Considerations for High Occupancy Vehicle (HOV) to High Occupancy Toll (HOT) Lane Conversions Primer

HOV Pooled Fund Study

U.S. Department of Transportation

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Prepared for the

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Prepared by

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16. Abstract This primer presents key issues and challenges related to the conversion of high occupancy vehicle (HOV) lanes to high occupancy toll (HOT) lanes. The primer is intended for community leaders, administrators, the public, and other stakeholders responsible for making policy decisions for improving HOV lane and highway mainline operations through conversion to HOT lanes. More detailed information is available in the Considerations for HOV to HOT Lane Conversions Guidebook. The primary audience for the guidebook is transportation professionals responsible for planning, designing, funding, operating, enforcing, monitoring, and managing HOV and HOT lanes.		
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Table of Contents

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Introduction

Welcome to the primer for the *Considerations for High Occupancy Vehicle (HOV) to High Occupancy Toll (HOT) Lane Conversions Guidebook*. This primer presents key issues and challenges related to the conversion of HOV lanes to HOT lanes. The primer is intended for community leaders, administrators, the public, and other stakeholders responsible for making policy decisions for improving HOV lane and highway mainline operations through conversion to HOT lanes.

More detailed information is available in the *Considerations for HOV to HOT Lane Conversions Guidebook*. The primary audience for the guidebook is transportation professionals responsible for planning, designing, funding, operating, enforcing, monitoring, and managing HOV and HOT lanes.

The *Considerations for HOV to HOT Lane Conversions Guidebook* represents one of several studies sponsored by the HOV Pooled Fund Study Group and the Federal Highway Administration (FHWA). Participating state transportation agencies include those in California, Georgia, Maryland, Massachusetts, Minnesota, New Jersey, New York, Tennessee, Virginia, and Washington.

The HOV Pooled Fund Study Group is sponsoring other handbooks and primers of interest to transportation professionals and policy makers. Topics addressed in other projects include HOV lane eligibility requirements and operating hours, HOV lane safety considerations, and HOV lane enforcement.

Defining HOT Lanes

91 Express Lanes, Orange County, CA

The HOT lanes concept is a managed lane that combines HOV with pricing strategies to improve facility operations.

A managed lane *is a highway facility, or a set of lanes, in which operational strategies are proactively implemented and managed (in real time) in response to changing conditions*.

Unlike HOV lanes, HOT lanes allow single occupant vehicles (SUVs) to gain access to HOT lanes if the drivers choose to pay the toll. To maintain the "improved facility operations" and the service benefits of an HOT lane, HOT lane operators typically charge differential toll by time of day.

With electronic toll collection (ETC) technology, HOT lane facility operators collect tolls electronically, eliminating the need for toll booths and manual toll collection.

- HOT lanes typically are limited-access; normally barrier-separated highway lanes that provide free or reduced-cost access to qualifying HOVs, and also provide access to other paying vehicles not meeting passenger occupancy requirements.
- By using price and occupancy restrictions to manage the number of vehicles traveling on them, HOT lanes maintain volumes consistent with uncongested levels of service even during peak travel periods.
- Most HOT lanes are created within existing highway facilities and offer potential users the choice of using mainline lanes or paying for premium service on the HOT lanes.
- HOT lanes utilize ETC and traffic information systems. Information on price levels and travel conditions is normally communicated to motorists via variable message signs (VMS), providing potential users with the facts they need to decide whether or not to use the HOT lanes or the parallel general-purpose lanes that may be congested during peak periods.

Barrier separation on 2-lane reversible I-15 Express Lanes

Benefits of HOT Lanes

HOT lanes are intended to provide a wide variety of benefits to multiple user groups. When applied in conjunction with other management tools and sensible, targeted provision of additional lane capacity, HOT lanes have the potential to generate significant improvements in congested travel corridors.

HOT lanes can also afford a wide range of secondary benefits, including:

- New revenues that can be used to support the construction of the HOT lanes themselves or other initiatives, such as improved transit service or regional transportation initiatives
- Traffic service improvements on congested, parallel highway, mainline lanes by drawing vehicles off parallel local streets and improving corridor-wide mobility
- Faster highway trips for express transit services such as bus rapid transit (BRT)
- Environmental advantages by providing opportunities to encourage carpooling, improve transit service, and move more people in fewer vehicles at faster speeds
- Increased efficiency of managed-lane facilities making them attractive in regions that might not otherwise consider them
- Improved utilization of HOV lanes and therefore elimination of potential pressure to convert underperforming HOV lanes to general-purpose use.

The Primary Benefits of HOT Lanes

- HOT lanes provide the driving public with a choice—premium and predictable travel conditions—on corridors where conditions would otherwise be congested.
- HOT lanes maximize the use of managed lanes—including HOV lanes—without causing traffic service to fall below desired levels.

MnPass Express Lane

Baseline Performance of HOV Lanes

Minimum occupancy requirements for the HOV lanes should be set to avoid both underutilization and overcrowding of the HOV lanes. The primary benefit of adding an HOV lane is increased total highway capacity, causing preexisting HOVs to divert onto the new HOV lane and to allow single occupant vehicles (SOVs) to share highway mainlines with fewer vehicles.

After this initial shift in lane utilization, the resulting travel time differential between the HOV lane and highway mainline lanes could induce secondary shifts (second order changes) from SOV to HOV up to the point where service levels in the HOV lanes are impacted.

HOV lane performance studies typically collect peak vehicle and passenger counts for HOV lanes and highway mainline lanes and obtain average travel speed and travel time data. HOV lanes can average 3 to 20 times the person movement of highway mainline lanes during peak hours.

HOV lanes that carry more peak passengers than comparable highway mainline lanes, and that maintain peak hour volumes between 800 and 1,000 vehicles per lane per hour -- generally represent effective system management strategy.

Many HOV lanes throughout the country, under existing HOV priority allowances, achieve performance consistent with those outlined in FHWA HOV Lane Performance Guidelines.

The remainder of HOV lanes currently in operation suffers from mild to severe underutilization or overcrowding or both, depending on prevailing traffic conditions. It is this subset of HOV facilities that represents the pool of potentially feasible HOT conversion projects.

HOV Lanes Are Intended To Meet Three Basic Objectives

1. Provide a cost-effective means of moving greater volumes of persons at higher levels of service than mainline highway lanes by reserving dedicated lanes for multi-person vehicles
2. Promote ridesharing by setting aside reserved HOV lanes and offering travel time savings and reliability
3. Reduce trip times of HOVs during congested times of day

Understanding the Effects of Converting HOV Lanes to HOT Lanes

Shifts from HOV to Low Occupancy Vehicle (LOV) and from LOV to HOV

After an existing HOV lane is converted to an HOT lane, the LOV toll buy-in feature will induce some additional shifts from HOV to LOV. Before the HOV lane was converted to an HOT lane, all motorists who could be induced to shift to HOV presumably had already done so. Converting the HOV lane to an HOT lane is unlikely to increase or even maintain existing levels of rider sharing.

HOVs that are made better off by disbanding the HOV in favor of paying for HOT lane service as an LOV will shift from HOV to LOV. Likewise, some travelers will disband HOVs simply because the diversion of LOVs onto the HOT lane will cause enough highway mainline delay reduction to make HOV travel no longer worthwhile.

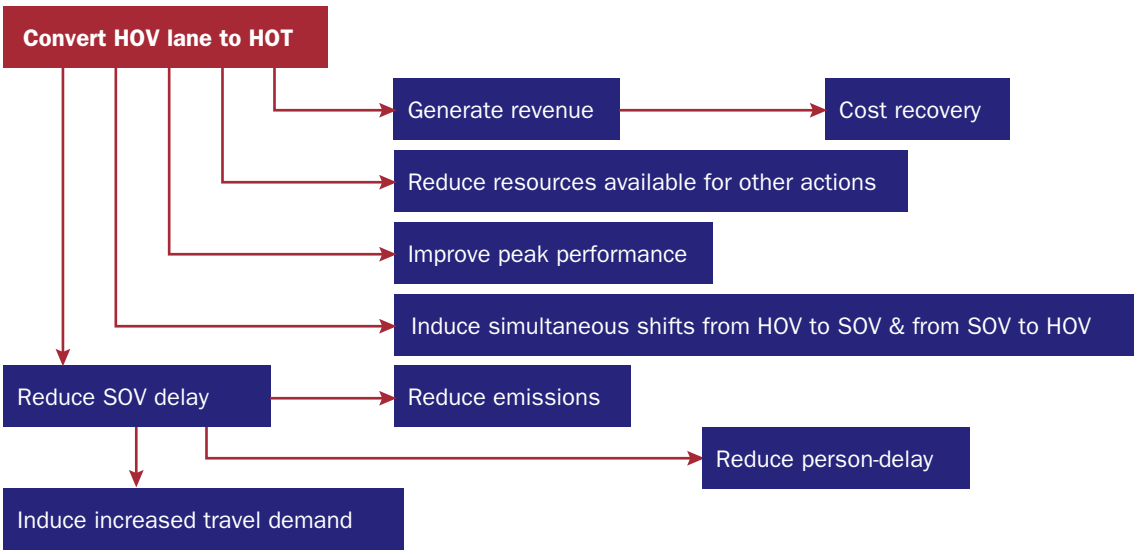
Shifts from Other Routes and Times

The travel time reduction on highway mainline lanes and the presence of an HOT lane will induce some secondary behavioral shifts:

- From alternative routes to the subject highway
- From off-peak to peak, which is not less congested.

With reduced delay on highway mainline lanes, LOVs that had previously shifted to alternative routes to save time will return to the highway via use of mainline lanes or HOT lanes. With reduced delay on the highway, both HOVs and LOVs that had previously shifted to alternative routes to save time will return to the highway. Both groups are better off.

The figure provides a diagrammatic overview of the effects of converting to HOT lanes.



When are HOV Lanes Suitable for HOT Lane Conversion?

Not every HOV lane, under its current operating configuration, can be readily converted to an HOT lane without some significant physical improvements to the existing facility envelope.

The planning process should address a number of questions to determine how effectively a potential HOT conversion project addresses a current unmet transportation need and to identify design and other issues, some of which may include:

- Is there sufficient excess peak capacity to allow SOV toll buy-ins on an existing HOV lane without the need to expand lane capacity? HOT feasibility largely depends on the amount of excess capacity that can be sold to SOVs. If there is abundant excess capacity on the existing HOV lane and traffic congestion on highway mainlines is moderate, it may be feasible to attract just enough SOVs onto the HOT lane through optimally priced dynamic tolling without necessitating any change in HOV toll exemption policies.
- If there is not enough excess peak capacity in the existing HOV lane(s) to allow for SOV tolling, is there additional capacity that can be added to the existing HOV facility as part of an HOT conversion project? Many HOV lanes are only one-lane facilities with either limited or no barrier separation from highway mainline lanes. It may be necessary to: 1) change the HOV exemption from HOV 2+ to HOV3+ or higher, 2) add a second HOT lane, or 3) do both.
- If changing the HOV exemption from HOV-2+ to HOV-3+ or higher is necessary, will it result in behavioral shifts that undermine the mobility improvement objective? The existing HOV eligibility status in the HOV exemption policy should be preserved in the HOT lane context whenever possible. In some instances, however, preserving the current HOV exemption may not free up enough capacity to auction to LOVs willing to pay a toll for premium HOT lane service.
- Are there any unique operational and physical characteristics of the existing HOV lane facility that will require major reconfiguration?

Pre-Planning Issues/Challenges

- How should HOV exemptions be modified to accommodate SOV toll buy-ins?
- What should be the minimum operating standard for HOT lanes?
- To what extent should access (ingress/egress) be limited to segregate traffic and preserve level-of-service performance goals on the HOT lane?
- How much are system implementation and ongoing operating costs for HOT lanes?
- What are the tradeoffs between implementing an HOT lane and a toll lane with no HOV exemption?
- What legislative barriers need to be removed to convert an HOV lane to an HOT lane?
- How should toll revenues be used?
- Who should own and operate the HOT lane?

Public Outreach and Education

Perhaps the biggest barrier to wider HOT lane implementation is public opposition. Recent experience demonstrates that HOT conversion projects are feasible from an operational and technological standpoint. With the mainstreaming of HOT lanes on the state and federal level, the public is increasingly familiar with the HOT lane concept and the benefits these facilities offer in terms of congestion relief.

Today, they are not as controversial as they once were. However, HOT lane conversion projects—because they include a tolling component—often raise spirited opposition based on equity and fairness concerns.

With the increased federal support for tolling initiatives, states and metropolitan regions throughout the country have looked closely at their highway assets for opportunities to improve mobility via facility-specific electronic tolling or "smart road" applications.

Over the past decade, public acceptance of electronic tolling applications on urban highways has increased, with the maturation of landmark projects like the 91 Express Lanes in Orange County, CA, and the I-15 Express Lanes in San Diego, CA. Today, these facilities are commonly accepted by the public as critical elements of the region's transportation system.

A common thread in every successful HOT conversion project is the execution of a coordinated effort among key stakeholders to convey the justification for and benefits of the project and to address public concerns about the implementation and ongoing operation of the project.

It is important to note that the success of an HOT lane implementation should be measured by public acceptance as well as by the ability to provide added capacity. Public consensus for the planned project requires a strong public involvement program throughout the life of the project, especially from the early planning stages.

In states like California, Texas, Utah, Minnesota, Colorado, and Washington, HOT lanes have been folded into statewide and regional transportation management plans that place increasing emphasis on system and regional management objectives.

Key Stakeholder Outreach Actions

- Anticipate opposition early.
- Arrange focus groups to determine local issues and strategic opportunities to address specific concerns.
- Develop program objectives that address and mitigate social equity concerns.
- Gain consensus from key influential civic and community gatekeepers.
- Enlist advocacy from a respected local official who will serve as project champion.
- Manage expectations by establishing reasonable and achievable project objectives.
- Deliver the project on time and on budget.

Public Outreach Strategies

Project sponsors that manage inclusive, responsive, and effective outreach to stakeholders establish their own legitimacy and the legitimacy of the technical analyses, decision-making, and public processes that support project implementation. Establishing transportation taskforces and technical committees consisting of businesses, community members, and elected officials is a proven key to successful implementation for managed-lane projects.

For example, for the QuickRide Program in Houston, TX, over 1,400 individuals participated in 14 public meetings, which helped bring forward issues such as access points and directional flow. In addition, having a strong public champion is a critical element in lending credibility to the outreach process and influencing key decision makers who may initially oppose HOT conversion projects without a clear understanding of potential project mitigations.

The Minnesota Department of Transportation (Mn/DOT) created a local taskforce, the I-394 Express Lane Community Taskforce, at the outset of the MnPass program to address issues, desires, and design options. In addition, they also held continuing public forums to keep the public informed and to address relative issues.

The San Diego Association of Governments (SANDAG) as well as Mn/DOT began public outreach programs very early in the project planning. SANDAG conducted stakeholder interviews, established a program of continuing surveys with both stakeholders and the public, and held numerous public forums throughout implementation.

Public outreach model used at Mn/DOT

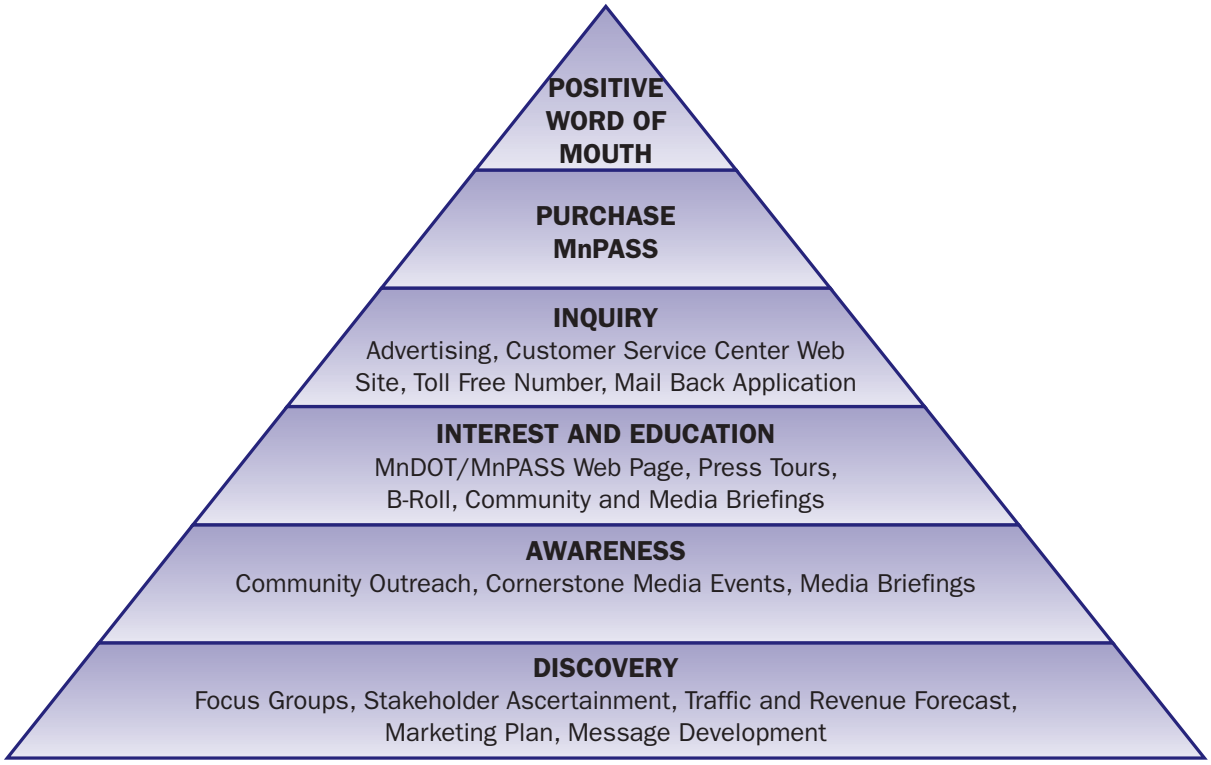


Chart provided by Frank Wilson Associates and Tanaka Advertising, PowerPoint presentation *MnPass I-394 Express Lane Marketing Outline*, October 28, 2004.

HOT Lane Project Development Process

The sketch development approach shown in the graphic illustrates the relationships of the multiple phases involved in the project development of the conversion of an HOV lane to an HOT lane.

Following an initial assessment of conversion feasibility and the decision to investigate the HOT lane conversion further, the conceptual framework for the HOT lane project is then developed and refined. The conceptual refinement phase evaluates various system design alternatives, including both roadway and technical alternatives, and eventually recommends a preferred approach or alternative.

The third phase focuses on clarifying the design, operational, and technological elements of the HOT lane conversion project. The fourth phase of the project involves developing the functional and operational requirements of the system.

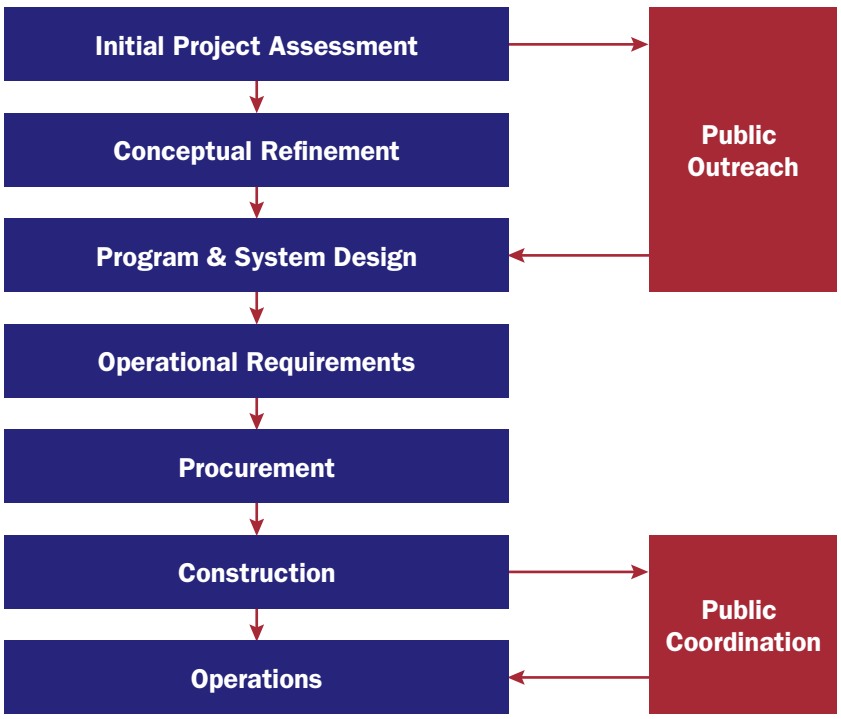
The project sponsor, most likely the state department of transportation (DOT), will complete detailed engineering and design studies for the recommended alternative and develop the design specifications for the HOT lane project.

The fifth phase involves the preparation of procurement documents for the advertisement and selection of a contractor through a competitive solicitation process. The contractor will proceed with the construction phase consisting of the design, installation, and testing of the HOT system.

When the operational acceptance test has met the system operational requirement, the project sponsor can accept the system for full period operations.

During all phases of the project, it is essential to maintain an effective outreach program and to provide current information to the public at all times. This is as important after operations begin as it was in the conceptual and relation-building phase.

HOT lanes development approach



Areas of Potential Risk

A risk mitigation plan is an important element of a successful HOT lanes project. The plan should identify all risks associated with the project, the degree of impact should the risk occur, and the likelihood of that risk occurring. Examples of categories of these risks are schedule, technology, operating, public acceptance, and environmental. Within these categories, numerous sub-categories specific to the project can be identified and therefore mitigated. All HOT lane implementations must address the following areas to minimize potential areas of risk.

Strong Interagency Support – Creating a strong public campaign that explains intended benefits and outcomes is critical to advancing an HOT conversion project from the earliest planning stages through implementation to promote understanding and support for the project.

Definition of Objectives – HOT conversion projects must identify objectives clearly from the outset, because these objectives influence both project financing and potential for public/private partnership (PPP). The program objectives should be realistic and defensible.

Traffic Forecasting – It is critical that traffic forecasts are rigorous and conservative in testing the program alternatives, as these projections serve as input into potential revenue bonding and other project financing mechanisms.

Project Costs – It is also critical that estimates for the initial capital costs and ongoing operating costs are conservative and realistic, as these factors will determine the basic economic viability of the project.

Project Financing – Some HOT conversion projects will be financed entirely with state and local funds, with some federal matching support. Others may be viable as investor-owned utilities underwritten by private investment. The financing arrangement may present risks to both the public and investors if project rates of return are lower than expected, and debt cannot be adequately serviced.

Procurement – There are both financial and schedule risks associated with traditional versus more innovative procurement strategies. Development of solid ETC system specifications and selection of a vendor (system integrator) are critical to the success of the project.

Achievement of Operational Goals – The HOT lanes can only be successful if they provide consistent and reliable level of service. If the customer does not get value commensurate with the toll charge, then public trust in the HOT lanes will erode and the system will fail.

Establishment of the Right Operating Model – It is critical that the operating framework for the HOT conversion project reflect the program objectives. The operation and pricing strategies must be feasible, reasonable, and compatible with the program objectives.

System Design Consideration – Creating a toll facility within an existing highway requires attention to all system design considerations including facility operations. Desired operational characteristics must be considered during both the planning and design phases of implementation so that the facility design is operationally functional.

HOT Lane Implementation and Design Issues

There are several transportation organizations that can successfully plan, build, operate, and manage an HOT lane program. The specific organizational and management structure may differ based on a variety of factors including state enabling legislation; asset ownership; project financing (e.g., revenue bond or general funds); and the role of the state DOT, regional planning organizations (RPOs), and metropolitan planning organizations (MPOs) in the region. It is important to identify the players involved in the HOT lane implementation process and describe their roles and responsibilities.

Creating a toll facility within an existing highway requires attention to system design considerations, which must be evaluated on the toll facility's potential impact within a corridor or region. A feasibility study assists in developing support for the venture and provides the basis for developing a project design plan.

Design considerations include, but are not necessarily limited to, roadway geometrics, pricing strategies, access, and technology applications.

Regardless of the design issues, a HOT lane project progresses through the typical project design and implementation stages as indicated in the figure.

HOT lane implementation may involve single or double lanes operated on a reversible-flow basis, or one or two lanes providing continual service in each direction, or multiple lanes that can operate concurrently.

Roadway geometry is a major factor in the design of an HOT lane facility.

GEOMETRICS FOR MANAGED-LANE FACILITIES CAN BE DIVIDED INTO FOUR GENERAL CATEGORIES:

- Barrier Separated
- Buffer Separated
- Contiguous
- Grade Separated

An example of multiple lanes that can operate concurrently is the planned SANDAG I-15 Managed Lanes, which will comprise four lanes that can operate on a concurrent flow basis such as 2/2 or 3/1. However, to maintain premium traffic service levels and discourage toll violations, HOT lanes generally require access control along with effective enforcement. Additionally, the physical configuration of HOT lanes and accesses to the HOT lanes should minimize excessive weaving between highway mainlines.

Conversion of HOV lanes to HOT lanes should move through the key stages of project development

System/Sketch Planning	HOT Lane Implementation and Design	Procurement	Final Design and Construction	Operations and Management
▪ Feasibility Assessment	▪ Define Objectives	▪ Determine Method	▪ Technology	▪ Hours of Operation
▪ Project Champion	▪ Ensure Stakeholder Understanding	▪ Prepare Procurement Document	▪ Toll Rate Concept	▪ HOV Use / Fee
▪ Stakeholder Support	▪ Clarify Design	▪ Competitive Selection Process	▪ Separation Type	▪ 24/7 Maintenance
▪ Develop Conceptual Framework	▪ Engineering and Design Studies	▪ Continued Champion Support	▪ Ingress / Egress	▪ Account Management
▪ Legislative Action	▪ Develop Engineers Cost Estimate		▪ Signage	▪ Enforcement
▪ Public Outreach	▪ Develop Specification		▪ Toll Zone Location	▪ Violation Noticing
	▪ Public Outreach		▪ Construction and Test	▪ Stakeholder and Champion Support
			▪ Public Information	▪ Public Information

Consider that managed (HOT) lane cross-section standards have essentially evolved as indicated in the table.

Cross-Section	Element Standard
Lane Width	■ 12 feet, 3.6 meters
Shoulder Width (Right and Left)	■ 10 feet, 3.0 meters preferable 2 feet, 0.6 meters minimum (dependent on number of lanes, type of operation, sight distance)
Separation (Buffer) Width for non-barrier separated operation	■ 4 feet, 1.2 meters
Sight Distance	■ Standard stopping sight distance for facility type
Safety Considerations	■ Crash attenuation for exposed barrier ends ■ Transition treatments with HOV or general-purpose lanes ■ Adequate access opening lengths

These basic cross-section requirements must be fully integrated with all of the design considerations to determine an effective and safe HOT facility.

Almost as important as the many design considerations that must be addressed is the identification of the players involved in the HOT lane implementation process and clear definitions of roles and responsibilities -- since there are often multiple organizations with key roles in planning, building, operating, and sustaining a typical HOT lane program.

Specific organizational and management structures may differ based on a variety of factors including state enabling legislation, asset ownership, project financing (e.g., revenue bond or general funds), and the role of the state DOT, RPOs, and MPOs.

Typical entities that are involved in the planning and implementation of the program are:

- Owner: The agency that legally owns the HOT facility and right of way, usually the state DOT.
- Sponsor: The agency with responsibility for overall project planning, design, and implementation. (Note: The sponsor can be the same as the owner but may be a separate transportation agency.)

Operator: The organization responsible for the operations and management of the HOT lane facility. (Note: The operator can be the same as the owner and sponsor but may be a different organization.)

Interfacing Organizations and Institutions: There are several other agencies, including those involved in the development, implementation, and operation of the HOT lanes.

HOT System Procurement Options

There are two major elements of the HOT lane system that will be procured: 1) roadway-related work, and 2) the ETC system. For several important reasons, the two elements should not necessarily be procured using the same strategy.

Roadway Work

Improving the roadway involves civil work such as widening, paving and surfacing, gantry installation, and electrical work. There are two procurement options for roadway work:

1. Design-Bid-Build. Under this option, the sponsoring agency provides all of the roadway design detail and puts the package out for bid on a low-bid basis.

2. Design-Build. Here, the sponsoring agency develops preliminary designs and then puts the package out for bid to a design-build team. (Note: This procurement option may lend itself to the RFP process discussed in the next bullet in order to facilitate an evaluation of the design-build team's overall design capabilities and concepts.)

ETC Systems Work

ETC work involves designing (including developing and integrating), installing, and potentially maintaining and operating an ETC system, including software and communications to the lane equipment and critical back-office operations. Because the ETC work is highly specialized, it does not lend itself to a selection solely on a low-bid basis. There are three basic models to consider in the ETC system integrator procurement:

3. Design-Build. The system integrator designs, builds, and installs the system and then turns it over to the sponsor, who then hires a separate entity to maintain the system (or use in-house resources). The sponsoring agency can obtain these services through a separate RFP or can make an agreement with another agency to "piggyback" on its existing customer service center (CSC) operations.

4. Design-Build-Maintain. Where the system integrator not only designs, builds, and installs the ETC system, but also maintains the system for a fixed period of time (e.g., 5 years). Here, the sponsoring agency would again have a separate agreement for CSC operations or could operate the CSC.

5. Design-Build-Operate-Maintain. The system integrator is completely responsible for all aspects of HOT lane implementation and operations, including maintenance and CSC operations for an agreed-upon period of time.

HOT Lane Enforcement Issues

Enforcement is critical if an HOT lane facility is to be successful and effective. Enforcement of HOT lane usage must accomplish the following key operational functions:

- Verify toll payment (or credit)
- Verify vehicle occupancy
- Assess fine to violators.

Facility design influences the types of enforcement needed. Barrier separation features act as a deterrent to potential violators, but require areas along the facility to monitor, apprehend, and cite violators.

Barrier-separated facilities generally make apprehension fairly easy, since the violator is confined in the lanes after entering the facility. However, it should be noted that the larger the facility (i.e., number of lanes) and the larger the quantity of entry and exit points, the more difficult manual enforcement is.

I-15 Express Lanes in San Diego, CA

Non-barrier separated HOT lanes are the most difficult to enforce, since it is easy to enter and exit the lane simply by changing lanes. Facilities that use delineators, such as the SR91, deter violators, but may still experience violators "diving" through the delineators. Locations where delineators are used typically do not have adequate shoulder space for effective roadside enforcement.

The MnPass Approach

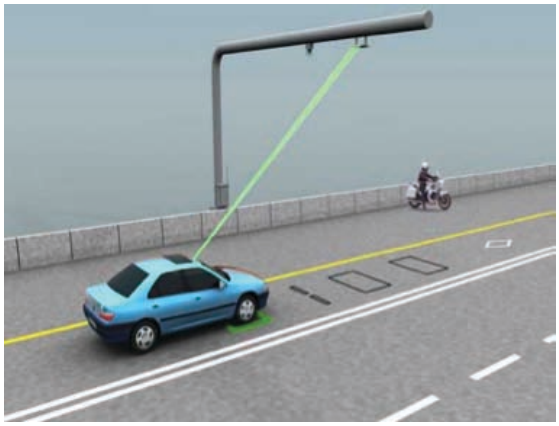
- MnPass uses a solid, double, white line to separate HOT lanes from general-use lanes.
- Double striped lines indicate authorized access and exit points.
- According to MnDOT, after lane striping was implemented, the violation rate has dropped from >20 % to less than 10%.
- Most drivers observe the double and striped markings. Violators of marked striping are fined $165.00 per occurrence.

Accurately determining the number of occupants in a vehicle is difficult at best and often results in having an enforcement officer mistakenly stopping HOV vehicles because an occupant, such as a child, in addition to the driver, is not readily visible in the back seat.

Enforcement of occupancy requirements is the most difficult operational challenge facing toll agencies and enforcement officers in HOT lane implementations because automatic technologies have not yet met reliability and field accuracy requirements required for operational deployment. In addition, there are a host of cost and privacy considerations associated with the technology.

Some actions that can be taken to enhance the performance of HOV and HOT violation enforcement may include:

- During the design phase, have engineers meet with highway patrol officers to determine locations best suited (safe adequate space) for roadside enforcement, similar to that shown in the photo.
- If there is adequate space in lanes, consider installing concrete barriers.
- Prominently and with consistency, post the fine for HOV and HOT violations on roadside signs.



Having a strong enforcement presence is key to deterring violations and maintaining the integrity of HOT lane operations.

HOT System Operations

Operational strategies alone will not ensure reliable system operation. The HOT lane facility must include operational resources to provide maintenance, customer service, and account management

- Maintenance. Since HOT lane systems employ totally automated ETC equipment, it is critical to the seamless use of the system by customers and to sustained revenue collection capability to employ 24/7 maintenance of the system.
- To minimize down time and facilitate maintenance actions, it is critical that a maintenance online monitoring (MOM) system is included with the HOT ETC system. Monitoring all toll zone collection equipment for failures or malfunctions that could impact the collection of revenue will minimize down time and revenue losses.
- Customer Account Service Center. Customers should have easy access to account information via a variety of means including the Web, telephone, and mail and should be able to manage their accounts with the tools provided.
- The service center must provide customer support and promptly handle customer problems and complaints. The center must maintain ongoing communication with the public as well as stakeholders and provide ongoing outreach information to present the latest information on the HOT lanes operations and status.
- Video Processing Center. As video tolling becomes more widespread together with video image capture of violators, the Account Service Center may well develop into a dual purpose Customer Service and Video Processing Center (CSC/VPC) that not only establishes and manages transponder and video toll accounts, but also ensures that true violations are processed and funds are recouped.

Operational Strategies

- Restrict HOT lane ingress and egress to specifically designated and marked locations to / from the general-purpose lanes.
- Limit vehicle eligibility.
- Use a variable time-of-day pricing structure to manage demand and congestion.

Case Study Interviews

In trying to identify lessons learned from HOV to HOT conversion projects, three case studies were chosen. The sites chosen for the case studies are Denver, CO; Minneapolis, MN; and San Diego, CA.

Site	Length	Type Lane	# Access Points	Toll Points	GP – ML Separation
I-394	11 mi	8 mi - SLn 3 mi – 2 Ln Rev.	Multiple – SL Rev. Entry / Exit	7 WB 6 EB	Double White, Rev. with Barrier
I-15	8 mi	2 Ln Rev.	Entry / Exit	1	Rev. with Barrier
I-15 Exp	12 mi	2 Ln HOT	Multiple	Multiple	Dbl Yellow, Movable Barrier
I-25	10 mi	3 mi SLn 7 mi 2 Ln Rev.	Entry / Exit	1	Dbl White, Rev. with Barrier

These three case studies were chosen to supplement the growing body of research exploring the relationship between program objectives, system design, concept of operations, toll collection strategies, and operational requirements.

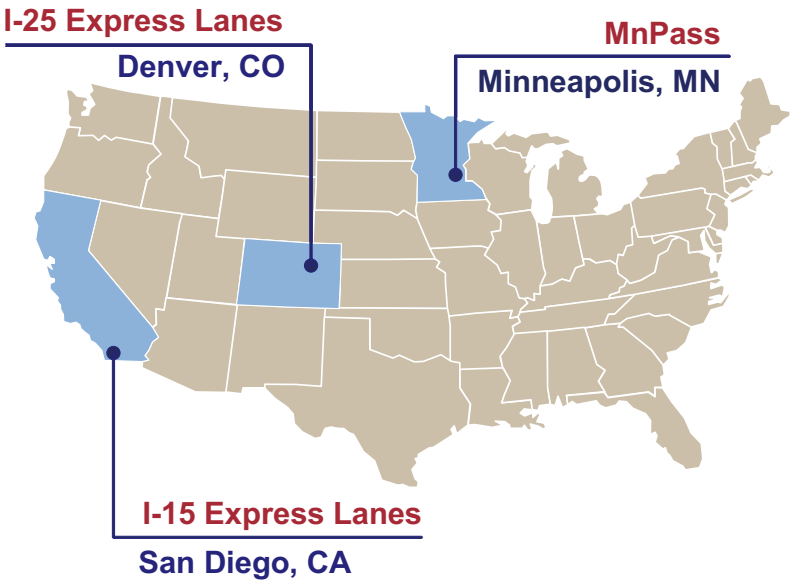
Each case study attempts to identify outcomes (intended and unintended) based on specific operational choices and to address key lessons learned, or best practices in the planning, design, and implementation.

Data Collection Approach

Information available from published data for each of the operational case study sites was integrated with focused interviews conducted at the project site, when possible. To provide a common baseline, or starting point for the interviews, a focused interview guide was developed to facilitate in-depth probing of key project development issues and challenges in four main areas:

1. Public Outreach and Communications
2. Planning and Policy
3. System Design Procurement
4. Management and Operations

The three cases provide diverse implementations implementation characteristics and conditions for evaluation.



Best Practices

As more agencies consider converting existing HOV facilities to HOT lanes, it is important for planners, designers, and other practitioners not to "relearn" the lessons others have learned in transitioning HOV lanes to HOT lanes.

All HOT lane practitioners should be cognizant of industry best practices to avoid problems and challenges that may arise during each phase of project development and implementation. The following presents the best of the best practices in each phase.

Project Pre-Planning and System Planning

- Engage local and state leadership early and often during planning and design phases.
- Develop an extensive and effective public outreach program that begins at the earliest stages and continues through operations.
- Ensure that the HOT project is included in the MPO planning requirements as soon as possible.
- Develop strong political champions at the state and local levels.
- Foster a revenue and sharing plan that includes transit when possible to do so.

System Design

- Design for efficiency, safety, and ease of participation by the public.
- Provide the public with a viable travel option.
- Utilize electronic and video tolling concepts; no toll booths.
- Consider using dynamic tolling strategies to control traffic volumes.

Project Financing

- Federal funds and grants are essential to implementing a project.
- Investigate PPP options either as stand alone or as supplemental to federal funding.
- Use local options, such as a SPLOST[1] as appropriate, to temporarily address shortfalls.

Implementation

- Utilize electronic and video tolling concepts.
- Consider outsourcing back-office and/or customer services with an established CSC.
- Ensure the establishment of maintenance services to provide 24/7 operations to include an MOM.

Operations and Management

- Determine if 24/7 toll operations meet objectives and are generally supported by resources and the public.
- Use dynamic pricing strategies to maintain free-flow speeds.
- Implement an enforcement system that is visible, effective, and fair (from the public's perspective) to ensure the integrity of the facility.
- Share information and research with agencies along the corridor to obtain their support and ensure the success of the facility.
- Implement a continuing and comprehensive evaluation of the facility to maintain support, encourage continued growth, use in marketing campaigns, and inform the public.

1 *Special purpose local-option sales tax*

Lessons Learned

Although each of the case studies differed from one another and from a number of the implementations reviewed in the literature, there were a number of key lessons learned that were either the same or nearly the same for almost every implementation. The ones repeated most frequently are presented here as a flag to alert and assist practitioners to avoid similar troublesome areas.

- A political champion is a MUST to ensure project success. It was evident that champions at both the state and local levels are essential for both political and public acceptance.
- An extensive public outreach program with stakeholder interviews, focus groups, public forums, and surveys are absolutely necessary for success and acceptance. A successful program is critical for obtaining buy-in politically as well as with the public.
- HOT lanes should not be implemented as a revenue generator for added capacity. They should be "sold" to the public and implemented as a congestion management tool first and a possible source of revenue second.
- Fully understand the impact of creating added capacity to HOV lanes and potentially creating unexpected, new congestion hot spots.
- Enforcement of occupancy requirements is the most difficult operational challenge facing toll agencies and enforcement officers because automatic technologies have not yet met reliability and field accuracy requirements for operational deployment.
- Signage among the various tolled facilities was not consistent especially when announcing enforcement provisions for lane violations. This lack of consistent enforcement signage was found to contribute to unauthorized users accessing the facilities and appeared to contribute to the practice of lane diving from the general-purpose lanes into the managed lanes that were not barrier separated.

Directions for Future Practice

Each HOV transition to HOT operations will, by necessity, be evaluated on the unique circumstances for each area. While each implementation will be a unique application dependent on road geometry, right-of-way availability, density, and alternative corridors, it is important that consideration be given to the utilization of common, and to some degree, interoperable technologies for an HOT facility.

Legislative

Legislatures are becoming more proactive in providing enabling legislation that will provide the states with the authority to collect tolls, toll HOV facilities, implement an effective violation enforcement policy, provide authorization to collect administration and processing fees, and provide for a PPP policy.

Electronic and Video Toll Payment

As congestion increases and the average number of HOT lane facilities increases to beyond two lanes in each direction, the HOT implementations will begin to resemble open road tolling implementations using a combination of electronic and video tolling. Toll booths will not be used for HOT lane operations and will tend to obsolescence in all cashless implementations.

Enforcement

Visible and effective enforcement is critical to the successful operation of any HOV/managed-lane facility. To gain and maintain public acceptance of the project, the enforcement strategy and the technology implemented must be reliable and highly visible and must promote fairness and maintain the integrity of the facility. Even with continued technology improvements that provide more reliable and accurate image capture of license plates for optical character recognition systems, it will still be necessary to implement an accurate mobile enforcement system that complements the improved video systems. A visible and fair enforcement presence remains an essential element of an effective enforcement strategy.

Occupancy Enforcement

Probably the most frequent type of violation infraction that enforcement officers encounter is occupancy violations, which requires them to see inside a vehicle and count the number of occupants. Enforcement of occupancy requirements is the most difficult challenge facing toll agencies today. Automated technologies that meet reliability and field accuracy requirements have not yet been achieved for operational deployment.

Perhaps within the next 10 to 15 years, an onboard unit capable of determining vehicle occupancy will be fully integrated in a vehicle and capable of communicating this information to the enforcement officer at the roadside using dedicated short-range communications technology.

Until this technology is available, it is likely that DOTs and toll agencies will require all HOT users to establish either a transponder or a video toll account to assist in separating HOV authorized users from SOV users.

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