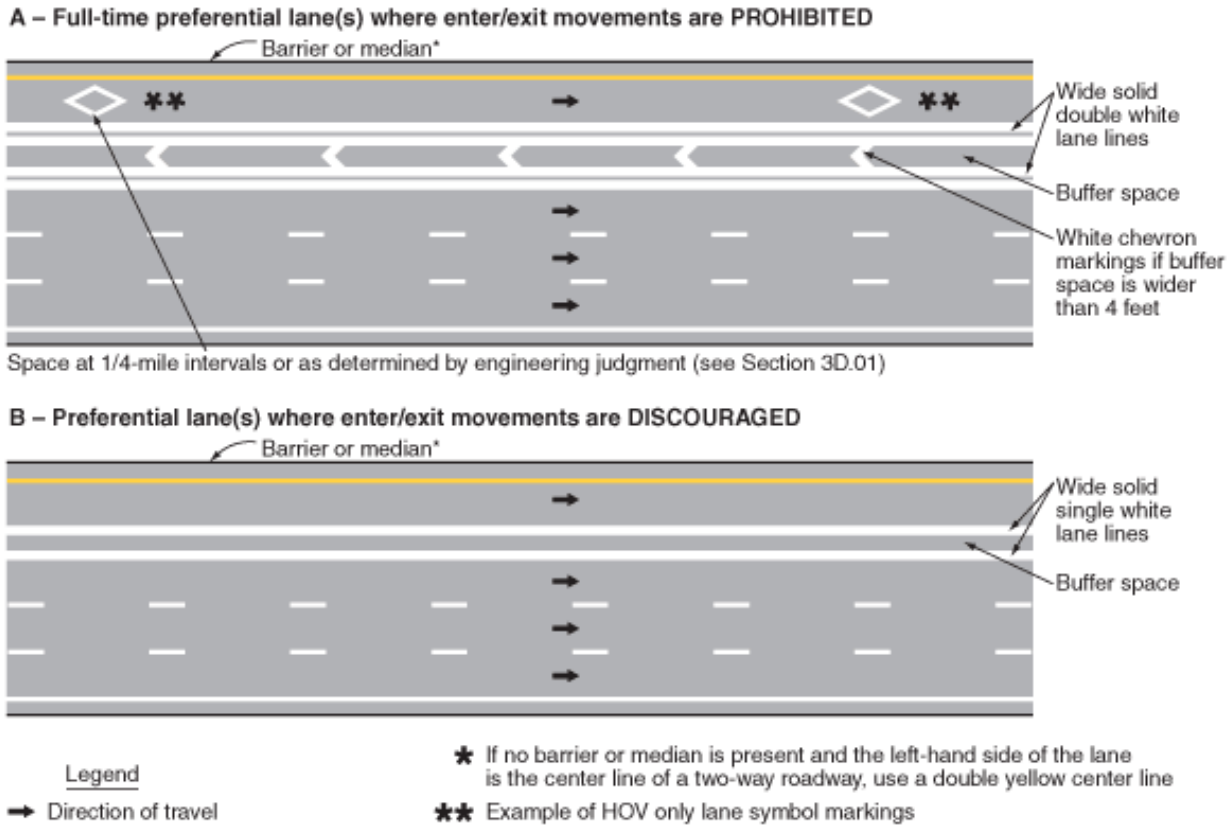
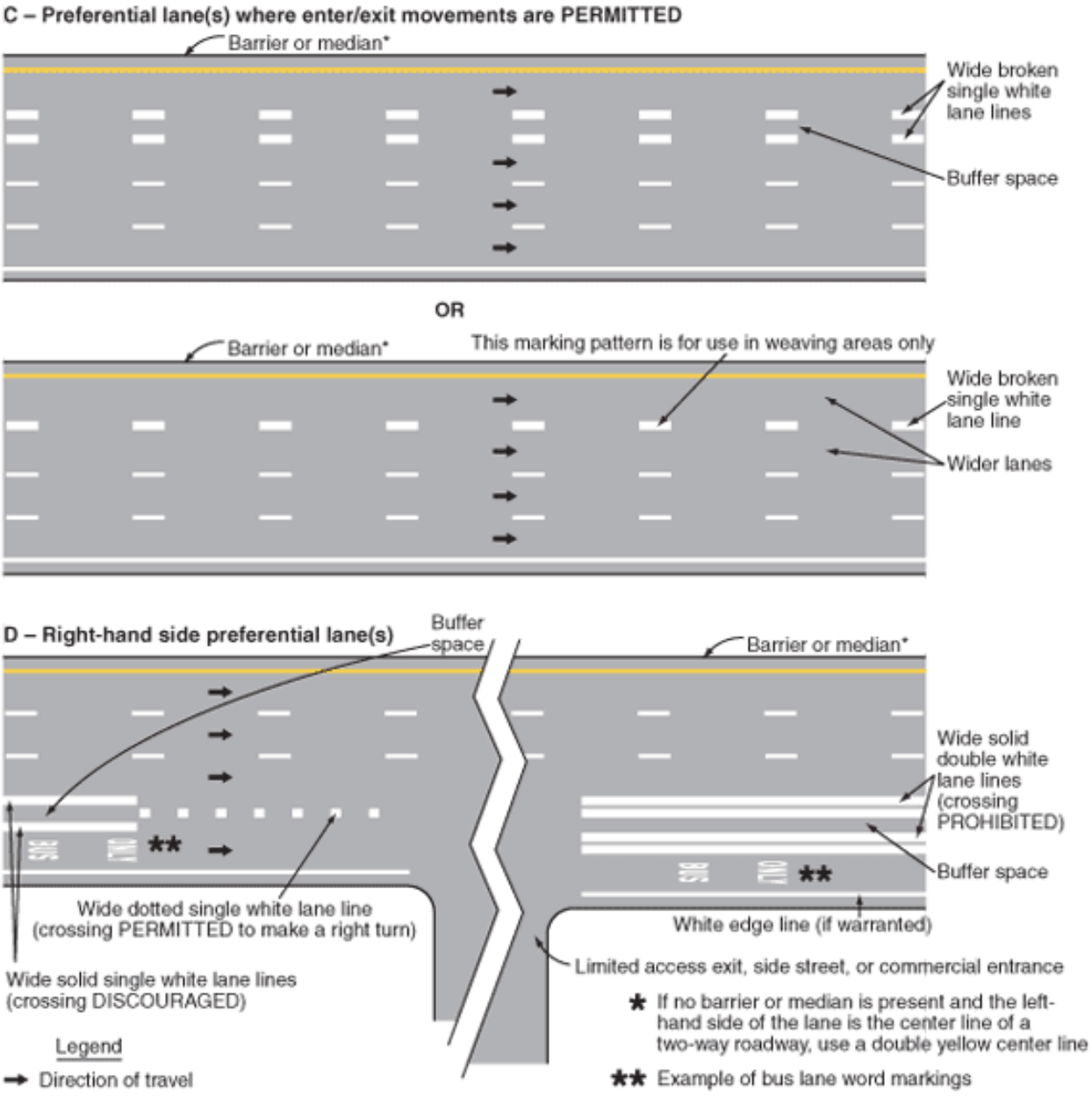


Figure 4-2 Open Access Buffer-Separated Lane Markings (2009 FHWA MUTCD)



For the MAG region, a continuation of the current HOV lane separation techniques is generally recommended in conjunction with the implementation of managed lanes. This approach would continue to primarily utilize a combination of painted line and painted buffer lane separation. Barrier separation would continue to be the preferred separation technique where elevated segments (including DHOV) or contraflow traffic conditions are involved.

It is recommended that ADOT begin the process of modifying the existing HOV lane marking to reflect the recently adopted provisions of the MUTCD. Specific

modifications involve the use of wide broken striping to designate continuous access, as illustrated previously in Figure 4-2. Modifying lane marking to be consistent with MUTCD will be critical to ensure limited access can be clearly demarked and enforced should managed lanes implementation in the region result in the use of near-continuous or limited access treatments. Similarly, ensuring lane markings reflect MUTCD requirements will ensure managed lanes facilities in the MAG region and consistent with applications elsewhere in the nation.

5.0 HOURS OF OPERATION

HOV lanes in Maricopa County currently operate part time. Occupancy restrictions on the lanes are in effect Monday through Friday between 6:00 AM to 9:00 AM, and 3:00 PM to 7:00 PM. During all other periods and during weekends the HOV lanes effectively operate as general purpose lanes and are open to all traffic.

As one of several tools available for managing traffic, implementing a consistent policy for hours of operation for a managed lane facility should complement other demand management strategies such as occupancy restrictions, tolling policy and access treatments. In the context of a managed lanes network spanning a metropolitan area, efforts should also be made to ensure that policies such as hours of operation are consistent to promote familiarity and support of the managed lanes concept. Any expansion to the hours of operation coupled with the introduction of pricing will require extensive public outreach and further analysis to explore potential impacts to traffic.

For the MAG region, it is recommended that the hours of operation expand from the current part-time hours of operation with the introduction of pricing to ensure time savings and reliability benefits throughout a greater portion of the day. Initially this approach could include expanded peak period hours of operation (e.g., 5:00 AM to 10:00 AM; 2:00 PM to 7:00 PM) as a means to maintain part-time operations while affording greater ability to manage HOT demand during the shoulders of the peak period. This approach could also be accompanied by establishing system performance thresholds that would trigger further incremental expansion of hours of operation to ultimately achieve daytime hours of operation (e.g., 5:00 AM to 9:00 PM) across the system. This approach could also include consideration for implementing weekend hours of operation that would extend the ability to manage HOT demand during weekends when recreational and special event traffic in the MAG region can create congestion at certain times in specific corridors (e.g., recreational traffic on southbound I-17 on Sunday or holiday Monday afternoons; sporting or concert event traffic near University of Phoenix Stadium, Sun Devil Stadium, downtown Phoenix, spring training baseball stadiums).

6.0 OCCUPANCY REQUIREMENTS

HOV lanes in Maricopa County currently operate part time. A uniform HOV 2+ (two-or-more persons per vehicle) minimum occupancy policy is enforced during these operational times.

Due to the high level of interconnectivity across the existing regional HOV system, it is recommended that a uniform minimum occupancy requirement for HOT facilities be applied in the MAG region to ensure consistency across corridors and to minimize driver confusion. However, due to the clear differences between HOT and HOV lane operations, it could be possible to utilize a different uniform occupancy requirement for all regional HOV facilities compared to regional HOT facilities. For the MAG region, it is recommended the existing carpool minimum occupancy requirement of two or more persons per vehicle (2+) be maintained during the initial deployment of HOT operations to ensure existing carpool users continue to be rewarded for their beneficial travel behavior. To continue to promote carpool, vanpool and transit modes as the highest priority for using managed lanes, it is recommended that eligible carpools be permitted to utilize managed lanes facilities without a requirement to pay a toll. In light of continuous advances in technology and associated reductions in costs to acquire tolling related equipment, it is recommended that all managed lanes users be required to carry a transponder with switchable settings to self declare carpool status, like the example depicted in Figure 6-1 which is being developed for projects in Los Angeles, California. The requirement for all managed lanes users to carry a switchable transponder simplifies the process of delineating and enforcing eligible carpools from other users, while also ensuring sufficient flexibility to adjust policies over time.

Figure 6-1 Example Switchable Transponder

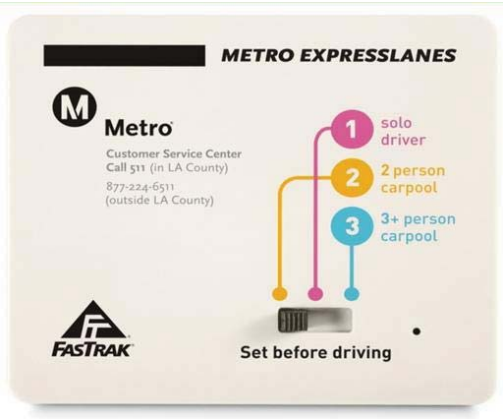


Image source: LA Metro

The recommended approach for managed lanes occupancy should also be supplemented by establishing system performance thresholds that would trigger further incremental changes in minimum occupancy requirements (i.e., increases in minimum occupancy to 3+) for both HOV and HOT facilities, and commensurate changes in HOV tolling policy specifically on HOT facilities (i.e., HOV 3+ no-toll; HOV 2 discounted toll). Initial system design considerations and requirements for all managed lanes users to utilize a switchable transponder will ensure the flexibility to facilitate changes in occupancy requirements without the need for significant design or technology changes.

7.0 PRICING METHODS

Phoenix's HOV lane system currently permits certain vehicle types during specified periods of the day (morning and afternoon peak periods), wherein other vehicle types are restricted from the lanes. The current system has approximately 375 lane miles, with more under development. Existing permitted users include carpools with two or more occupants, vanpools, motorcycles, and buses.

For the implementation and operation of priced managed lanes, additional permission would be granted to single- and/or low-occupancy vehicles (SOV/LOV) – depending upon either HOV 2+ or HOV 3+ definition for the corridor – that do not meet the prevailing occupancy requirements and carry an active transponder/account, or otherwise meet established criteria for paying tolls. Nationally, initial priced managed lane applications involved existing HOV facilities with demonstrable underutilization. However, more recent proposals have examined the potential of implementing priced managed lanes in more constrained conditions, including in conjunction with increasing the occupancy requirement where overutilization is degrading the performance of the HOV facilities, or as a means of providing higher returns on investment from the provision of new capacity.

As both revenue generation and demand management attributes are incorporated within any pricing scheme, the challenge is how to balance the effects of each objective within the pricing system. As with any management system, capabilities and limitations of the pricing system will have consequential effects on achieving the pricing objectives. Consistent application of any tolling program is important to customer understanding and as an equitable means of adopting and implementing a tolling policy. Overall, the business rules must anticipate all scenarios, and apply them consistently. For the managed lanes these may include:

- Balancing the needs of revenue generation and demand management within the toll algorithm;
- Establishing differential toll rates by vehicle class and occupancy
- Determining minimum toll rates for uncongested conditions, maximum toll rates for saturated conditions on general-purpose lanes, maximum toll rates for incidents on the managed lanes; and
- Determining toll rates for downstream segments from point of entry (e.g., charged the prevailing toll per segment or the "entrance toll" locked in at point of vehicle entry to system).

Operational and system parameters affect the customer's use of the pricing system. There are multiple points of contact with the customer:

- Hours of Operation. When are the managed lanes open and accepting customers?

- Exemptions. Exemptions and discounts can be offered by vehicle occupancy, class, or other qualifications. All *operational* priced managed lanes offer free access to at least HOV 3+. In order to provide exemptions or discounts, it is necessary to determine a declaration mechanism.

- Communication of Price. In order to make an informed decision concerning use of the priced managed lanes, the customer must understand the price for making his or her trip. The more complicated the system of pricing (e.g., per mile pricing), the more difficult it will be for the customer to estimate the trip cost.

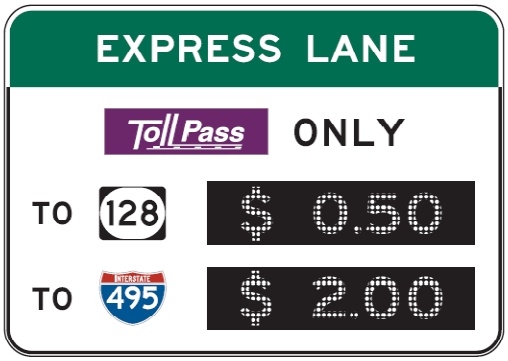
- Lock in of Price. After communicating the price, the customer must have reliance the price will not change once he or she has committed to use of a managed lane toll segment or facility.

- Overrides. In certain cases, conditions will deteriorate rapidly within the managed lane facility. In this situation, refunds or toll negation may be necessary as travel time reliability is jeopardized. Furthermore, diversion of general purpose traffic into a managed lane may also be necessary during periods of incident response.

Fixed-schedule variable and dynamic pricing provide the ability to price managed lanes relative to the level of congestion with segments of each facility, although options and tradeoffs exist. Fixed-schedule variable pricing provides predictability for users because the toll schedule is published in advance, although the use of fixed-schedule pricing precludes the ability to adjust tolls to manage demand in real-time based on prevailing traffic conditions. In contrast, dynamic variable pricing can better adjust toll to reflect for real-time demand but reduces the ability for drivers to be aware of the toll rate in advance of their travel.

A consistent customer experience on the managed lane system will be informed by a combination of interactions with the customer. As it pertains to pricing, applying a consistent pricing algorithm (particularly in the case of dynamic pricing) and pricing interval are critical. In terms of the pricing interval, per-mile, per-segment, and per-facility, are each workable options, but come with benefits and challenges. Calculating tolls on a per mile basis is typical, especially on dynamic pricing facilities that utilize automated tolling algorithms to calculate tolls. Per-segment pricing is generally applied as the most effective option for communicating toll rates to customers, as illustrated in Figure 7-1. Per-segment pricing can also be used in conjunction with per-facility pricing for full length trips on multi-segmented facilities.

Figure 7-1 Segmental Toll Rate Regulatory Signs for Managed Lanes (MUTCD 2009)



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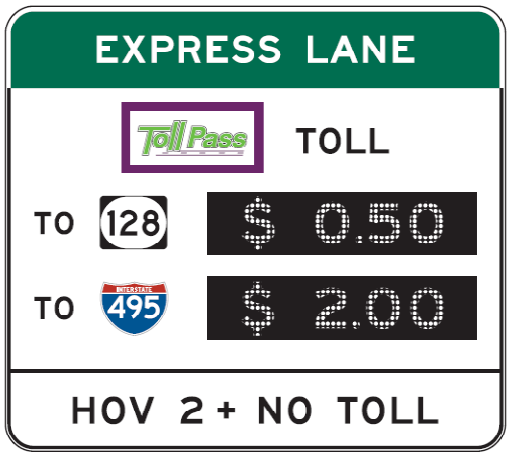

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8.0 ACTIVE TRAFFIC MANAGEMENT AND MANAGED FREEWAYS

Since the 1990's, Phoenix area agencies have been engaged in a variety of traffic management and ITS endeavors, including the following:

- Freeway Management
- Incident Management
- Traveler Information
- Arterial System Operations
- Managed Lanes

Active Traffic Management (ATM) utilizes various ITS technologies to manage traffic flow and lane use. The key differentiator of ATM from other ITS applications is the approach to ***dynamically*** manage and control traffic using and integrating the following strategies:

- **Speed Harmonization/Lane Control**: utilizing regularly spaced, over lane speed and lane control signs to dynamically and automatically reduce speed limits in areas of congestion, construction work zones, accidents, or special events to maintain traffic flow and reduce the risk of collisions.
- **Queue Warning**: utilizing either side mount or over lane signs to warn motorists of downstream queues and direct through-traffic to alternate lanes, effectively utilizing available roadway capacity and reducing the likelihood of collisions related to queuing.
- **Hard Shoulder Running**: using the roadway shoulder (inside or outside) as a travel lane during congested periods to alleviate recurrent (bottleneck) congestion for all or a subset of users such as transit buses. Hard shoulder

running can also be used to manage traffic and congestion immediately after an incident.

- **Junction Control**: using lane use control, variable traffic signs, and dynamic pavement markings to direct traffic to specific lanes (mainline or ramp) within an interchange area based on varying traffic demand, to effectively utilize available roadway capacity to reduce congestion
- **Dynamic Re-routing**: changing major destination signing to account for downstream traffic conditions within a roadway network or system.
- **Traveler Information**: providing estimated travel time information and other roadway and system conditions reports allowing travelers to make better pre-trip and in-route decisions.

The concept of Managed Freeways builds upon the ITS applications of ATM and the dynamic demand management capability of managed lanes to implement a comprehensive package of strategies to fully manage access to and demand for a freeway facility. Managed Freeways utilize integrated data collection sensors along the roadway and advanced system management tools to monitor and control real time traffic conditions to ensure a more consistent level of freeway performance.

ATM strategies have been successfully implemented in Europe for many years. In the US, both WSDOT and MnDOT have successfully implemented ATM strategies, as depicted in Figure 8-1. Beyond ATM, fully integrated managed freeways are emerging as a strategy for maximizing the efficiency of roadways. The successful deployment of the M1 Freeway Management System in Melbourne, Australia, as pictured in Figure 8-2, has demonstrated the effectiveness of implementing a comprehensive package of strategies to fully manage access to and demand for a freeway facility by combining the ITS applications of ATM and the dynamic demand management capability of managed lanes. The MAG region has previously demonstrated a commitment to implementing advanced traffic management techniques. ATM and managed freeways represent the latest techniques for regional stakeholders and decision makers to consider as they collectively address existing and ongoing travel demand.

Figure 8-1 Example Active Traffic Management

I-35W, Minneapolis, Minnesota

Image source: MnDOT

Figure 8-2 Example Managed Freeway

Image source: VicRoads