MANAGED LANES

a primer

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Foreword

This primer is designed for community leaders, key policy makers, transportation agency managers, and those working to find solutions to today's transportation challenges. The purpose is to provide information on managed lanes as a mobility strategy, and to give the reader a starting point for exploring managed lanes in their own community.

Topics covered in the primer include the following:

- defining managed lanes,
- managed lane success stories,
- issues and challenges unique to managed lanes projects, and
- the future of managed lanes.

DEFINING MANAGED LANES

The total number of vehicle miles traveled in the United States has increased more than 70 percent in the last 20 years. At the same time, highway capacity has only grown by 0.3 percent.

Departments of transportation, metropolitan planning organizations (MPOs), and other agencies involved in the planning process are simply unable to build enough capacity to keep up with growing demand. Many factors, including increased construction costs, right-of-way constraints, environmental concerns, and societal impacts, contribute to the escalating challenges of adding new general-purpose lanes—especially in developed urban areas. Moreover, many agencies are grappling with a serious transportation funding crisis.

As a result, these agencies are seeking ways to better manage the flow of traffic on existing facilities. Typically, this has been done by using lane management strategies that

- regulate demand,
- separate traffic streams to reduce turbulence, and
- utilize available and unused capacity.

Application of such operational policies is evolving into the notion of "managed lanes." The managed lanes concept is gaining interest around the country as an approach that combines these elements to make the most effective and efficient use of a freeway facility.

What Are Managed Lanes?

The managed lane concept may vary in specific definition from one agency to the next, but all the definitions have common elements:

- The managed lane concept is typically a "freeway-within-a-freeway" where a set of lanes within the freeway cross section is separated from the general-purpose lanes.
- The facility incorporates a high degree of operational flexibility so that over time operations can be actively managed to respond to growth and changing needs.
- The operation of and demand on the facility is managed using a combination of tools and techniques in order to continuously achieve an optimal condition, such as free-flow speeds.
- The principal management strategies can be categorized into three groups: pricing, vehicle eligibility, and access control.

Examples of operating managed lane projects include high-occupancy vehicle (HOV) lanes, value priced lanes, high-occupancy toll (HOT) lanes, or exclusive or special use lanes. Each of these concepts offers unique benefits; therefore, careful consideration is given to project goals and objectives in choosing an appropriate lane management strategy or combination of strategies. Project goals may include increasing transit use, providing choices to the traveler, or generating revenue.

This primer focuses on the following definition of managed lanes:

> "Managed lanes" are defined as highway facilities or a set of lanes where operational strategies are proactively implemented and managed in response to changing conditions.

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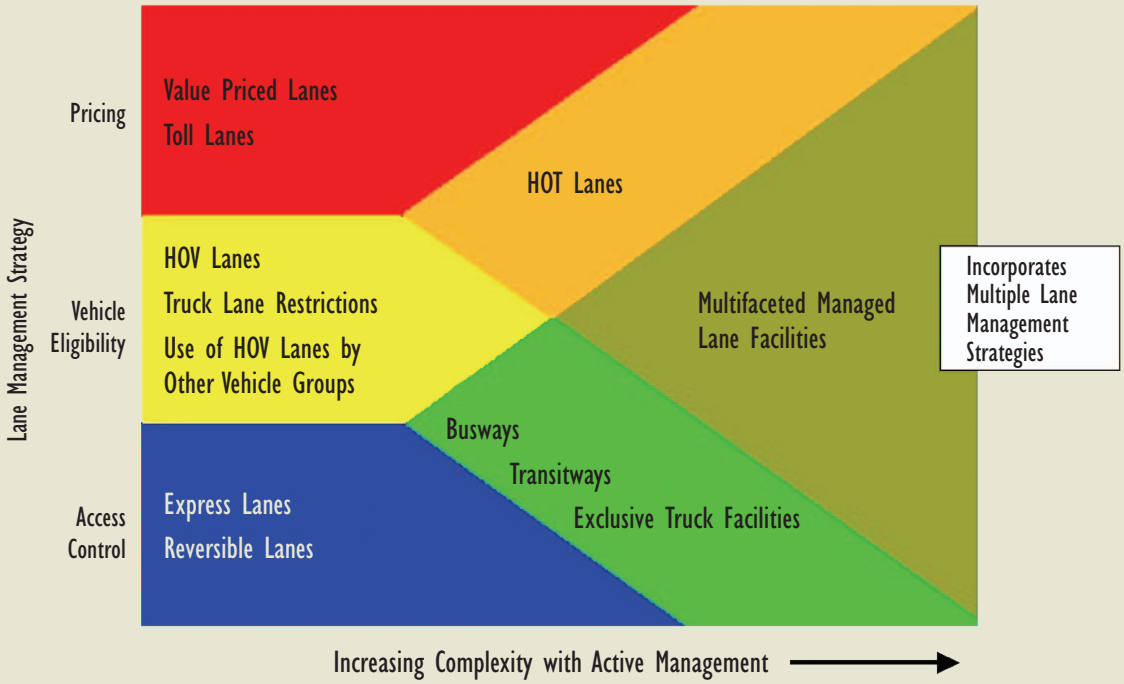
Exhibit 1 is a diagram that captures the potential lane management applications that fall into this broad definition of "managed lanes." On the left of the diagram are the applications of a single operational strategy—pricing, vehicle eligibility, or access control:

- *Pricing* — Includes both traditional toll lanes and toll lanes that use congestion pricing, where price is varied during certain time periods in order to manage demand (e.g., peak-period surcharge or off-peak discount).
- *Vehicle eligibility* — The lanes are managed by allowing certain vehicles or restricting others; minimum occupancy is an example of an eligibility restriction.

Exhibit 1. *Managed Lane Applications.*



- *Access control* — An example would be express lanes where all vehicles are allowed but access is limited during long stretches of the facility, minimizing turbulence in the flow of vehicles.

As you move to the right on the diagram, you get into the more complicated managed lane facilities that blend more than one of these strategies:

- *Combined pricing and eligibility* — HOT lanes where higher occupancy vehicles such as buses, vanpools, and carpools are given free or discounted passage and all other vehicles are tolled.
- *Combined vehicle eligibility and access control* — Examples include exclusive busways, transitways, or truck facilities serving a specific type of vehicle, with barrier separation and limited access points
- *Multifaceted managed lanes* — Integrates all strategies for an actively managed facility that incorporates a high degree of operational flexibility

The Principle of Active Management

Lane management strategies have been used by agencies for decades to improve flow on freeway facilities. The distinction between managed lanes and other traditional forms of freeway lane management is the philosophy of "active management." Under this philosophy, the operating agency proactively manages demand and available capacity on the facility by applying new strategies or modifying existing strategies.

The agency defines from the outset the performance objectives for the managed lanes and the kinds of actions that will be taken once pre-defined performance

thresholds are met. Here are some examples of how demand can be managed to meet performance objectives:

- raising the toll rate on a priced facility to maintain a speed of 60 mph,
- raising the occupancy requirement to use an HOV lane so that bus operating speeds of 50 mph can be maintained, and
- closing an on-ramp to express lanes during peak periods so that the express lanes can operate within a volume threshold of 1500 vehicles per hour per lane.

The premise of "active management" is one of the distinguishing features of managed lanes.

Why Consider Managed Lanes?

As noted earlier, increasing vehicle miles traveled with limited roadway expansion has led to serious traffic congestion especially in the nation's urban centers. Funding shortages and other constraints prevent the necessary expansion of the systems. Fortunately, the evolution of geometric design criteria and emerging technology has helped transportation agencies refine the available strategies to meet growing freeway operations challenges. Flexible operating strategies make implementing managed lanes a practical solution for improving mobility by providing viable travel options in congested corridors.

MANAGED LANE SUCCESS STORIES

Every corridor is different with its own unique operating characteristics. The success of a managed lanes project will depend on the effectiveness of the operating strategy to address these characteristics. Careful forethought of project goals is critical to choosing the most appropriate management techniques to implement on the facility. The case studies presented in this document incorporate all three forms of lane management: pricing, vehicle eligibility and access control.

State Route 91 Express Lanes ◊ Orange County, California

Project Goal:
Provide motorists a congestion-free alternative and maintain financial viability of the lanes.

- ◊ Toll Express Lanes
- ◊ 10 miles in center median of SR 91
- ◊ 2 lanes in each direction
- ◊ Fully automated; must have registered account
- ◊ Privately developed
- ◊ Tolls vary by time of day

QuickRide ◊ Houston, Texas

Project Goal:
Utilize available HOV capacity while preserving bus operating speeds

- ◊ HOT Lanes
- ◊ I-10 (Katy Fwy) 13 mile single lane reversible
- ◊ US 290 (Northwest Fwy) 13.5 single lane reversible
- ◊ Fully automated; must have registered account
- ◊ Allows 2 occupant vehicles access during 3+ restriction
- ◊ $2.00 per trip flat fee
- ◊ Operates only during peak hours

Interstate 15 Express Lanes ◊ San Diego, California

Project Goal:
Utilize available HOV capacity to fund new transit service in the corridor

- ◊ 8 mile HOT lane
- ◊ 2 lane reversible
- ◊ Fully automated; must have registered account
- ◊ Tolls vary dynamically
- ◊ Tolls rates based on level of congestion in the lanes

New Jersey Turnpike: Dual-Dual Section ◊ New Jersey

Project Goal:
Enhance safety and improve operations through increased flexibility

- ◊ 31 mile dual-dual section of turnpike
- ◊ Each section has its own ingress and egress points
- ◊ Trucks must travel on outer lanes; passenger vehicles may travel on inner or outer lanes
- ◊ HOV lane on outer section; operates during peak
- ◊ HOV and EZ-Pass discount
- ◊ Variable pricing to shift travelers out of peak

State of the Art in Managed Lanes: Value Pricing

Value pricing, or congestion pricing, was introduced to transportation officials through a federal pilot program included as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and continued in the Transportation Efficiency Act for the 21st Century (TEA-21). The pilot program allows agencies to work with the Federal Highway Administration (FHWA) to employ road pricing strategies, including the idea of charging motorists a toll for travel during the most congested times or offering a discount for traveling in the off-peak period.

On the New Jersey Turnpike, operators have used pricing to better manage peak period demand on the facility. The Turnpike Authority currently offers an off-peak toll rate to E-Z Pass customers that is generally 25% lower than the cash rate. ◊

The program ushered in the use of HOT lanes as an operational strategy. HOT lanes take advantage of available unused capacity in an HOV lane by allowing vehicles that do not meet the minimum occupancy requirement to pay a toll for access to the lane(s). The price may be set in a regular toll schedule, it may change by time of day or day of the week, or it may change dynamically in response to the current level of congestion. HOT lanes use both vehicle eligibility and pricing to regulate demand.

Pricing is a strategy that can be used to both manage demand and generate revenue. The SR 91 Express Lanes in Orange County, California; the I-15 Express Lanes in San Diego; and the QuickRide program in Houston each seized an opportunity to test pricing as a demand management tool and, as a minimum, pay for operation of the facility. Of the three types of lane management strategies — pricing, vehicle eligibility, and access control — only pricing

Combining pricing and vehicle eligibility results in a more complex operating strategy. The QuickRide program varies vehicle eligibility by time of day but also incorporates pricing for a portion of that time. Utilizing two strategies makes the maximum use of the HOV lane but also makes enforcement more challenging. Enforcement officers must perform a visual inspection to verify the required number of occupants. If there are fewer occupants in the vehicle the officer must then verify that the motorist is a registered participant in the QuickRide program by checking a light indicator. ◊

The New Jersey Turnpike is a limited access facility that has also successfully improved operations by separating types of vehicle traffic. A 32-mile segment of the roadway has been expanded into two separate roadways, resulting in a dual-dual facility. Large trucks are limited to the outside roadway but passenger vehicles may travel on either the inside or the outside roadway. Each of these roadways offers very limited access and the access is through independent ramps for the inside and outside roadways. Using gates, operators can limit access to a particular roadway as needed to manage demand or in the event of an incident. The result is a roadway that operates efficiently because turbulence in the traffic flow is minimized. ◊

has demonstrated in practice that it offers real-time active management capabilities.

State of the Practice in Managed Lanes: Traditional Lane Management Strategies

Vehicle Eligibility

Vehicle eligibility is an important tool in managing demand while meeting policy objectives, as has been demonstrated by the success of numerous HOV lanes across the country. Vehicle eligibility may vary by time of day or day of week and may change over the life of the facility as conditions change. This strategy has not been used in the way pricing has to regulate traffic flow on a dynamic basis.

Most lane management strategies based only on vehicle eligibility show a preference for HOVs, but as in the case of the QuickRide program and the I-15 Express Lanes, vehicle eligibility may be combined with a pricing strategy to most effectively manage a facility. Other applications of vehicle eligibility may take the form of exclusive truck lanes, bus lanes, or truck-restricted lanes. In theory, a multifaceted managed lane facility could vary vehicle group eligibility over the course of a day serving, for example, commuter trips during peak periods and trucks at other times.

Access Control

Access control is used to limit entry to a facility based upon congestion levels or operational conditions, such as an incident or maintenance needs. Access is not necessarily restricted by type of user, although it may be in situations where direct connect ramps are provided exclusively for bus or carpool use. Demand can be managed by limiting access to fewer entry and exit points, using grade-separated ramps as opposed to at-grade ramps, or utilizing actual barriers at ramp locations to control access.

BEST PRACTICES IN MANAGED LANES

The managed lane projects in operation today use a combination of strategies and have common characteristics that have led to their success. These best practices focus on three key areas: planning and project development, facility monitoring and evaluation, and life-cycle considerations.

The development of the SR 91 Express Lanes capitalized on new legislation encouraging public-private partnerships. The private sector financed, built, and maintained the Express Lanes, and then sold the project to a public agency, the Orange County Transportation Authority. Building the SR 91 Express Lanes provided more options to travelers in a very congested corridor in a way that is financially self-sustaining. ◊

Planning and Project Development

Agency Collaboration

The successful projects have been the cooperative efforts of various agencies from the initial stages of project development throughout operations. These projects are large undertakings that required the assistance of several agencies. They have frequently crossed jurisdictional boundaries. Planning for the managed lanes projects has required input from the federal agencies, the state department of transportation, the metropolitan planning organization, and other local agencies.

None of the operating pricing projects highlighted in this primer were developed out of the long-range plan for the community, but rather they were largely opportunities to apply pricing strategies as pilot projects.

In addition to the traditional agency coordination, the success stories have shown that including as many potentially affected stakeholders as possible early in the process elevates your chances for success. Others to be included, based on project experiences, are:

- transit agencies,
- regional transportation authorities,
- toll agencies,
- law enforcement personnel,
- court personnel,
- environmental groups,
- special interest groups, and
- citizens.

Just as important as the cooperative efforts of agencies are the institutional arrangements that define the scope and the operation of the project. The institutional arrangements surrounding the construction and subsequent operation of a managed lanes project will involve many entities that may not have previously worked together.

Forging and fostering these relationships by clearly defining roles and responsibilities can forestall many issues as project development progresses.

Selecting a Managed Lane Strategy

An important factor in a successful project is the careful analysis of the design and desired operating characteristics of the facility. The lane management strategies may vary depending on (1) the objectives of the project, (2) whether the strategy is implemented on new capacity or an existing facility, (3) the availability of right-of-way, (4) current operational characteristics in the corridor, and (5) environmental and societal concerns.

The managed lane success stories have shown us that effective project development and planning results from a thorough understanding of the purpose of the project and the goals that may be achieved through project delivery. It requires an assessment of current conditions in the corridor and designing a facility that will operate in a manner that meets the needs of the community. Additionally, the facility incorporates the flexibility to alter those strategies as conditions in the corridor change or community goals change. On-going facility evaluation ensures that the facility functions at its peak performance under the chosen operating strategy. Successful projects employ operating strategies that can be adjusted as the facility matures and changes over time and as the community's needs evolve.

Identifying a Hierarchy of Users

Determining a hierarchy of users is a common characteristic of operating managed lanes projects. Essentially this means that the operating agency has defined its higher priority users and lower priority users, with the lower priority users experiencing the impact of increased prices and/or restricted access as strategies are applied to manage

Project agreements are useful in identifying the issues but should also be flexible enough to address unforeseen circumstances. For instance, the constructors for the SR 91 Express Lanes negotiated contracts with the California Highway Patrol to provide enforcement on the facility. Since this facility was the first of its kind, project agreements like this one were helpful in clarifying roles, and enough flexibility was build into the contract to account for unexpected situations. ◊

The I-15 Express Lanes and the QuickRide lanes were originally planned and designed as HOV lanes and they continue to operate first and foremost as HOV lanes. The HOV lanes were implemented as barrier-separated facilities which simplified the decision-making regarding operational strategies. The actual design and goals of the facilities—namely to preserve the HOV preference in the lanes—dictated the types of operating strategies considered for implementation. ◊

demand. For instance, each of the pricing projects in California and Texas has chosen to give preferential treatment to HOVs. On the I-15 Express Lanes and on the QuickRide project very specific parameters have been established so as not to adversely impact the HOVs that travel on these facilities. The QuickRide program gives priority to transit vehicles and ensures that the operating speeds of buses are not compromised by the High Occupancy Vehicles with only two occupants (HOV2s) allowed on the facility. The I-15 Express Lanes' parameters have been defined by state law. Level of service (LOS) requirements must be maintained for HOVs on the facility.

Establishing Threshold Values

Inherent in the premise of active management is the necessity for establishing threshold values for maintaining a prescribed level of operating service. That threshold value could be based on traffic volumes, operating speed, or similar measure. When the threshold value is exceeded, it triggers an action to modify the lane management strategies — whether that be price or occupancy or both — in order to maintain operating objectives.

Communicating the Managed Lane Strategy

It may be very easy for transportation professionals to understand the benefits of a managed lanes project that involves pricing. These professionals understand the project delivery process and are knowledgeable of the corridor characteristics. They may also be much more attuned to any transportation funding shortfalls.

On the other hand, politicians and the public may look at pricing as an unfair imposition. The managed lanes concept is new to most travelers and may often include very complex operating strategies. Public education and outreach have been critical to the success of operating projects. In the

case of the California projects, politicians championed the concept and facilitated it through enabling legislation. In addition, the idea of active management, with flexible operating conditions, involves challenging and repeated public education so that there is a clear understanding that the price may change or access may be restricted at some point in the future.

Facility Operations with Continual Monitoring

Project Flexibility

It is important to note that successful projects have the flexibility to alter operations as conditions warrant and priorities change. The two managed lanes facilities in California offer the flexibility of variable and/or dynamic tolling with the ability to adjust operations according to demand. As managed lanes projects are mainstreamed, planners and engineers will be exploring ways to include flexibility in the design of a facility, such as moveable barriers, larger design vehicles, and strengthened bridge structures to accommodate future rail in the corridor. By addressing flexibility as a design element, the facility's life may be extended because operations on the facility can be changed as traffic conditions in the corridor change or as community objectives for the project change.

Monitoring and Evaluation

Under the principle of active management, the need for continual monitoring and evaluation of the managed lanes is imperative. At the outset of a project, specific performance measures and threshold values are defined, and those measures are continually evaluated. For instance, I-15 established a performance measure of LOS and set that threshold at 1,525 vehicles per half hour. SR 91 Express Lanes operators monitor volumes in the lanes and have raised tolls several times as a

The Colorado Department of Transportation developed a graphic that illustrates the lifespan for a managed lanes project as a way to help communicate the changes in operation over time and the relative priority of the different vehicle groups. Exhibit 2 depicts the stage at which various strategies will be enacted over the life of the project so that free flow conditions can always be maintained. For instance, SOVs are permitted access when the project opens provided they pay the prevailing toll. Through the use of variable pricing, which sets the toll according to the level of congestion, the number of SOVs that use the facility is never allowed to exceed the "critical operating threshold," or the traffic volume at which operations become congested. As time goes on and HOV volumes grow, certain HOV users may be required to pay a toll so that congestion is avoided. ◊

result of increased congestion on the facility in an effort to maintain free-flow conditions and return a profit. In both cases, pricing is the strategy that is used to stimulate changes in demand.

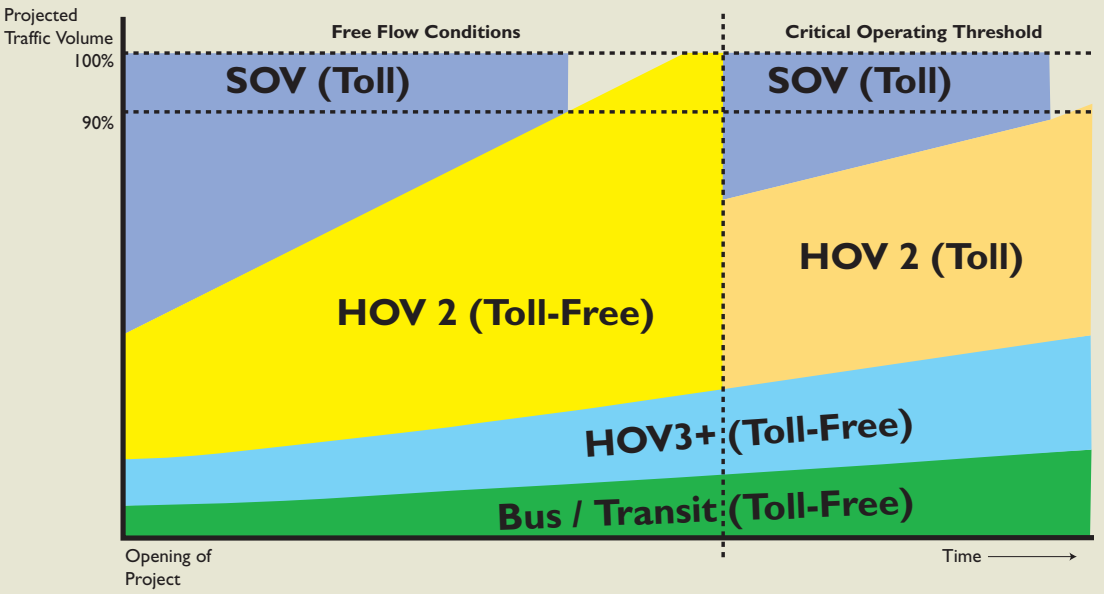
Monitoring technology used successfully today includes vehicle sensors, automatic vehicle identification, license plate recognition, and user information systems. Each of these components has demonstrated in the case studies that it is integral in ensuring effective operation of a facility. Likewise, more comprehensive, historical data can be collected and analyzed to determine if adjustments to the overall operating strategies should be made.

Life-Cycle Considerations

Given a flexible, actively managed facility, what are the expectations of its performance and mobility contribution over the full life of the project? The notion of life-cycle operations takes agencies beyond the day-to-day adjustments in price to a thoughtful plan of facility changes triggered by pre-established performance measures. It goes beyond the policies and procedures necessary to establish pricing changes to more long-term modifications: When should vehicle eligibility requirements be modified? How and when should access control, including ramp closures, metering, or exclusive use by specific vehicle groups, be used? Are the managed lanes envisioned to become a future rail corridor? And what are the performance thresholds that activate these changes? The challenge becomes communicating the long-term active management premise to policy makers and the public. It will be important to find effective ways to continually communicate the possibility of change as the project matures over time.

The New Jersey Turnpike uses an extensive array of ITS technologies to monitor the turnpike. This enables operators to assess when, if or how operations need to be adjusted. ◊

Exhibit 2. *Example of the Lifespan of a Managed Lane.*



MANAGED LANES MAPPING THE MINEFIELD

The managed lane projects in operation today are successful models for using multiple operating strategies to achieve intended objectives. The projects, by and large, have received widespread public support. However, these "first generation" projects enjoy relatively simple design and operating conditions.

There are plans underway to expand the I-15 Express Lanes and the I-10 Katy Freeway project to increase the number of managed lanes and provide new features. As transportation professionals

analyze various operating alternatives on these next-generation projects, new issues are brought to the forefront. Agencies now recognize that the more flexible the system is, the easier it is to manage demand that will only increase over time. But they also recognize the challenges in designing for projects that offer ultimate flexibility. Considerations are being given to distance-based pricing, time-of-day pricing, varying occupancies along with price, reversible lane operations, and design of facilities with multiple intermediate access points.

Expansion of I-15 San Diego and I-10 Houston

The managed lanes concept has recently been adopted into the long-range transportation plan for the San Diego region. The I-15 expansion plans are a huge undertaking that will still have a primary focus on HOV/transit use. The plans call for adding two additional Express Lanes to the existing lanes and extending the facility another 12 miles. A moveable barrier will be employed to allow adjustment of the lane balance as needed, such as operating three lanes inbound and one outbound in the morning, but two lanes each direction midday. Flexibility is being built into the design of the facility to allow operational adjustments that will meet the changing needs of the traveling public in the corridor.

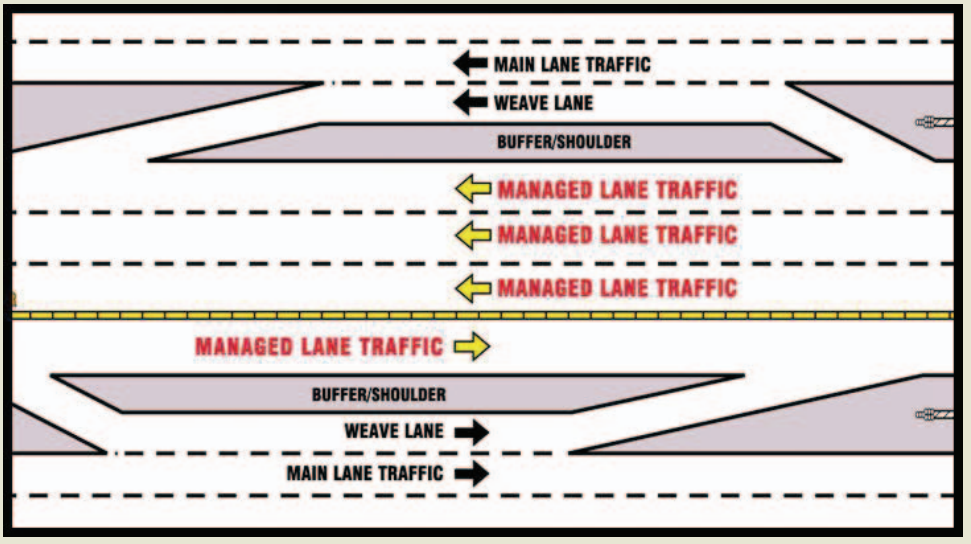
The Katy Freeway expansion plans are a cooperative effort of the transit agency, the department of transportation, and the local toll agency. This project is an example of agencies working cooperatively to speed project delivery and shore up funding for much needed improvements to a facility that is currently functioning far beyond its intended life. The reconstructed facility will add four managed lanes that will use price to manage demand and ensure that the facility operates at free-flow conditions for peak transit operations.

New Challenges

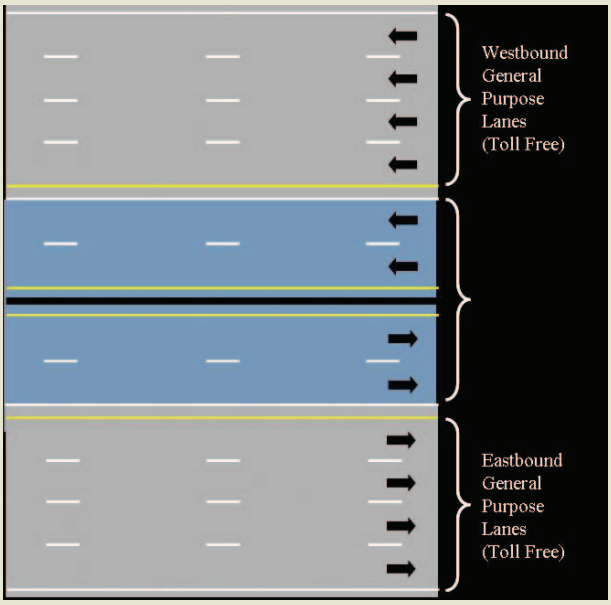
As these and other new projects are developed and the various operating strategies are assessed, it is apparent that the complexity of the managed lane operations is greater than those of the previous schemes. Critical issues are:

- access design,
- driver information and signing,
- enforcement,

I-15 expansion cross-section.



I-10 (Katy Freeway) expansion.



- revenue generation and equity,
- legislative authority,
- new institutional arrangements,
- analysis techniques and demand forecasting models,
- design flexibility,
- integrated transportation opportunities, and
- technology.

Access Design

The design of access and egress points impacts the operating conditions within a managed lanes facility and affects the agency's ability to readily modify operating strategies. Both the I-15 Express Lanes and the SR 91 Express Lanes act as pipelines with only one point of access and one point of egress, which greatly simplifies operation. Multiple access locations, such as those proposed for the I-15 and I-10 Houston expansion projects, increase the complexity of the operating strategy and make enforcement more challenging. Spacing of at-grade ramp connections and length of weaving sections could impact safety and operating conditions, both within the managed lanes and in the adjacent freeway lanes. Terminal access at either end of the facilities can also be a design challenge, particularly in fitting the facility within an existing freeway or arterial street system.

Driver Information and Signing

Dynamic message signs (DMSs) are typically used to alert drivers of conditions on the roadway or inform them of anticipated travel times.

They are also used to notify approaching drivers of current toll rates on a facility. Use of DMSs is fairly straightforward in a simple lane management strategy. However, if a strategy is more complex and depends on vehicle occupancy, access location, and pricing, it becomes much more difficult to communicate that information to the driver via a DMS. Also, because electronic toll collection technology is used in pricing projects, it is necessary to inform drivers that vehicles must be equipped with a transponder in order to access the facility.

Strategies being considered may use a combination of price, vehicle eligibility, or access location to manage demand on the facility. Communicating this information to drivers in a clear, concise manner while avoiding information overload is a difficult task that requires careful evaluation. Information that must be communicated may include:

- ingress and egress locations,
- occupancy requirements,
- operating hours,
- toll amounts, and
- operating agencies.

Drivers must process the above information, along with standard directional and informational signage, and still operate the vehicle in a safe manner. The driver may also need to make a decision on whether or not to use the facility. This can be particularly challenging for drivers who are unfamiliar with the corridor.

Enforcement

Another important element of a managed lane strategy is enforcement. On facilities that use pricing as a management tool, enforcement protects the integrity of the facility. A complex operating strategy that uses vehicle eligibility and vehicle occupancy as a restriction makes enforcement more challenging. But by considering enforcement early in the project development, accommodations may be made that will simplify visual verification by law enforcement officers, and allow enforcement approaches that better adapt to potential changes in the operating scenarios. Dedicated law enforcement personnel has been a key to driver compliance levels on the case study projects.

Furthermore, advancing technology will aid enforcement. Electronic toll collection makes variable pricing simple and easily accomplished. Technologies such as license plate capture further automate enforcement tasks. More research is needed in developing technologies that automate enforcement for all possible operating scenarios, including occupancy verification, and enabling legislation may also be warranted.

Revenue Generation and Equity

Revenue generation and equity are two issues that are somewhat intertwined. As more and more agencies struggle with shrinking budgets, finding solutions to growing congestion has become progressively more difficult. Some are looking at pricing in managed lanes as a mechanism to generate revenue. What transportation experts and economists originally envisioned as a

Table 1. *Characteristics of Operating Managed Lanes.*

Project	No. of Lanes per Direction	Project Objectives	Daily Corridor Volume*	Daily Managed Lanes Volume*	Percent Exempt Vehicles*	Revenue* (in millions, 2003)	Use of Revenue
SR 91 Express Lanes	*Two*	• *Fast, safe, reliable commute* • *Maintain financial viability of lanes*	*290,000*	*35,000*	*20%*	*$26*	*60% debt service* *40% operations*
I-15 FasTrak Express Lanes	*Two (reversible)*	• *Better use of available capacity* • *Fund new transit service*	*270,000*	*30,000*	*75%*	*$2.2*	*55% operations* *45% transit service*
Houston QuickRide	*One (reversible)*	• *Better use of available capacity* • *Maintain bus operating speeds*	*210,000*	*9,200*	*98%*	*$0.11*	*100% operations*
NJ Turnpike Dual-Dual Section	*Six*	• *Separate large trucks* • *Provide flexible operations during heavy congestion*	*200,000*	*200,000*	*0%*	*$200***	*45% debt service* *45% operations* *10% other*

* *Approximate values given for comparison purposes*

** *2003 total revenue proportioned by VMT for dual-dual section*

demand management tool is now being viewed as a way to address funding shortfalls. Increasingly, elected officials see tolling, in general, and value pricing, in particular, as a way to finance additional capacity.

Theoretically, this improves conditions for everyone. Allowing drivers to choose whether or not to pay a toll to travel on certain lanes relieves some congestion in the general-purpose lanes. The currently operating projects certainly have made great strides in addressing social equity concerns. Studies indicate that travelers of all income levels take advantage of the managed lanes.

Agencies are also seeking the best ways to balance revenue generation with community goals. If increasing transit use or person movement is a community goal and there is a desire to accomplish this through free or discount cost of travel on a facility, the potential for revenue generation can be diminished. Project sponsors are considering revenue generation, the mobility goals of the facility, and the desires of the community, and then assimilating these findings into a management strategy that addresses each.

Legislative Authority

Using pricing as a lane management strategy may require the need for legislative changes at both state and national levels. Currently, tolling is not explicitly allowed on the interstate system. Automated enforcement may also require enabling legislation. Additionally, legislation may facilitate cooperation between local agencies, state agencies, transit agencies, regional transportation authorities, and private developers.

New Institutional Arrangements

Once project planners have the legislative authority necessary to administer a pricing program and there is a broad understanding of the objectives of a particular project, it may be necessary to forge new relationships with partners not previously involved. As noted earlier, managed lanes projects may encompass a number of different operating strategies. This will bring more players to the table, including transit authorities, toll authorities, and private interests. Most likely, there will also be a need to bring entities that can offer additional financing options. For these reasons, it may be necessary to identify successful institutional agreements that have been negotiated on international projects. The United States has very limited experience with private-party participation in transportation projects. A review of best practices will aid in structuring these new agreements and fostering a collaborative approach.

Analysis Techniques and Demand Forecasting Models

Most of the managed lane projects operating today are the result of agencies taking advantage of available opportunities. Most did not have the benefit of having managed lanes included in the long-range regional transportation plans. Additionally, the HOT lane projects operating today each have very limited access points and typically operate based on a simple strategy. Therefore, extensive technical analysis of various operating scenarios was not performed prior to implementation. The need exists for more comprehensive tools to address the impacts of managed lanes design, access, and operational strategies on factors such as demand management, revenue generation, and air quality conformity.

Design Flexibility

The design flexibility of the facility greatly impacts the operating scenarios available to facility operators. Design flexibility must consider potential changes to user groups or varying tolls based on user groups. Additional management techniques such as charging based on distance, charging based on access point, or a combination of techniques will present more challenges in

designing a facility that can accommodate various operational strategies. More complex operational scenarios will have to consider multiple tolling and enforcement zones. Topics related to design flexibility that require further research are safe lane separation and access.

Integrated Transportation Opportunities

In order to fully understand the benefits and impacts of priced lanes, the lanes need to be evaluated in conjunction with other strategies, not alone, to ensure effectiveness. Evaluation tools are needed to estimate the impacts of combined strategies and to evaluate the combined strategies against conventional strategies. Missing in the managed lanes experience to date is the initiation of these projects through the regional planning process. Most were developed at the facility level to take advantage of a specific opportunity. MPOs and other transportation agencies are only beginning to identify ways to incorporate managed lanes into regional strategic network planning (e.g., MPO 20-year regional transportation plan), system planning (e.g., 20- to 50-year freeway network plan for a region), or corridor planning. Several MPOs, including the San Diego Association of Governments (SANDAG) and the North Central Texas Council of Governments (NCTCOG) in Dallas/Fort Worth, have recently begun incorporating managed lanes into regional plans.

As was the case with the early projects, many agencies are looking to take advantage of all available resources. The result is a greater opportunity to combine project types and funding. Managed lanes can certainly do this by incorporating opportunities for bus rapid transit (BRT) and carpool programs combined with greater land use planning and travel demand management strategies. When several of these strategies are implemented in conjunction with each other, the effective management of the entire transportation network is enhanced.

Technology

The case study projects have indicated that technology has not been a concern. It is generally believed that technology will not limit long-term success. With the development of standards for dedicated short-range communications (DSRC), specifically related to the 5.9 GHz band, the implications for integration of intelligent transportation systems (ITS) and toll collection will further support proactive operation of managed lane facilities. However, in short-term applications, current technology could limit operational characteristics. There is still a void in automated enforcement of vehicle occupancy, a shortcoming that will complicate the implementation of any managed lane that has occupancy requirements separate from or in combination with other management strategies.

CONCLUSION

The managed lane approach is the evolution of traditional lane management strategies, with the primary difference being the idea of active management over the life of the facility. It is a way to address the issue of growing congestion in a proactive manner within the constraints of limited resources. Successful projects will build upon the best practices and lessons learned in early projects. As lane management techniques become more complex, many new issues will need to be addressed. Careful and coordinated planning and design, along with community support, will allow projects to proceed from an idea on the drawing board to an effective facility on the ground. ◊

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400 7th Street, S.W. (HOP)
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Toll-Free "Help Line" 866-367-7487
www.ops.fhwa.dot.gov
Publication No.: FHWA-HOP-05-031
EDL 14110

HOP/Aug. 2008/QE