

Managed Lanes Network Development Strategy – Phase I

Managed Lane Occupancy Policy

MARICOPA ASSOCIATION OF GOVERNMENTS

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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.

The purpose of the MAG Managed Lanes Network Development Strategy – Phase I study is to examine the existing and planned freeways in the region to identify where managed lanes strategies, policies or actions could improve overall system efficiency. For those corridors where such strategies or policies are considered most promising, the study will then provide an action plan that establishes the framework for subsequent phases to further define the network concept including establishing a preliminary concept of operations and design concept, develop corridor specific concepts including preliminary design and environmental clearance, and complete implementation including business rules, market grade traffic and revenue forecasts, construction and operations.

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.

1.1. Purpose and Methodology

HOV lanes can be considered important elements of the transportation system for supporting highway efficiency, transit and rideshare goals. MAG, ADOT, and partnering agencies in the Phoenix region have learned a great deal about the use, market, design, operation, and enforcement of HOV lanes and how these aspects influence transit and rideshare demand, safety and performance.

Across the United States, several HOV lane segments have not met speed and reliability standards over the past several years due to extensive use, while other segments are not fully utilized. There are several shortcomings to using auto occupancy alone to manage HOV lane volumes, so MAG is now considering whether and how to evolve HOV lanes into a system of priced managed lanes that would provide a more robust means to achieve reliable performance and throughput, and to potentially generate funding for transportation uses.

With the potential conversion of freeway HOV facilities to priced managed lanes, there is a need to properly consider, define, and accommodate the role of HOV users under

a variety of operation scenarios, and, examine the tradeoffs between carpool exemptions and other project objectives. The inclusion of pricing may have complementary or adverse impacts on one or more existing and potential users, with policy variables including accessibility, performance, throughput, efficiency of operations, rideshare and transit impacts, enforceability, and the generation of revenue. Furthermore, the specific pricing options chosen may have consequences upon public acceptance, with differing levels of acceptance and opposition from different user groups.

The primary objective of this technical memorandum is to examine these issues, based upon the latest state of practice and knowledge concerning carpools in priced managed lanes. This paper develops policy options for the treatment of HOV users on priced managed lanes and identifies impacts and implications of managed lane tolling as it pertains to carpool users.

1.2. Current Maricopa County HOV Lane Occupancy Policy

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. Occupancy restrictions on the lanes are in effect Monday through Friday between 6:00 AM to 9:00 PM and 3:00 PM to 7:00 PM. During all other times of the day and during weekends the HOV lanes effectively operate as general purpose lanes and are open to all traffic.

1.3. Policy Basis for Occupancy Policy on Priced Managed Lanes

The *Intermodal Surface Transportation Efficiency Act of 1991* (ISTEA) provided the first policy basis for implementing congestion pricing on interstate facilities. Although a variety of pricing applications were considered under the Congestion Pricing Pilot Program (CPPP), including area-wide and cordon congestion pricing concepts, highway-based congestion pricing quickly coalesced around priced managed lane concepts. These concepts involved the allowance of previously prohibited vehicles, such as single occupant vehicles (SOV), to utilize underutilized HOV lanes in exchange for the payment of a fee, which would vary with either anticipated or realized volume of traffic to maintain speeds. This variation upon HOV lanes quickly became known as High Occupancy Toll (HOT) lanes. The commonality amongst all HOT lane proposals was the inclusion of the previously prohibited vehicles without any direct change in status of existing users. For all but the Houston HOT lanes on I-10 and U.S. 290, this policy meant that HOV 2+ users could continue to use the HOT lanes without payment of toll.

Whereas the initial HOT lane applications involved HOV facilities with demonstrable underutilization, more recent proposals have examined the potential of implementing priced managed lanes in more constrained conditions, including overutilization that is degrading the performance of the HOV facilities below the standards prescribed in Federal statute, or as a means of providing higher returns on investment from the provision of new capacity. In order to respond to these additional objectives, the preferential treatment of carpools is re-examined in light of facility, regional and state transportation objectives.

HOV lanes have a much longer history of operations in North America than HOT lanes. The first HOV lane in the United States was implemented on Virginia's I-395 in 1973 with an HOV 4+ minimum occupancy requirement after four years of operation as an exclusive busway. This policy decision was made during a time of high fuel costs, fuel shortages throughout the United States, and public concerns regarding mobility, providing an opportunity to experiment incentivizing the use of carpools.

Nationally, from 1990 through 2007, vehicle miles traveled have increased 30 percent, while the percentage use and absolute number of HOV 2+ carpools for commute trips has actually declined to 14,860,000 (10.6% of total commuters in 2007), down from 15,380,000 in 1990 (13.4% of total commuters). Between 1990 and 2000, HOV lane miles have more than doubled, from approximately 1,300 lane miles in 1995 to over 2,500 in 2000, with more stagnant HOV growth since 2000. The majority of HOV lane miles are located in California (1,000+), Arizona (350+), and Texas (300+).

Carpooling rates have increased significantly within HOV lane corridors (over 100 percent) even as carpool rates nationwide have declined (30 percent) during the past two decades. As a result, many HOV lanes, including those in Arizona, California, Washington, Texas, and Virginia, have witnessed occasional breakdown in free flow conditions on the HOV lanes reflecting a case of insufficiently managed utilization. Many other HOV lanes, though, have continued to experience underutilization. Given severe congestion in the general purpose lanes, the public has often expressed animosity toward adjacent HOV lanes if they are perceived to be underutilized.

Priced managed lanes are promoted as a means of responding to both overutilization and underutilization of HOV lanes. As evidenced by the operational HOT lane facilities, priced managed lane concepts have proven to be an effective way of utilizing the available capacity without yielding the HOV lanes' travel time advantages. Furthermore, financial packages compiled for the facilities on I-635 freeway in Dallas and I-595 in Ft. Lauderdale have shown the possibility of using pricing as a means of enhancing financial resources to construct new capacity across the freeway corridor, if so desired.

For converted HOV lanes, established practice implies maintenance of HOV operations. Conversely, toll lanes that are built without an initial HOV designation carry no such implication. The first (and to date, only) toll lane implemented with no explicit HOV benefit is on SR-91 in Orange County, CA, which was originally developed as a privately built and operated express toll lane (ETL) corridor. However, upon the facility's acquisition by the Orange County Transportation Authority (OCTA) in 2003, the SR-91 Express Lanes operating policy has been adjusted to provided toll-free use by HOV 3+ users during most time periods, and only requiring a 50% toll payment by these users during times of heaviest congestion (currently only Thursdays and Friday PM peak periods in the eastbound direction). Toll lane concepts that require all users to pay a toll are more attractive than HOT lanes for those transportation agencies driven by enhancing sources of revenue, demand-driven management of express lane facilities, fairness by being mode-neutral, and/or ease of enforcement.

Regions with significant HOV facility investments have not been immune to declines in carpool rates. In Southern California, representing the greater Los Angeles metropolitan region, carpooling as a share of work trips declined from 15.2 percent to 10.8 percent between 2000 and 2009, despite the availability of over 930 lane miles of HOV lanes across five counties. Similarly, the San Francisco Bay Area, with over 420 lane miles of HOV lanes, has seen carpooling decline from a peak of 19.0 percent of commuters in 1995 to 12.9 percent in 2000 and 10.2 percent in 2009. As a point for comparison, the Phoenix area, with approximately 375 lane miles of existing HOV facilities, witnessed a decline in carpool mode share from 15.3 percent in 2000 to 12.7 percent in 2009, indicating better performance than its West Coast peers, but a decline nonetheless during a period when HOV lane miles in the region increased substantially. Ideally, managed lane operators will evaluate HOV use effectiveness per-facility (reflecting localized demand); however, the emerging context of regional policymaking indicates that regional metrics may be as important as localized metrics.

As MAG considers the implementation of priced managed lanes, there is a need for deliberation and guidance that defines the role of carpools in these facilities and the tradeoffs between carpool toll exemptions and other project objectives. Unlike early HOT lane projects that allowed solo drivers into underused HOV lanes without displacing anyone, MAG and ADOT will likely need to seek to reduce HOV lane volumes in certain cases to attain uncongested levels. Increasingly, project objectives are reflecting not only mobility concerns but funding deficiencies and the need to actively manage all users of managed lanes.

1.4. Role of Public Acceptance

While this white paper focuses on technical issues affecting occupancy policies, it is worth noting that public acceptance is also an important factor. HOV lanes have always been popular among those who benefit from them, and less popular from those ineligible to use them, due to perceived underutilization concerns (the “empty lane syndrome”) or concerns over equity. As evident by New Jersey’s experience with HOV lanes (and their discontinuation) in the late 1990’s, public acceptance is a prerequisite for maintaining HOV policies over time.

Any change to carpool policies must be done carefully. Two-person carpools make up the majority of current HOV lane users, and these users may consider HOV lane access an entitlement (a concept called “modal equity” in the literature). Those who would benefit from a different carpool policy are by definition less engaged and supportive of the current policy than those standing to lose something they currently utilize. A key policy challenge in evolving from HOV to priced managed lanes will be to maintain public acceptance, recognizing that some users may be affected negatively.

2.0 OCCUPANCY POLICY CONSIDERATIONS

2.1. Occupancy Policies on Priced Managed Lanes

Given the progression of HOV facilities to priced managed lanes over the last decade in the U.S., there is still very little in the way of research and guidance defining the role of carpools and the tradeoffs between carpool preference and other project objectives. In examining the projects in operation today, decisions related to carpool preference have been based largely on policy decisions with little documented quantitative analysis.

One Texas Department of Transportation (TxDOT) study provided a synopsis of the priced managed lanes state of the practice in 2006:

- All facilities toll or intend to toll single occupant vehicles.
- Most facilities provide toll-free access to HOV-3+.
- HOVs either pay the full toll or travel toll-free.
- Most communities have a standard HOV toll policy that apply for all HOV and express lane facilities.

This TxDOT study also conducted interviews with technical staff from all operational and planned priced managed lanes in 2005. One of the questions involved the decision factors for the determination of managed lane carpool policies. These factors may be constituted in official transportation policy or may reflect prevailing concerns of agency stakeholders in the development of priced managed lane facilities per region. The scale for each factor is rated simply as “high importance,” “moderate importance,” and “low importance” in terms of its effects on decision making in the region. The findings from this questionnaire are shown below in Table 2-1, organized by region. As noted, these results do not lend themselves easily to overall trends.

There is no factor that will rate uniformly high or low in the regional decision making process for managed lanes. As stated by the report, “This finding confirms that each region is different and has its own core issues to address in setting managed lane policies. Furthermore, the different importance values assigned to each factor suggest that nationally standardized criteria regarding HOV toll policies not only do not exist but are also inappropriate, relative to regional issues.” However, there are some factors that rate consistently moderate to high across all regions, including: enforcement of carpool vehicles, maximizing vehicular throughput, and uniformity/equity issues.

Since 2006, however, new managed lane facilities have opened (or are under construction) which have changed these common practices concerning carpools. The initial priced managed lanes, with the notable exception of the SR- 91 Express Lanes in Orange County, California, involved the conversion of operational HOV lanes into HOT lanes. In all cases through 2006, the converted HOV lanes maintained toll-free use of the new priced managed lane for all pre-existing allowed users. Only newly authorized classifications of users would be charged a toll. In all but two cases, this involved HOV 2+ maintaining toll-free access.

Table 2-1 Decision Factors for HOV Policies on Managed Lanes (TxDOT, 2009)

	San Francisco - Oakland	Orange County, CA	San Diego	Minneapolis	Denver	Seattle	Virginia	Maryland
	Operational Managed Lanes					Planning-stage		
Separating toll vs. HOV vehicles in toll zones	●	●	●	○	●	○	●	●
Regional air-quality goals / objectives	⦿	●	●	⦿	⦿	○	●	⦿
Technological concerns	●	●	●	○	⦿	●	⦿	○
Carpool enforcement concerns	●	⦿	●	●	●	●	⦿	●
Achieving mode use goals / objectives	●	⦿	●	●	○	●	⦿	○
Back office accounting concerns	○	○	○	○	●	●	○	●
Maximize person throughput	●	●	●	●	⦿	●	⦿	○
Maximize vehicular throughput	⦿	●	●	⦿	●	●	⦿	●
Maximize revenue generation	⦿	⦿	○	○	⦿	○	●	●
Uniformity and equity concerns	●	●	●	●	●	●	●	⦿
Previous carpool operations consistency	⦿	-	●	●	⦿	⦿	⦿	○
	● = High ⦿ = Moderate ○ = Low							

After 2006, larger “mega” projects involving the construction of priced managed lanes have occurred, and these have tended to change the policies concerning carpool vehicles. In some cases, such as the I-15 Express Lanes expansion in San Diego, no change to carpool access policies ensured HOV 2+ toll-free access to the facility. Dallas, by comparison, recognizes that its HOV lane network will inevitably become a priced managed lane system, and be completed concurrent with corridor reconstruction efforts, such as those currently underway on I-635 and I-35E. As a result, the Dallas MPO adopted a regional managed lane policy that phases tolls on all priced managed lane facilities. Whereas HOV 2+ now has access to all HOV lanes, the priced managed lanes will require HOV 2+ to pay full toll rates in off-peak periods, a 50% toll discount in peak periods, and if the Dallas Metroplex region moves from an air quality maintenance area to a non-attainment area, then full tolls across all times of day. This is a substantial change in the carpool access policies for the region.

Table 2-2Table provides an illustration of how HOV 2 and HOV 3+ policies differ among regions and corridors on priced managed lanes.

Table 2-2 Carpool Pricing Policies on Priced Managed Lanes

Carpool Preference Combinations		HOV 3+				
		Free 24/7	Free Peak Periods Only	Free Off-Peak Periods Only	Discount Peak Period Only, Pay All Other Times	Pay 24/7
HOV 2	Toll-Free 24/7	I-15 (CA), I-110 (CA)*, I-680 (CA), I-25 (CO), I-394 (MN), I-35W (MN), I-15 (UT), SR-167 (WA)				
	Toll-Free Peak Periods Only		I-10 (TX)			
	Toll-Free Off-Peak Periods Only	I-10 (CA)*, US-290 (TX)				
	Discount Peak Period Only, Pay All Other Times				I-30 (TX)*, I-635 (TX)*	
	Pay 24/7	SR-91 (CA), I-85 (GA), I-95 (FL), I-595 (FL)*, I-495 (VA)*, I-95 (VA)*				TBX (FL) Loop 1 (TX)*

Note: * - Facility currently planned or under construction

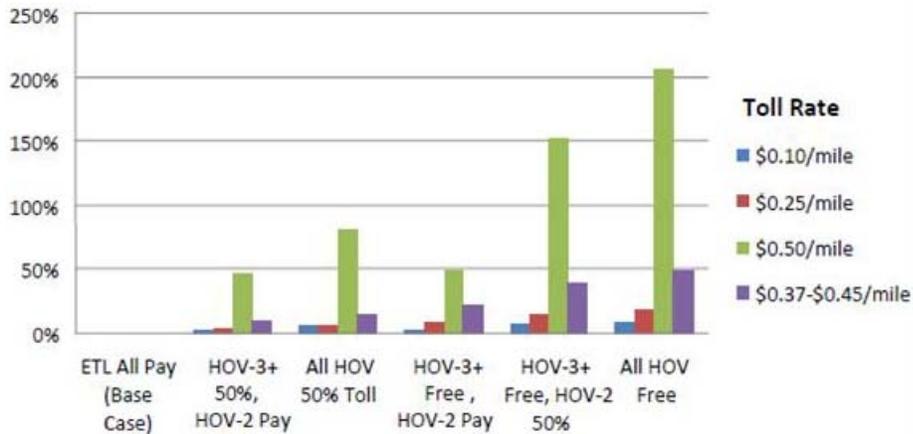
2.2. Impacts of Pricing on Carpool Utilization Rates

As MAG considers the implications of pricing on the regional HOV lanes system, it may be helpful to consider the tradeoff between different pricing policies, and the impacts on carpool utilization rates and the net social benefit of different carpool pricing policies. One recent study published in the Transportation Research Record investigated the potential impacts of different pricing policies and incentives for HOV's. Starting with the premise that carpool formation is inherently a net benefit for society (due to vehicular demand and emissions reduction), the study found that access to HOV lanes is the single most important factor contributing to the formation of carpools by commuters. Conversely, for those SOV users who do not carpool, structural and social factors (such as difficulty forming carpools and need for flexibility) were indicated as the primary reasons for their mode choice.

The aforementioned TxDOT study investigated the responses of carpools to different pricing levels, through the use of an adaptive scenario stated-preference study of commuters in Houston and Dallas. This study looked at 24 different policy scenarios (randomly assigned) with toll values ranging from 10 cents per mile to 50 cents per mile (including an adaptive toll rate that fell between 37 and 45 cents, reflecting a mean between the 25 cents and 50 cents per mile rates), and various toll-free, discounted toll, and full toll rates applied for HOV 2 and HOV 3+ users. Various performance measures were used for the impact analysis. In terms of person throughput, tolling everyone is the least effective solution for increasing person throughput, whereas toll-free access for all

HOV's yields the greatest amount of person throughput (Figure 2-1). The percentage increase in person throughput remains in parity between HOV 3+ toll-free and HOV 2+ toll-free (at low toll rates). The percentage difference between these rates is within 10% of one another, which is within the variance as developed by the model. Thus, for toll rates between 10 and 25 cents per mile, there is not a substantive difference in person throughput, due to the formation of new HOV 3+ with an HOV 2 toll. This result indicates that person throughput is not significantly harmed by a HOV 3+ toll-free policy.

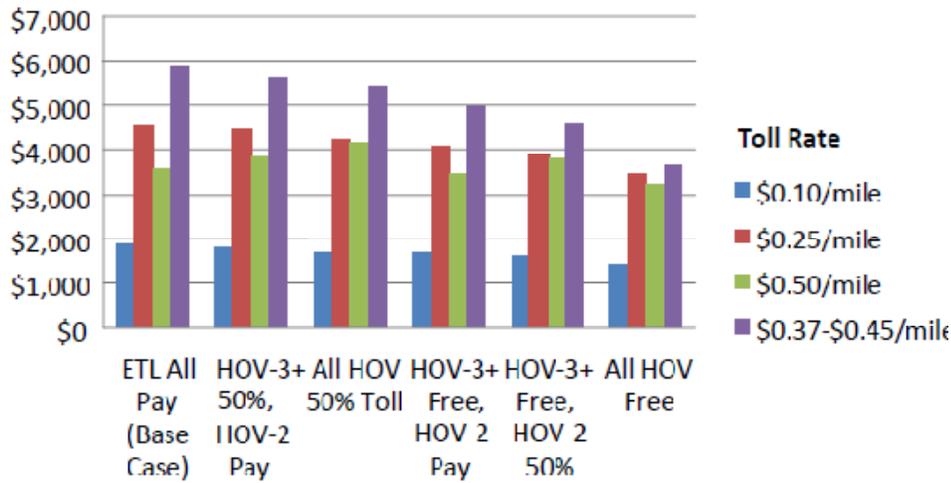
Figure 2-1 Increase in Person Throughput with HOV Pricing Scenarios (TxDOT, 2009)



From an emissions perspective, the pricing of HOV's has a negligible effect on emissions across all types (carbon monoxide (CO), volatile organic compounds (VOC), nitrous oxide (NOx), and sulfur dioxide (SOx)). However, with increasing toll incentives for HOV's, CO and NOx increase slightly (but within the variance in the model). One exception is the production of carbon dioxide (CO₂) emissions, which is a key contributor to Greenhouse Gas emissions, under high toll rates. For CO₂ emissions, the provision of toll-free benefits to HOV 2+ produces almost twice the CO₂ savings from that of any priced managed lane policy which tolls HOV 2's (but maintains HOV 3+ toll-free).

Finally, the TxDOT study investigated the revenue impacts of different HOV policies (Figure 2-2). As would be expected, HOV toll-free incentives reduce overall net revenue for the priced express lanes, with each incremental HOV toll incentive decreasing revenue (up to a 40 percent reduction from an all-tolled policy).

Figure 2-2 Peak Hour Revenue with Different HOV Pricing Scenarios (TxDOT, 2009)



As such, the findings from the TxDOT study indicated, “HOV preferential treatments at any given toll level tend to reduce toll revenue, have no impact on or reduce system performance on managed lanes, and increase CO and NOx emissions.” Table 2-3 shows the combined summary comparison for choosing an appropriate carpool policy (independent of access requirements):

Table 2-3 Comparison of HOV Pricing with Policy Objectives (TxDOT, 2009)

Express Lanes Performance Objectives	HOV3+ pay, HOV2 pay	HOV3+ 50%, HOV2 pay	HOV3+ 50%, HOV2 50%	HOV3+ free, HOV2 pay	HOV3+ free, HOV2 50%	HOV3+ free, HOV2 free
Person throughput	○	○	○	●	●	●
Revenue generation	●	●	●	○	○	○
Emissions reduction	○	○	○	○	○	○
Operational performance	○	○	○	○	○	○
Enforcement simplicity	●	○	○	○	○	○
Public perception and support	○	○	○	○	○	○
● = High ○ = Moderate ○ = Low						

2.3. HOV Access Requirements on Priced Managed Lanes

As there is no commercially reliable method for automatically counting the occupants of vehicles, the enforcement of the managed lane facility falls upon visual inspection by police officers. On many of the initial HOT lanes where right-of-way was not an overriding issue, vehicles that complied with occupancy requirements (and therefore were entitled to toll-free use) are physically separated from toll-paying vehicles in “carpool declaration lanes” at toll zones (as shown in Figure 2-3 for I-25 in Denver). Enforcement personnel only verify the occupancies of vehicles in the “carpool lane”, while any toll evasions in the “toll lane” are captured by license plate recognition (LPR) technologies and reported using a back-office violation enforcement system (VES). This method

reduces the total number of users that enforcement personnel must positively verify for system compliance.

Figure 2-3 Physical Separation of HOV and Toll Traffic, I-25 Express Lanes, Denver



Although there are advantages to physically separating HOV from non-HOV users in toll zones, this strategy requires significant amounts of right of way not only for the separation but also for enforcement detention and citation. In the Phoenix region, many potential corridors for priced managed lane implementation will not provide sufficient space to accommodate such physical separation, and may have complications associated with a lack of shoulders for lane enforcement.

Other communities have faced similar issues. For all, the goal remains the same – to reduce the total number of compliance checks that must be accomplished by in-field enforcement personnel. While seeking an alternative to physical separation, other communities have evaluated the availability of new technology and HOV toll policies to yield differential solutions. Assuming that some vehicles (whether HOV 2+ or HOV 3+) are provided toll-free use of the managed lanes, there are primarily three methods to check compliance without implementing physical separation (with the latter two discussed in detail below):

1. ***Unrestricted access for eligible carpools.*** As is currently applied on SR-167 (Washington), I-15 (Utah), and both Minnesota facilities, stationary and/or roving patrol vehicles view the number of occupants in all vehicles using the managed lanes for which a beacon mounted on the toll gantry indicates toll payment was not collected. Photo-based enforcement or toll collection cannot be used in this method, as the VES would have no means to differentiate a photo-based toll payer (or violator) from an eligible carpool.

2. ***Mandatory transponders with trip registration.*** All users of the facility must have a transponder (also commonly referred to as toll tags). Eligible carpools must either pre-register their vehicles (as is done on I-95 in Miami) or pre-register their trip (as is done on I-85 in Atlanta). Photo-based toll collection or enforcement can be used in this method.
3. ***Mandatory transponders with technology enhancements.*** This method implies a technological method for declaring carpool status on the managed lanes. This may be accomplished through a switchable transponder (such as that currently being developed for implementation in California) or by physically exchanging transponders on the customer's windshield with separate toll and HOV transponders (as is considered in Texas). Both carpool registration and photo-based toll collection / enforcement can be used in this method (although the need for a carpool registration program can be eliminated by the use of a switchable transponder that indicates carpool status).

Mandatory transponders, whether by carpool registration or by technology, have been a means for other express lane operators to reduce the strain on enforcement of HOV occupancy policies by introducing toll-paying vehicles to the facilities. Each of the mandatory conditions is described below.

2.3.1. Carpool Registration Options

The rationale varies for each toll operator, but carpool registration generally helps with enforcement and limits more casual forms of carpooling, in favor of those formed for commuting purposes. Although registering all vehicles can improve enforcement efficiency, registration carries a higher operations and maintenance (O&M) cost burden, raises public concern that HOVs will choose to drive as SOVs, and may be construed as a deterrent to carpool formation even if carpools use the lanes toll-free. Experience from Miami and Houston shows that the higher toll system costs and performance efficiencies are somewhat offsetting, insofar as added transponder and account management costs can be offset by improved enforcement performance and less field exposure to police. To the extent that mandatory registration would present an additional cost to HOV motorists, either in money or convenience, the policy will discourage drivers from hosting a carpool. If there are restrictions on the types of users and trips eligible to form a carpool, the number of drivers forming carpools will be lower still.

For Georgia, carpool registration serves as the primary means of differentiating HOV and SOV customers. All HOV customers must carry a transponder, for which an initial toll is charged. In order to have the toll nullified, HOV customers must declare (either by phone or online) their HOV status for that day's trip. The toll nullification occurs in the back office as a correction to the toll transaction for the customer. This process works similar to London's congestion charging scheme, where drivers of vehicles that cross the cordon line must make a payment online, by phone, or at vendors for the day of travel into the zone. Conceptual variations of nullified tolls with carpool registration may include pre-cleared transponders (with null tolls applied), prepaid transponders (by the regional ridesharing agency), or bulk declarations. The benefits of the registration

process is a reduction in enforcement requirements, better facility compliance, and enhanced performance monitoring capabilities for rideshare incentives. Conversely, the user inconvenience is much greater, and public comments received from the proposal are generally unfavorable.

2.3.2. Technological Options

The registration scenario could be extended to technological switching options in the field. In Georgia and Florida, carpoolers must pre-declare their carpool trip. Conversely, with technological switching, the carpoolers can declare their trip just prior to entering the priced express lane.

One technological option is issuing standard toll transponders and “carpool” toll transponders, which could be made interchangeable on the customer’s windshield. When a carpooler approaches the managed lane, the customer places the appropriate transponder on the windshield. Each customer may have multiple transponders associated with their account – a regular, an HOV 2, or an HOV 3+ transponder. WSDOT uses a detachable sticker-based transponder that attaches using Velcro®, which allows for a cost-effective means of using this multiple toll tag option (Figure 2-4).

Figure 1 Detachable Sticker Pass (Secured with Velcro)



Another option is a “switchable” transponder. These transponders allow the customer to self-declare his or her occupancy status on the transponder itself. Currently available switchable transponders, such as that used by WSDOT (Figure 2-5a) provide for a simple binary mechanism (toll or no-toll). Switchable transponders currently being tested for use in California use multiple status identities for each tag allowing transmissions from the toll tag to the lane reader to associate the correct toll for a vehicle based upon its occupancy status (Figure 2-5b). These identities can be associated with an SOV, HOV-2, and HOV-3+ setting directly on the transponder.

Figure 2 Prototype Switchable Transponders, Washington (a) and California (b)



The identified benefits associated with switchable transponders include the following:

- Flexibility to respond to changes in operation policies, based on HOV and toll vehicle demand,
- Revenue could be optimized to offset added costs if two-occupant vehicles were tolled during periods when demand is high,
- Occupancies could be raised during times warranted without the need for added on-site enforcement costs to distinguish HOV occupancies, and
- If augmented with mandatory account registration and use of transponders for all customers, as is currently being proposed for Express Lanes facilities on I-10 and I-110 in Los Angeles, overall enforcement costs could be reduced due to the inherently lower transaction costs associated with transactions completed using a positive toll tag match (compared to those completed using LPR which often requires manual verification of the license plate number) combined with the use of license-plate recognition systems to automate enforcement of toll evasions.

By deploying a switchable transponder that would be required to be carried by all users of the managed lanes coupled with automated enforcement of those not carrying valid toll tags, MAG and/or ADOT could pare down the enforcement responsibilities and reduce potential confusion to customers. Under this approach, all eligible users would be required to use a transponder or be subject to photo enforcement at toll zones and subsequent receipt of a violation notice. Buses, vanpools, and other special-access vehicle classifications can be verified (at the issuance of a transponder) by motor vehicle records, and given a “zero dollar” transaction in the toll zone by either non-revenue accounts or facility-specific rate tables. To the enforcement officer, the in-field beacon would recognize these vehicles as successful toll transactions. For compliant HOVs, the user would declare the vehicle’s status on the transponder (e.g., switching the pass to “HOV2” or “HOV3+”), and the appropriate toll rate (including “zero dollar”) would be collected. If the same vehicle is being operated without the required occupancy, it would be required to declare appropriately on the transponder and the correct toll would be collected. If no transponder is present (or if it is malfunctioning), license plate recognition (mounted on gantries or median poles) would be used to record the vehicle license plate information. License plate information can then be obtained using optical character recognition (OCR) or manual verification. License plate numbers matched with an existing valid transponder account would be charged the full toll, regardless of vehicle class or occupancy status. License plate information that is not matched to an existing account would be forwarded to MVD to obtain the owners name and address in order for a violation notice to be forwarded by mail. A similar system can be deployed with the moveable and detachable transponders, provided the customer carries multiple “cards” to deploy as required.

Altogether, Table 2-4 illustrates the different systems that are being deployed around the U.S. on new priced express lanes and Table 2-5 provides an evaluation of each of the above systems.

Table 2-4 Access Requirements for HOVs on New Priced Managed Lanes

Access Requirements		HOV Strategies			
		Unrestricted	Registration Required	Switchable Transponder (no-toll)	Mandatory Transponder (toll)
Facilities	SR-167 (WA)	X			
	I-95 (FL)		X		X
	I-495 (VA)		X	X	
	SFO HOT Network (CA)		X	X	
	I-680 (CA)	X			
	I-10 / I-110 (CA)			X	
	I-85 (GA)		X		X

Table 2-5 Evaluation of Access Options

Relationship to Access System	No Pass requirement, no physical separation	No Pass requirement, with physical separation	Switchable Pass	Exchanged Pass	Vehicle registration with pre-trip declaration	Vehicle registration with static declaration
Encourages regular carpools	○	○	●	●	○	○
Serves infrequent carpools	●	●	○	○	○	○
Customer ease of access	●	●	○	○	○	●
Ease of in-field enforcement	○	●	●	●	○	○
Customer convenience	●	●	●	○	○	●
Reduces violations	○	○	○	○	○	●
Public acceptance	●	●	○	○	○	○
Minimizes capital costs	○	○	●	●	●	●
Minimizes ongoing costs	○	○	●	●	○	○

● = High ○ = Moderate ○ = Low

3.0 OCCUPANCY POLICY OPTIONS

The findings from this analysis are used to examine key issues and options for carpool access to managed lanes in the Phoenix area.

3.1. Carpool Access Policy

Developing an access policy for carpoolers is a desired outcome from the managed lane network effort. This table considers the tradeoffs between adopting a single policy applied systemwide, versus allowing for different approaches to carpooling in different corridors. There are two primary options, although variations within these have been discussed within this technical memorandum (see Table 3-1 below).

Table 3-1 Options for Managed Lane Occupancy Policy

Option	Pros	Cons	Experience
Adopt a Universal Access Policy (HOV-2+ or HOV-3+ across all facilities)	<ul style="list-style-type: none"> • Easy to understand • Consistent with region’s carpool objectives • Treats all corridors equally for access 	<ul style="list-style-type: none"> • Does not allow for tiered pricing, unless the system is pre-defined as tiered for all facilities • May impede upon efficient operations • Risks service breakdown on high-demand managed lane corridors • May yield lower person throughput 	<ul style="list-style-type: none"> • Phoenix-area HOV lanes
Differential carpool access by corridor, time of day, or toll-rate incentives (HOV-2 and HOV-3+ access policies are specific to each mode and corridor)	<ul style="list-style-type: none"> • Allows for tiered pricing • Optimizes efficiency of each specific corridor • Encourages higher person throughput 	<ul style="list-style-type: none"> • Higher O&M and marketing costs • Creates additional burden on ridematching system to account for policies unique to each corridor • More difficult to understand as a customer 	<ul style="list-style-type: none"> • Los Angeles, San Francisco, Houston, and Northern Virginia currently have differential access policies on their HOV facilities

3.2. HOV Declaration Method

As the regional managed lane network is developed, the Phoenix area will face additional enforcement requirements from that of their HOV system. Providing sufficient personnel to enforce both occupancies and toll evasions across all facilities may be expensive. Whereas automated occupancy verification is not yet ready for deployment, automated toll payment enforcement is ready and can be deployed provided the tolling method and HOV policy is appropriately designed and implemented. These options are explored further in Table 3-2:

Table 3-2 Options for HOV Declaration

Option	Pros	Cons	Experience
<p>Use transponder for <u>toll payers only</u></p>	<ul style="list-style-type: none"> • Current practice in many other communities • Consistent with existing HOV operations • Low cost • Publicly accepted • Encourages carpooling without restrictions 	<ul style="list-style-type: none"> • Does not allow tiered pricing • Requires construction of HOV declaration lanes to allow for automated enforcement • Enforcement officials must enforce occupancy and toll evasion separately • Revenue leakage, due to inability to use license plate recognition • Inability to manage non-tagged vehicles for traffic management purposes 	<ul style="list-style-type: none"> • SR-167 (WA) • I-25 (CO) • I-35W (MN) • I-394 (MN) • I-680 (CA) • I-15 (CA) • I-15 (UT)
<p>Adopt a <u>switchable transponder</u> allowing for differential pricing between SOV, HOV2 and HOV3+; require all managed lane users to carry a transponder</p>	<ul style="list-style-type: none"> • Of three options, best for express lane traffic management • Allows for tiered pricing • Reduces revenue leakage • Allows for license plate recognition • Ease of occupancy declaration for users • Eliminates toll evasion enforcement 	<ul style="list-style-type: none"> • Higher capital and O&M cost to sign-up carpoolers. • Requires all users to be registered, which may discourage casual carpools • Emerging technology 	<ul style="list-style-type: none"> • I-10 (CA)* • I-110 (CA)* • SFO HOT Network (CA)* • I-495 (VA)* <p>* Proposed facilities - not in use currently; no proven track record</p>
<p>Adopt a <u>universal transponder</u> requirement. Require HOVs to be registered, with static or pre-trip declaration as a carpool for the registered passes.</p>	<ul style="list-style-type: none"> • No financial penalty to HOV users • Reduces revenue leakage • Allows for license plate recognition of non-tagged vehicles • Provides benefits to regular carpools 	<ul style="list-style-type: none"> • May discourage casual and irregular carpools • Higher capital and O&M cost • Static declaration will presume the vehicle to be a carpool when using registered facilities; no ability to use legally as an SOV. • Per-trip declaration requires a separate, planned effort by carpoolers prior to trip initiation. 	<ul style="list-style-type: none"> • I-95 (FL) • I-85 (GA)

3.3. Carpool Tolling Policies

Finally, a concern is that the high reliability standards ascribed to managed lanes require a consequentially higher level of performance monitoring in order to ensure they maintain functionality. In the current system, HOV users neither contribute towards the cost of operating the system nor are they managed in real time for access to the facility (absent a toll to use). As such, there may be a benefit to applying a charge (either partial or full toll) to HOV's in order to partially recover operating expenses or to provide for more active management of the managed lanes. However, charging HOV's may be construed as a penalty to existing carpool users and could deter carpool formation. Mitigating this concern may require additional incentives to prevent loss of average vehicle occupancy. These options are described below in Table 3-3.

Table 3-3 Options for Carpool Pricing

Option	Pros	Cons	Experience
Toll-free use of the Managed Lanes by HOV's	<ul style="list-style-type: none"> • Easy to understand • Consistent with state's current carpool objectives • Publicly acceptable 	<ul style="list-style-type: none"> • Does not provide ability to completely manage use in real time • Reduced incentive to shift to bus / rail • Risks service breakdown on high-demand corridors • Lower revenue generation for ongoing capital and O&M requirements • Loss of O&M cost capture 	<ul style="list-style-type: none"> • Most existing HOT lane conversions (see Table 2-2).
Charge HOV's (partial or full toll) for use of the Managed Lanes	<ul style="list-style-type: none"> • Allows for corridor-specific tiered pricing (e.g., HOV-2 half toll, HOV-3+ free use) • Provides ability to fully manage demand for facility • Encourages higher person throughput, by incentivizing HOV-3+ or bus • Captures incremental O&M costs for all users • Higher revenue generation 	<ul style="list-style-type: none"> • Change in policy and operations for HOV access to Managed Lanes. • Some may question the reasonableness of access charge • May yield loss of carpools in short term before shifts to higher occupancies • Modal equity concerns • May induce shift to SOV from HOV 2 	<ul style="list-style-type: none"> • SR-91 (CA) – specific peak periods only • I-10 (CA) – HOV 2 during peak periods only • Texas priced managed lanes in Dallas, Houston, and Austin. <p>(see Table 2-2)</p>

4.0 CONCLUSIONS

As one of several tools available for managing traffic, implementing a consistent occupancy for a managed lane facility should complement other demand management strategies such as hours of operation, 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 minimum occupancy, HOV status declaration and HOV tolling policy are consistent to promote familiarity and support of the managed lanes concept. Any changes in HOV requirements coupled with the introduction of pricing will require extensive public outreach and further analysis to explore potential impacts to traffic.

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. 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.

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.

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