Managed Freeway Lanes

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MANAGED LANES

A CROSS-CUTTING STUDY

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16. Abstract
Increasing traffic congestion in the major metropolitan areas is costing billions of dollars each year in lost productivity, wasted fuel, increasing air pollution and hours of delay. Adding new general-purpose lanes is increasingly difficult because of factors such as construction costs, limited right-of-way, environmental and societal concerns. As a result, agencies are looking for solutions to improve the flow of traffic on existing facilities.

One concept being considered is that of "managed lanes". Managed lanes employ various strategies to improve flow and maximize the efficiency of the freeway system. Common types of managed lanes include high-occupancy vehicle (HOV) lanes, high-occupancy toll (HOT) lanes, value priced lanes, or exclusive or special use lanes. For the purposes of this study, managed lanes are defined as a limited number of lanes within an expressway cross section where multiple operating strategies are utilized, and actively adjusted as needed, for the purpose of achieving pre-defined performance objectives.

The intent of the report is to review the state-of-the-art in managed lanes in order to increase the understanding of (1) what managed lanes are, (2) how to plan for implementation, (3) what operational and design issues are considered, and (4) how active management of the lanes over the life of the facility affect its implementation. This report describes operating managed lane projects through a case study approach, highlighting best practices of the projects the lessons learned. Emerging issues and knowledge gaps are also presented. The intent of the report is to provide a cross-cutting study of the issues and experiences of various agencies as managed lane projects are implemented and policies are drafted.

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MANAGED LANES
A Cross-Cutting Study

Federal Highway Administration
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Chapter One. Introduction

Scope and Purpose

This cross-cutting study was developed to document the successful practices used in managed lane projects in operation, to identify gaps between the state-of-the-practice and the state-of-the-art, and to highlight emerging issues. The intent of the report is to provide a study of the cross-cutting issues and experiences of various agencies as managed lane projects are implemented and policies are drafted.

The intended audience for this report is transportation professionals who are involved with developing and operating managed lane facilities in freeway corridors. It is anticipated that the information provided in this document will offer valuable insight for professionals who want a basic understanding of issues associated with developing managed lane projects. Secondarily, it will serve to identify critical research and development needs related to managed lanes.

Defining Managed Lanes

WHAT ARE MANAGED LANES?

The term "managed lanes" has different meanings to different agencies. In some agencies the term is commonly thought of as high-occupancy toll (HOT) lanes. In other agencies a broader definition is customary, one in which a variety of management tools and techniques are combined in order to improve freeway efficiency and meet certain corridor and community objectives. This broader definition of "managed lanes" includes HOV lanes, value priced lanes (including HOT lanes), and exclusive or special use lanes (such as express, bus-only, or truck-only lanes).

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 - and on the right are the more complicated managed lane facilities that blend more than one of these strategies. The multifaceted facilities on the far right of the diagram are those that incorporate or blend multiple lane management strategies.

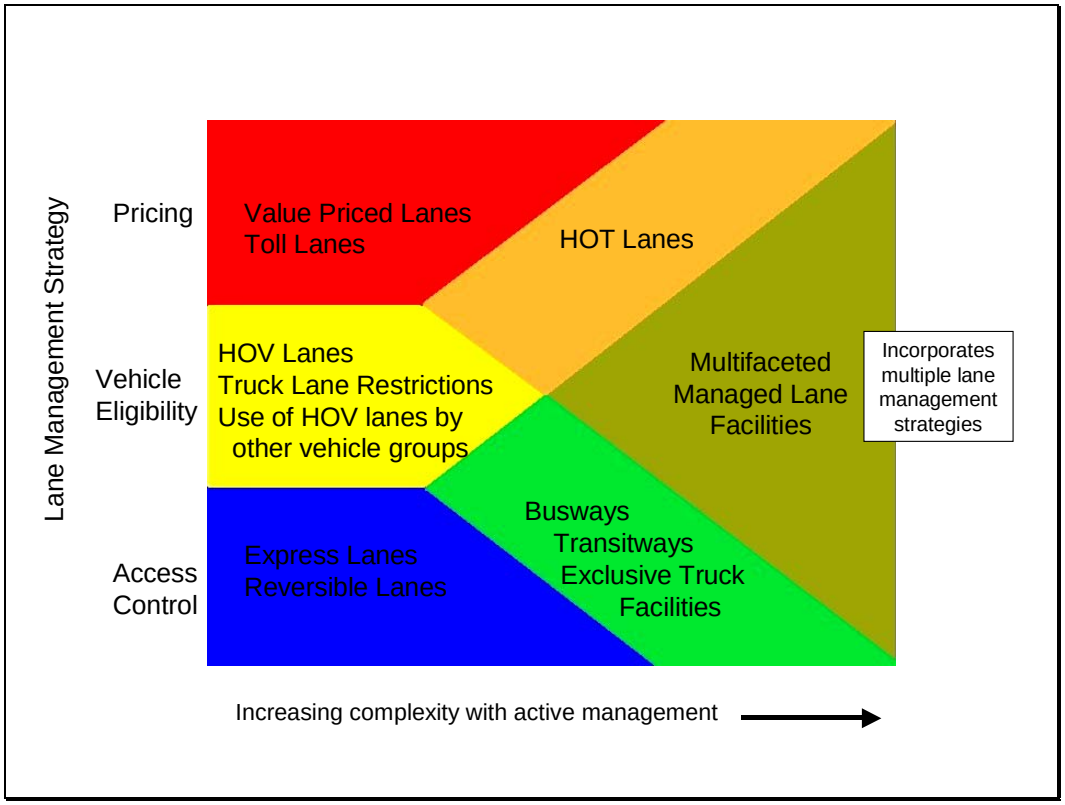

Exhibit 1. Lane Management Strategy Complexity

The common themes among the different managed lane definitions in use today are as follows:

- The managed lane concept is typically a "freeway-within-a-freeway" facility, where a set of lanes within the freeway cross-section is physically separated from 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 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.

For the purposes of this study, the following definition of managed lanes was developed:

> "Managed Lanes" are defined as a limited number of lanes set aside within an expressway cross section where multiple operational strategies are utilized, and actively adjusted as needed, for the purpose of achieving pre-defined performance objectives.

WHY MANAGED LANES?

Major metropolitan areas are facing increasing traffic congestion that costs billions of dollars every year in lost productivity, wasted fuel, and hours of delay. In FY 1999 the nation lost an estimated $ 72 billion dollars due to this waste (1). Congestion is growing over the entire highway system but its effects are most profound in urban areas. These areas are also struggling to rebuild a system that has outlived its design life.

Compounding this problem, Americans are driving more now than ever before. Vehicle travel has increased more than 70 percent in the last 20 years while highway capacity has only increased by 0.3 percent each year for the last decade (1). Growing traffic congestion is not only impacting the traveling public it is also having a serious effect on commercial vehicle operations especially in the nation's urban areas.

In light of these challenges, state transportation departments, metropolitan planning organizations and other involved in the planning process realize that they cannot build their way out of congestion. Many factors, such as construction costs, limited rights-of-way, and environmental and societal impacts make adding capacity through new general-purpose lanes unrealistic. These agencies are looking for solutions to improve the flow of traffic on existing facilities.

The evolution of geometric design criteria and emerging technologies has helped transportation agencies refine available strategies to meet growing freeway operations challenges. Transportation officials are now seeking to take advantage of opportunities to address mobility needs and provide travel options through a combination of limited capacity expansion coupled with flexible operating strategies that seek to manage travel demand and improve transit and other forms of ridesharing. 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, address project and community objectives, and offer an alternative to congestion.

State of the Practice and State of the Art: A Look at Managed Lanes

The intent of this report is to review the state of the practice and state of the art in managed lanes in order to increase the understanding of (1) what managed lanes are, (2) how to plan for implementation, (3) what operational and design issues should be considered, and (4) how active management of the lanes over the life of the facility affect its implementation. This study describes operating managed lane projects through a case study approach, highlighting best practices and lessons learned. As a new concept in freeway management, managed lanes involve a number of design and operational issues that have yet to be addressed in practice. As such, emerging issues and knowledge gaps are also presented in this study.

For the purposes of this study, the "state of the practice" is defined as:

> The proven practices in common use and the effective application of planning methodologies, financing approaches, public outreach strategies, highway geometric design techniques, and technologies commonly installed and operated in managed lanes within freeway facilities.

By comparison, the "state of the art" is defined as:

> Innovative and effective practices in the application of leading edge methodologies, techniques, and technologies that are ready for deployment in managed lanes in terms of operating accurately and efficiently, but are not fully accepted and deployed by practitioners.

This study also addresses gaps in the knowledge, where emerging issues associated with methodologies, techniques, and technologies have not been fully implemented as the state-of-the-art and yet are critical elements of a fully flexible managed lane facility.

As an example, consider value-priced toll lanes as one form of managed lanes, and specifically the use of electronic toll collection on toll lanes:

- The "state-of-the-practice" would be the utilization of electronic toll collection, a proven practice in common use.
- The "state-of-the-art" would involve the use of electronic toll collection for variable pricing, with the toll rate set based on level of congestion in the toll lanes.
- An emerging issue that has not been demonstrated in field application is the deployment of dynamic toll pricing in the presence of multiple ingress and egress points.

Chapter Two. Managed Lanes: State of the Practice

Traditional Lane Management Strategies

State departments of transportation (DOTs) have for many years employed a variety of lane management strategies in an effort to address congestion in urban areas. The earliest of these strategies is the use of controlled access facilities to concentrate ingress and egress points and minimize the effects of weaving and slowing vehicles. Over the years the menu of lane management strategies has grown to encompass a wide range of tools and techniques for maximizing the efficiency of the network. Exhibit 2 lists a variety of lane management strategies in use by transportation agencies. Typically, lane management strategies seek to optimize flow by:

- Regulating demand,
- Separating traffic streams to reduce turbulence, and
- Utilizing available and unused capacity.

Two common approaches to lane management are restricted use based on vehicle eligibility, and control of access through limited ingress/egress express lanes and ramp metering. Examples of managed lane facilities that represent the state of the practice include high-occupancy vehicle (HOV) lanes and exclusive or special use lanes (3).

Exhibit 2. Eligibility and Access Control as Lane Management Strategies.

Lane Management Strategies			
Management Strategy		**Management Characteristics**	**Management Techniques in Operation**
ELIGIBILITY Eligibility refers to management based on vehicle type or user group.	**Occupancy**	Lanes based on occupancy provide a priority to HOVs. Typically implemented in congested corridors to encourage shift to HOVs. Designed to provide travel time advantage and trip reliability.	California, Texas, Washington, Virginia, Minnesota, Colorado, Pennsylvania. Arizona, Florida, Connecticut, Georgia, Maryland, New York, New Jersey, Oregon, Tennessee, Hawaii
	Vehicle	Management based on vehicle type. May provide a superior service as in the case of transit-only facilities. May seek to improve operations by separating vehicles types.	• Bus-only facilities o Pittsburgh, Ottawa, Canada • Dual-Dual facility o New Jersey Turnpike • Separation/Bypass lanes o California, Hawaii, Washington Minnesota, Texas, Illinois, New Jersey
ACCESS CONTROL Limited or controlled access allows management of the flow and throughput of traffic on a facility.	**Express Lanes**	Express lanes have limited access and egress points thereby reducing weaving and disruptions in traffic flow	• I-90 and I-5, Seattle • Dan Ryan Expressway, Chicago
	Ramp Meters	Meters control the flow of traffic onto a facility to reduce turbulence, resulting in smoother flow.	• Various cities throughout the US

HOV LANES

Exhibit 3. HOV Lane.

High Occupancy Vehicle (HOV) lanes, as shown in Exhibit 3, are some of the earliest lane management strategies that provide priority for certain vehicle types. Preferential treatment for transit began in Northern Virginia on I-395 with the bus-only lane in the 1960s. Since then over 2,000 centerline miles of HOV lanes have been developed around the country. HOV is by far the most common managed lane strategy. Most HOV lanes have the common goals of increasing person-movement within a facility by increasing vehicle occupancy, improving transit operations, and providing an attractive mobility choice for travelers in the corridor (4). HOV facilities use vehicle eligibility as the primary mechanism for regulating demand and achieving optimum operating conditions.

EXCLUSIVE OR SPECIAL USE LANES

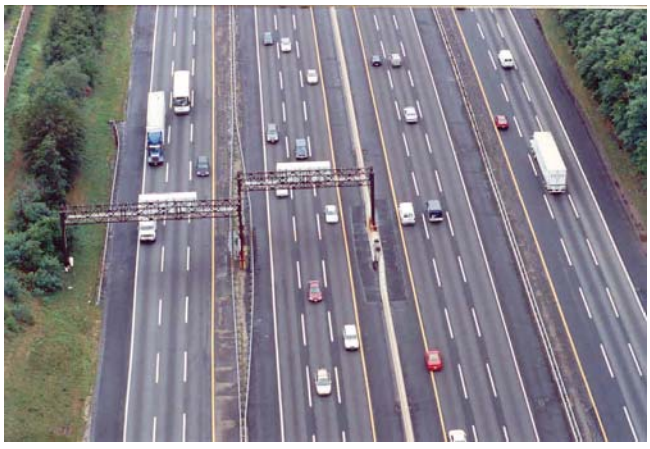

Exhibit 4. Dual-Dual Roadway (6).

This strategy is used to provide an exclusive lane to certain vehicle classifications (Exhibit 4). Most often this is dedicated to buses or large trucks (3). Exclusive bus-only lanes act to provide an incentive to transit riders. By providing a special lane for the exclusive use of buses, these vehicles achieve a travel time advantage as opposed to vehicles in the general-purpose lanes.

Truck lanes operate in much the same fashion as bus-only lanes. However, the objective is different. The goal in separating truck traffic from passenger traffic is to improve the flow of a facility and provide an increased level of safety by reducing possible conflicts between large trucks and other vehicles. Separate truck lanes may be feasible in areas where truck volumes exceed 30 percent of vehicular traffic, peak-hour volumes exceed 1800 vehicles per lane-hour, and off-peak volumes exceed 1200 vehicles per lane-hour (3). Exclusive lanes use vehicle eligibility to achieve operational objectives.

Chapter Three. Managed Lanes: State of the Art

The Introduction of Pricing Strategies

Value pricing, once known as congestion pricing, was introduced to transportation officials through a federal pilot program included as part of 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. Value priced lanes use pricing as the primary mechanism to regulate demand.

The program ushered in the use of High-Occupancy Toll (HOT) lanes as an operational strategy. HOT lanes take advantage of available unused capacity in the 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.

Exhibit 5 illustrates the ways in which pricing can be used as a demand management strategy for managed lanes. The primary advantage of pricing over other forms of lane management is the demonstrated ability of variable tolling to actively managed demand. Variations in vehicle eligibility and access control as dynamic active management strategies have not been demonstrated in field application as pricing has.

Exhibit 5. Pricing as a Lane Management Strategy

PRICE Price refers to management that uses prices to regulate demand.	**HOT Lanes**	HOT lanes give access to vehicles that do not meet occupancy requirements by assessing a toll for these vehicles.	• SR 91, San Diego • I-15, San Diego • I-10 and US 290, Houston
	Variable Toll Lanes	Toll lanes may charge a toll that fluctuates depending on time of day, day of week or amount of congestion in an attempt to more effectively distribute traffic.	• New Jersey Turnpike • Port Authority of New Jersey and New York

Highlights of Case Studies

An essential first step for the study team was defining the type of managed lane facilities that would be examined under this research effort. For the purposes of this study, the research team focused on state-of-the-art case study facilities that utilized pricing, but also demonstrated a combination of the other basic managed lane operational strategies: vehicle eligibility, and access control.

This chapter highlights several of the managed lane projects in operation around the country. The four selected case studies, which represent a geographical and operational cross section of managed lanes currently in practice, are:

- State Route 91 Express Lanes, Orange County, California
- Interstate 15 Express Lanes, San Diego, California
- Interstate 10 and US 290 HOT Lanes, Houston, Texas
- New Jersey Turnpike Dual-Dual Section, New Jersey

Each is unique in the operational strategy or combination of strategies that are used. The profiles of these projects, which were developed from published information and phone contacts, include five categories of questions that are integral in the success of the project. The five categories are:

- Concept Planning
- Project Planning and Design
- Operations
- Enforcement
- Public Outreach.

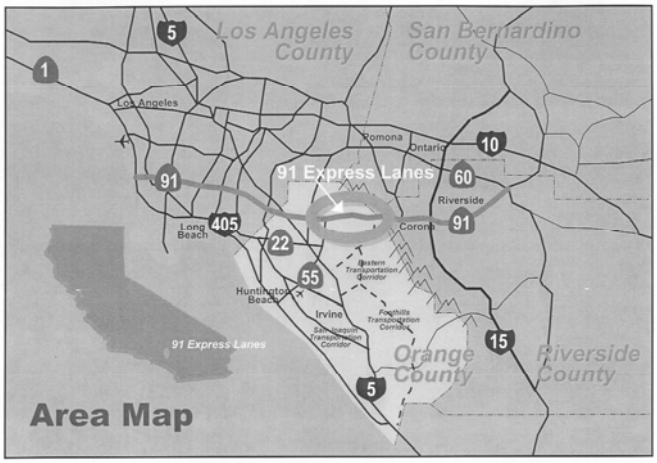

Exhibit 6. SR 91 Express Lanes Boundaries (7).

State Route 91

State Route 91 (SR 91) in California (Exhibit 6) was the first fully automated toll road in the world and the first toll road in the United States to vary tolls by the level of congestion on the roadway. The four-lane roadway, built within the median of SR 91, is 10 miles in length with no intermediate access. Two lanes are provided in each direction and they are separated from the mainlanes by plastic pylons and a painted buffer. The toll rates are set according to level of congestion typically experienced on the roadway, thereby making travel during the peak periods the most expensive time to travel. Although, the facility is open 24 hours a day, seven days a week

and tolls are charged at all times, the operators use price in an attempt to shift vehicles out of the peak period.

Motorists that choose to use the lanes are notified of the current toll well in advance of the facility via dynamic message signs. The tolls are paid exclusively through electronic toll collection. Users of the facility must have an account and a transponder. The facility is also managed to encourage travel in high occupancy vehicles. Carpools with three or more occupants, motorcycles, zero-emission vehicles and vehicles with disabled person license plates are free at all times with the exception of the evening peak period in the peak direction, when HOVs are charged 50% of the posted toll. Again, price is used to encourage certain travel behaviors and conveyances.

The operators of the SR 91 Express Lanes have implemented a toll policy that is based on active management of the facility. The lanes are continuously monitored and this data is used the make adjustments to the tolls as necessary to keep the facility free-flowing. Hourly traffic volumes are monitored over a 12-week period. If vehicle volumes per hour, per direction approach levels were speeds become unstable or slow the tolls may be adjusted. The new toll rate will stay in effect for six months. If, after six months, it is determined that traffic volumes have fallen, creating excess capacity, the toll may be reduced. The operators of the facility are actively managing the lanes to optimize traffic flow.

Interstate 15, San Diego, CA

The I-15 Express Lanes in San Diego, California, is an eight-mile, two-lane reversible facility that stretches between State Route 52 and State Route 56. Exhibit 7 depicts the Express lanes boundaries. The lanes are separated from the mainlanes by concrete barriers. Access is only available at the termini. The lanes originally operated as HOV lanes but often had unused capacity available. The lanes operate Monday through Friday from 5:45 – 11:00 am in the southbound direction and 1:00 – 7:00 pm in the northbound direction. In 1996 the HOV lanes were converted to HOT lanes, where SOVs are charged to use the facility and HOVs travel in the lanes free of charge.

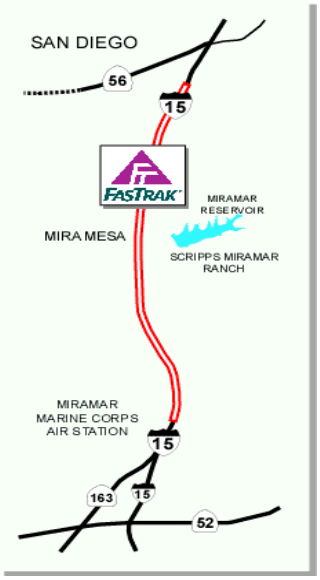

Exhibit 7. I-15 Express Lane Boundaries (5).

I-15 employs dynamic tolling, the first of its kind implemented. Toll rates typically vary from $ .50 to $ 4.00 but can rise as high as $ 8.00 during severely congested conditions. Technology deployed in the corridor allows for the assessment of current traffic conditions and the toll rate is adjusted dynamically to ensure free flow conditions in the express lanes. Dynamic message signs prior to the entrance of the facility alert drivers to the current toll. The drivers then have ample time to choose whether or not to enter the lanes and pay the toll. As with SR 91, all users must be registered and have an established

FasTrak account. A FasTrak account allows tolls to be collected electronically. No manual or cash toll collection is accommodated. The average daily traffic on the Express lanes is between 25,000 and 35,000 vehicles.

I-10 and US 290, Houston, Texas

A slightly different pricing project has been implemented on I-10, also known as the Katy Freeway, and US 290, known as the Northwest Freeway, in Houston, Texas. The program is marketed under the name QuickRide. QuickRide began operating on the Katy Freeway in January 1998 and was expanded to the Northwest Freeway in 2000. The project was implemented as part of the Value-Pricing Pilot Project Program. The facility essentially operates as a HOT lane although SOVs are not allowed on the facility.

I-10, KATY FREEWAY

The HOV lane on the Katy Freeway is a one-lane reversible facility separated from the mainlanes with a concrete barrier with access allowed at intermediate locations in addition to the termini. The lane is 13 miles long and provides access to downtown Houston and the Galleria area from suburban communities west of the city. The HOV lane operates Monday through Friday from 6:00-11:00am in the inbound direction and 2:00-8:00pm in the outbound direction. Since 1986 the HOV lane operates with a 3+ restriction during the peak periods which are from 6:45-8:00am and 5:00-6:00pm. Exhibit 8 shows the dynamic message used to alert drivers of the restriction. The lane is also open from 5:00am – 8:00pm in the outbound direction on Saturdays and the same hours in the inbound direction on Sundays. There is a 2+ restriction on both these days. However, this 3+ restriction left unused capacity while allowing all HOV2s on the facility impeded operations. The Metropolitan Transit Authority of Harris County (METRO), working with the Texas Department of Transportation (TxDOT), and FHWA implemented tolling of HOV2s during the 3+ restriction to utilize the available capacity on the HOV lane.

US 290, NORTHWEST FREEWAY

Many of the same issues were encountered on the Northwest Freeway as well. By the late 1990s congestion on this 13.5 single lane reversible facility had caused speeds to slow to 20-30MPH in the HOV lane. This was particularly bad in the AM peak period.

Exhibit 8. Dynamic Message Board.

In early 2000 the occupancy requirement on the Northwest HOV was raised to 3+. This resulted in improved

conditions on the facility but, as expected, additional capacity remained. Therefore, in November 2000 the QuickRide program was expanded to the Northwest HOV lane. The program is in effect during the 3+ restriction which is in the AM peak only from 6:45-8:00am.

The QuickRide program is operated much like the FasTrak program in California. HOV2s are required to establish an account and are issued a transponder. HOV2s that wish to travel on the facility during the 3+ restriction are charged $ 2.00 each way via their transponder. HOV 3+ carpools are not required to establish an account nor are they required to have a transponder. If motorists do have a transponder and are traveling in a 3+ carpool the transponder is inserted into a silver static bag to prevent it from being read and a toll assessed.

New Jersey Turnpike

The New Jersey Turnpike is a limited access facility that utilizes a variety of management techniques to optimize flow. The entire toll facility is 148 miles long and connects New York to Philadelphia. The entire turnpike is shown in Exhibit 9. In the 1970s a 32-mile segment of the roadway was expanded into two separate roadways. The objective of the dual-dual roadway was to improve operations and safety by separating heavy vehicles from light vehicles and to increase capacity in the most heavily traveled section of the Turnpike. It was also intended to provide greater flexibility for using the roadway during periods of heavy congestion such as a major incident, since changeable message signs technology could be applied to warn approaching drivers and divert them to the less-congested roadway.

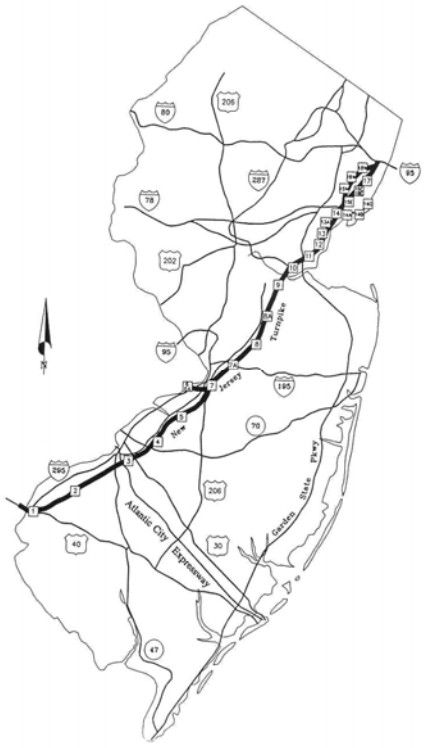

Exhibit 9. New Jersey Turnpike (6).

The inside lanes of the dual-dual roadway are for automobiles only while the outer lanes accommodate all vehicles types. These lanes are separated from the outer lanes by concrete barriers. Each part of the roadway has its own entrance and exit ramps and there are periodic openings in each of the roadways to allow traffic to be diverted from one facility to the other as conditions may warrant. Between Interchanges 11 and 14, the left-most lane of the outer roadway is designated as a HOV lane between the hours of 6 a.m. and 9 a.m. in the northbound direction and between 4 p.m. and 7 p.m. in the southbound direction. The HOV lanes are reserved for cars and vans carrying three or more persons and to all buses and motorcycles. These lanes act as general-purpose lanes at times other than the

peak and are open to all traffic at these times.

The Turnpike Authority has recently implemented a value pricing incentive to shift travel out of the peak. Customers using E-ZPass electronic toll collection, traveling in the off-peak hours (hours other than 7:00-9:00 a.m. and 4:30-6:30 p.m. Monday through Friday) receive a 20 percent discount off the toll rate.

This project differs from the others, foremost, in that the NJTP had adequate right-of-way to expand the facility and the financial ability to do so. The Northeast has a much longer history and familiarity with tolling than do other parts of the country. The corridor exists primarily to serve long distance trips. In fact, 35 percent of its toll revenue is derived from out-of-state motorists. The Authority continues to make improvements to the corridor that furthers the management capabilities of the facility. A recent interchange improvement, scheduled for completion in 2004, will provide travelers with direct access to a transit transfer station.

Chapter Four. Managed Lanes Case Studies: Project Development and Operation

In this chapter the study team has documented several key areas identified from the case study projects highlighted in the previous chapter. These areas focus on the development and operation of managed lanes projects, particularly the planning, analysis, and life-cycle considerations of an actively managed facility.

While there are a number of factors that determine the success of managed lanes throughout the planning, design, and operation of a facility, all factors must ultimately support the specific goals and objectives of the project, and implementation must focus on achieving these project objectives. Each project is unique and reflects the characteristics of the particular corridor and the desires of the community.

The key areas covered in this section are

- Planning and Coordination
    - How have the projects in operation developed within the context of the regional transportation planning process?
    - How have multiple agencies and private entities been involved in these projects?
- Selection and Analysis of Lane Management Strategies
    - How have pricing, vehicle eligibility, and access control been used as operational strategies on managed lanes?
    - What factors were considered in the selection of strategies?
    - How have these strategies worked in achieving project objectives?
- Active Management and Life-Cycle Considerations
    - What does "active management" mean in the context of managed lanes?
    - What are the key elements for actively managing a facility over its life?
    - How have the case study projects used active management in their operational approach?
- Public Outreach and Education

- What has been the role of public education and outreach for managed lane projects?

Planning and Coordination

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.

LONG-RANGE PLANNING

None of the operating pricing projects highlighted in this study were developed out of the long-range plan for the community. In the case of the existing HOT lanes, implementers had the benefit of having HOV as part of the long-range plan. The SR 91 Express lanes were originally planned as HOV lanes but financial circumstances caused the project to be developed as HOT lanes. The New Jersey Turnpike is the result of forward-thinking politicians working with local entities to make the project happen. Even before the dual-dual section opened in 1966 there was recognition that traffic could be better managed by separating vehicle types. In the 1940's designers envisioned controlling access to facilitate the movement of goods and people through the state of New Jersey.

Now that the pricing projects have been in operation for several years, agencies are able to learn from past experiences and incorporate findings into updated long-range plans. In the San Diego region, managed lanes and HOV improvements and expansion are important components of the recently adopted regional transportation plan, *Mobility 2030*. The plan includes a managed lane/HOV network to allow transit and HOV to operate on congestion-free highways thus making transit more competitive with car use as a transportation mode.

A major policy objective of the plan is to achieve double-digit peak-period mode share for transit. Planners believe that an extensive managed lane/HOV network can achieve this goal. Furthermore, HOV lanes have been an important element in a number of regional plans in California due to non-attainment requirements coupled with the role of the California Air Resources Board in reducing non-point source emissions. For these reasons, managed lanes with HOV preference are included in the plan for I-15, I-5, I-805 and SR 54. Additionally, the transportation plan calls for the utilization of the managed lanes during the off-peak periods for goods movement throughout the region.

Adding managed lane facilities to the regional transportation plan is due in no small part to the previous operational success of the I-15 Express lanes and the public's acceptance of pricing. Currently, the project partners are working together to expand the HOT lanes currently in operation to a more robust managed lanes facility. Flexibility is being built into the planning and programming of the facility to allow for operations to be adjusted to meet the changing needs of the traveling public in the corridor.

CORRIDOR PLANNING

The case study projects did not require any special efforts with respect to environmental review and approval above and beyond the traditional process. The I-15 and the Houston HOT lanes, which were originally built with Federal Transit Administration (FTA) funding participation, required review and approval from FTA. In those cases the emphasis on maintaining a high level of service for transit was reflected in the operational requirements that mandated no degradation in transit service. The fact that revenues in both cases are returned to transit operations and transit improvements supports the FTA's position.

To date, specific analysis tools used for project planning have not been developed. In the case of underutilized capacity on HOV lanes, planners and engineers have relied on experience and careful monitoring of roadway conditions to fine-tune an operational strategy. Traffic and revenue studies utilize planning models to provide freeway and ramp volumes to aid in an operational assessment. Likewise, surveys and focus groups can provide information on motorists' willingness to pay tolls and potential driving habits, which offer insight into applicable toll rates.

COOPERATION WITH OTHER AGENCIES

The QuickRide program, the I-15 Express lanes and the SR 91 Express lanes are projects that were undertaken as part of the Federal Highway Administration's Value Pricing Pilot program. Implementation of these projects required close coordination with FHWA, the departments of transportation and local agencies. It has been demonstrated that it is necessary to maintain this coordination to allow for expansion of these programs and assessment of operation changes.

In addition to the traditional agency coordination, the case studies have shown that a recommended practice is to include as many potentially affected stakeholders as possible and to include them as early as possible. 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.

These groups and individuals were involved in the QuickRide program, the I-15 Express lanes and the SR 91 project to identify issues that may not be addressed by the more traditional transportation planning agencies. Careful coordination in the early stages of the projects helped eliminate potential pitfalls later in the projects.

Additionally, as technology evolves the New Jersey Turnpike Authority (NJTP) is working with other toll agencies and project partners to make travel seamless to the customer.

The corridor exists primarily to serve long distance trips. In fact, 35 percent of its toll revenue is derived from out of state motorist. The New Jersey Turnpike Authority participates in a regional consortium with four other transportation agencies, including the Delaware Department of Transportation, the New Jersey Highway Authority, the South Jersey Transportation Authority and the Port Authority of New York and New Jersey. These agencies are also part of a larger group of agencies on the East coast that work cooperatively to promote mobility for the entire region.

INSTITUTIONAL ARRANGEMENTS

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 SR 91 Express lanes by a private entity was the first of its kind. As noted previously, the facility was built on state-owned right-of-way that the company leased from the state of California. When the franchise agreement terminated after 35 years the facility would revert back to the state. As such, the facility would become part of the state highway system; therefore, the company was obliged to construct the facility to statewide standards and specifications. The private company was also responsible for negotiating with the California Highway Patrol to provide enforcement on the facility.

Caltrans and the local agencies, including Orange County and Riverside County, worked with CPTC to develop a franchise agreement. CPTC designed and built the facility in the median of State Route 91 on right-of-way owned by the state. However, the non-compete clause caused frustration amongst all parties involved and the public was extremely upset in what they saw as a lack of responsiveness by a pubic agency. Caltrans was prohibited from making other improvements in the corridor that might possibly reduce traffic on the toll lanes. Consequently, the public became more and more dissatisfied as traffic conditions in the corridor worsened. Now that a public entity owns the facility it is expected that relations between all agencies will improve.

The I-15 Express Lanes and QuickRide are somewhat different in that the lanes previously operated as HOV lanes and most institutional arrangements were already in place. In the QuickRide program the lanes used are foremost HOV lanes that are operated and enforced by the transit authority. The lanes must operate according Houston Metro's Transitways plan. Additionally, the lanes were constructed by TxDOT but Federal Transit Administration (FTA) funds were also used for pay for construction. This has been cited as one reason that SOVs are not allowed on the lanes. This would trigger a repayment to be made to FTA for the funds expended. Expansion plans for the Katy Freeway, as discussed later in the report, will also require more institutional arrangements with other entities.

Selection and Analysis of Lane Management Strategies

The lane management strategies employed on the four case study projects 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. Each of three primary strategies – pricing, vehicle eligibility, and access control – are reviewed below from the standpoint of how lane management strategies were analyzed and selected.

PRICING

Pricing has been employed as a lane management strategy in an effort to manage demand and to make use of underutilized capacity. Value pricing is the nationally endorsed and recognized overview term currently applied to a system of fees or tolls that vary according to the level of congestion on a roadway facility. Higher tolls are usually charged when congestion is heaviest and delay is at its worst.

The Role of Pricing in Project Planning

In the following section each of the case studies will be examined from the standpoint of how pricing was utilized to achieve project objectives.

Project Objective: Private Funding Opportunity

The SR 91 Express lanes provide an example of several agencies taking advantage of circumstances to provide travelers in the corridor with more travel options without spending public dollars. The SR 91 Express lanes were originally planned as HOV lanes to be constructed in the median of SR 91 by the California Department of Transportation (Caltrans) in an effort to relieve the extreme congestion in the SR 91 corridor. However funding was unavailable from federal and state sources. Voters had twice defeated proposals to use bonds and special tax incentives to build the HOV lanes. This led Caltrans and the local agencies to explore other options. Assembly Bill 680 had recently been signed into law that encouraged public-private partnerships to help meet the funding crisis. The law authorized and encouraged the state to actively seek partnerships with the private sector to implement projects and allowed the private partners to charge tolls on the facilities to receive a return on their investment. Eventually, California Private Transportation Company (CPTC), a private company, offered a proposal to plan, finance, construct, operate, and maintain the facility. CPTC proposed four express lanes as a toll road with free or reduced costs to certain user groups.

Exhibit 10. SR 91 (8).

The SR 91 project was implemented in a corridor that was severely congested and motorists had very few options in dealing with congestion. The project was, and still is, marketed as providing an alternative to adjacent mainlanes of SR 91 (Exhibit 10). The motorists may choose to pay a toll and by-pass the congestion or determine that one can "afford" the time lost on the congested mainlanes.

Pricing as a lane management strategy for the SR 91 facility was planned to achieve a return on the investment for CPTC. Detailed traffic and revenue studies and data on motorists' travel habits were used to analyze and evaluate pricing as a management strategy.

Project Objective: Sell Capacity to Fund New Transit Service

On the I-15 Express lanes, the plan for pricing the HOV lanes was a result of excess capacity on the HOV lanes as well as a need to provide better transit service. Planners initiated studies to assess the viability of allowing single occupant vehicles (SOV) access to the lanes by paying a toll. The San Diego Association of Governments (SANDAG) also realized that transit users in the corridor were underserved. Managed lanes per se, were not specifically mentioned in the regional mobility plan at the time the project was initiated. However, with specific objectives in mind SANDAG applied for a grant under the FHWA Value Pricing Pilot Program. The project objectives included:

- Making better use of available capacity in the HOV lanes and
- Generating revenue to fund transit and HOV improvements in the corridor.

Careful study of the pilot project was conducted. Traffic conditions and roadway conditions were used to determine if the project objectives were being met. Additionally, state legislation authorizing the program mandated that the level of service (LOS) on the facility could not be degraded as a result of the program.

Project Objective: Allow Additional Users in the HOV Lane While Maintaining High Speed Transit Service

The QuickRide program in Houston also makes use of excess capacity on the HOV lanes on I-10 and US 290. The transit authority has worked with local, state and federal agencies to plan, build and operate an extensive HOV system as part of a plan to keep people moving throughout the Houston area. The Katy HOV lane was originally built as a traditional HOV lane as part of the HOV system although travel was initially restricted to buses and registered vanpools only. The severe restrictions led to under use of the facility and gradually requirements for the facility were relaxed to 2+ carpools. This caused traffic on the facility to grow and the lane eventually became congested. In an effort to address the congestion, 2+ carpools were eliminated from lane eligibility. This caused a 30 percent decline in the number of people moved in the peak hour. The Metropolitan Transit Authority of Harris County (METRO), working with the Texas Department of Transportation (TxDOT), and FHWA implemented value pricing on the facility to manage the demand while maintaining the travel time advantage of the HOV lane for buses. METRO has a policy to maintain speeds of 50MPH on HOV lanes.

Many of the same issues were encountered on the Northwest Freeway as well. This particular facility was designed to encourage transit uses since most of its access points are through transit stations or park-and-ride lots. The deteriorating service on this route and the impact on bus operations resulted in delays, reduced bus reliability and schedule adherence and customer complaints. METRO officials noted the success of the QuickRide program on the Katy freeway in achieving specific objectives and concluded that the program could restore travel time benefit to the Northwest HOV lane during the morning peak. The QuickRide program on the Katy Freeway had increased the number of 3+ carpools during the

peak and redistributed the 2-person carpools to outside the peak. The program also successfully increased the average operating speed while moving the same number of people. METRO engineers determined that the program could have the same effects if implemented on the Northwest Freeway.

Project Objective: Shift Traffic Demand Out of the Peaks

Initially, two different toll structures on the New Jersey Turnpike were a reflection of the higher costs of construction in Northern New Jersey. More recently, variable pricing has been used to shift traffic out of the peak period and to encourage the use of the electronic toll collection technology, E-ZPass. The turnpike serves long-distance commuter trips and planners and engineers recognized this by building an HOV lane as part of a widening project that operates as an HOV only during the peak periods.

Design Issues Associated with Pricing

Facilities that were converted from HOV lanes to HOT lanes did not have the ability to include a provision for pricing when the original facility was designed. The New Jersey Turnpike and SR 91 were both designed as toll roads enabling accommodations to be made for pricing. However, as conditions in the corridor change and operating strategies are modified, the design of a facility becomes important in assessing the available strategies.

Conversion of HOV Lanes to HOT Lanes

The I-15 Express lanes and the QuickRide program approached pricing from the standpoint of an existing facility. Both programs were implemented on currently existing reversible, barrier-separated HOV facilities. The design elements of the project were already in place. Moreover, QuickRide and the I-15 Express lanes took advantage of existing technology in the corridor. Automatic Vehicle Identification (AVI) readers were already in place on the Katy freeway as part of the freeway management system. METRO was able to minimize costs because the hardware was already in place on the facility for electronic toll collection. A similar situation existed on the I-15 HOV lane allowing SANDAG to implement the FasTrak system of electronic toll collection. The projects in California and Houston each have positive barrier separation between the priced and un-priced lanes either with concrete barriers or plastic pylons. Likewise, each has very limited access and egress points. These design features aid in enforcement of the facility.

New Facility within an Existing Freeway

On SR 91 CPTC designed and built the facility in the median of State Route 91 on right-of-way owned by the state. The company negotiated a 35-year lease with the state after which ownership of the facility reverted back to the state. One important provision of the franchise agreement was the "non-compete" clause that prohibited Caltrans from making roadway improvements in the corridor that may draw traffic from the Express lanes.

The private developers of the project began the design of the facility with certain parameters already in place. They knew that electronic toll collection was needed so the facility was designed to accommodate this. Since the project was to be constructed in the median of a freeway, available right-of-way was an established parameter in the design. Lastly, traffic and revenue studies helped the company decide that demand was high enough

in the corridor and that motorists had enough willingness to pay that two toll lanes were warranted in each direction.

Operational Issues Associated with Pricing

Electronic Toll Collection and Enforcement

An important component of pricing operations is the ability to assess the tolls electronically. "Back office" account administration and violation processing support this effort. When an account is opened and a transponder is issued, information such as name, address, vehicle make and model and license plate number is entered into a database. The account holder may also supply financial information allowing the account to be automatically replenished when the balance drops to a certain level. On I-15 when a transponder passes a reader the information is transmitted electronically to a central processing center. If the reader does not detect a valid account a light signals this to the enforcement officers stationed at the tolling zone located within the facility, as shown in Exhibit 11. The officer may then proceed to issue a citation.

Exhibit 11. Violation Light.

The same type of account administration is used on the SR 91 Express lanes. In fact, California state law mandates that all electronic toll collection technology in the state be interoperable. Hence, the same marketing name is used on both facilities.

In addition to automated account administration, SR 91 also uses automated enforcement technology. When a reader cannot detect a tag or detects an invalid tag read, it triggers a camera that takes a photo of the vehicle's license plate. Exhibit 12 is a picture of photo violation enforcement camera. The license plate image is matched against the database records to ascertain if the motorist does, in fact, have a valid account. If the system determines that there is no record of an account with that license plate number, the state motor vehicle records are searched to determine the registered owner of the vehicle. The owner is then sent a citation requesting the toll amount plus administrative fees.

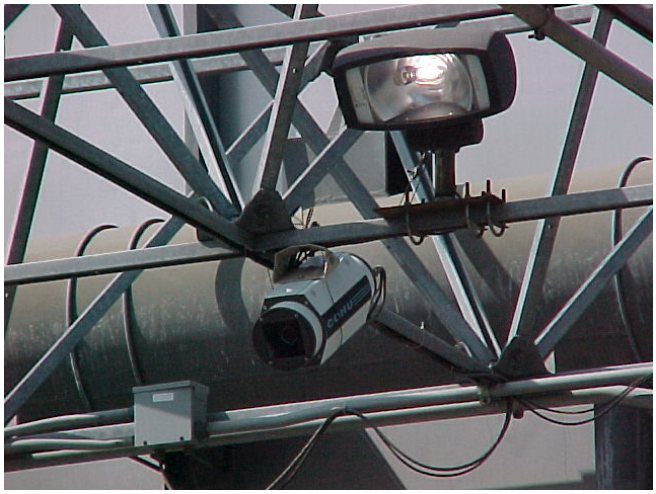

Exhibit 12. Enforcement Camera.

On the I-15 Express lanes, SANDAG contracts with a private provider that handles the administration of the program. OCTA has contracted with the former facility owners to continue providing this service on SR 91. METRO

handles account administration in-house and also has its own police department to facilitate enforcement. The New Jersey Turnpike employs a similar system using E-Zpass although this system does not include automated enforcement.

Preferential Users

Each of the case study projects employs a different pricing strategy. The QuickRide program and the I-15 Express lanes each identified preferential user groups and structured the pricing strategy to support this objective. Initially, the SR 91 Express lanes also provided preferential treatment to HOVs by way of a discounted toll but this strategy had to be balanced with the objective of generating sufficient revenues to provide a return on investment for the private developers. Subsequently, this pricing strategy was later adjusted. The New Jersey Turnpike has recently adopted pricing strategies that attempt to spread demand rather than having it concentrated in the peak. In each case, the project partners developed a pricing strategy that aided in achieving project objectives. Exhibit 13 demonstrates the different pricing strategies and HOV preference for each of the facilities.

Exhibit 13. Pricing Strategies of Case Study Projects.

FACILITY	Variable Pricing	Dynamic Pricing	Fixed Pricing	HOV Preference	Type of Facility
SR 91 Express Lanes	Yes	No	No	Yes – HOV3+	Express Lanes
I-15	Yes	Yes	No	Yes – HOV2+	HOT Lane
QuickRide	No	No	Yes	Yes - HOV3+	HOT Lane
New Jersey Turnpike	Yes	No	No	Yes – HOV lane through a portion of dual-dual section; same price as SOV	Toll Road

VEHICLE ELIGIBILITY

Vehicle eligibility is an important tool in managing demand while meeting policy objectives. Vehicle eligibility may vary by time of day, day of week, and may change over the life of the facility as conditions change. Vehicle eligibility has not been used to regulate traffic flow on a dynamic basis, like pricing.

Planning for Vehicle Eligibility

Early planning in each of the case study projects focused on separating user groups or vehicle types. The California projects and QuickRide showed a preference for HOV: SR 91 by way of discounted tolls, and QuickRide and the I-15 Express lanes by ensuring that HOV operations were not degraded. When the New Jersey Turnpike was expanded, planners and engineers determined that separating truck traffic from passenger vehicles would improve traffic flow and safety on this section of the facility. The schematic in Exhibit 14 is a depiction of the roadway on this portion of the turnpike.

HOV Preference

In the case of I-15, which previously operated as an HOV facility with 2+ vehicle occupancy, planners and engineers determined that the HOV facility could handle a certain number of SOVs vehicles on the facility. The program began very modestly with windshield stickers offered on a first-come, first-served basis, and gradually evolved to the system in place today.

Before the QuickRide program was implemented, Houston METRO had experimented with changing occupancy requirements. By allowing HOV 2s to pay a toll, agencies sought to better utilize the excess capacity on HOV lane that was a result of a 3+ restriction. Doing this also improved traffic flow in the adjacent general-purpose lanes. As in the case of the I-15 Express lanes, the QuickRide program began by issuing a set number of "passes" to allow HOV2s onto the facility. Assessments of roadway conditions, traffic volumes, and expected demand concluded that the single HOV lane could not accommodate the demand that would be created if SOVs were allowed access onto the facility.

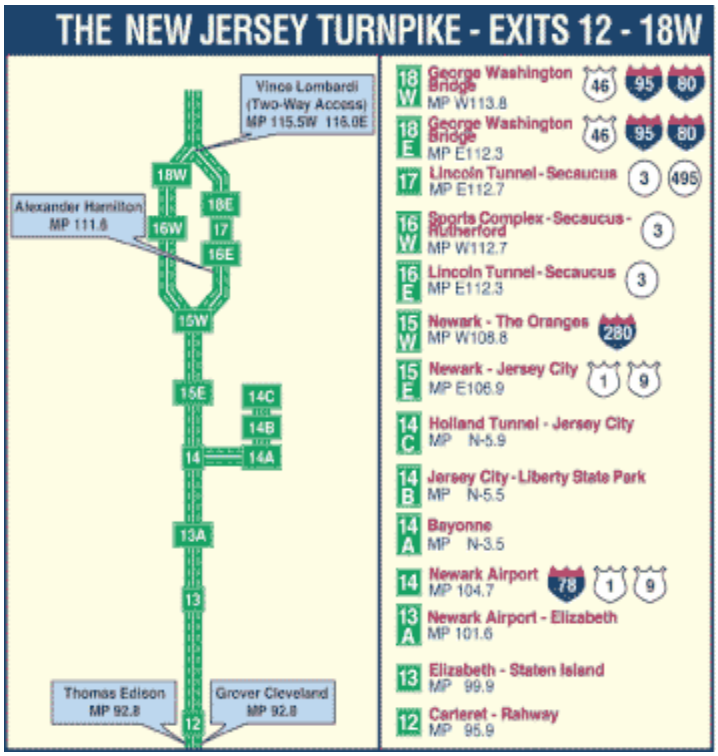

Exhibit 14. Schematic of Separate Truck Lanes on New Jersey Turnpike (9).

SR 91 does not specifically use vehicle eligibility as a qualification for admission to the Express lanes. However, the former operators and the current operators each offered either free or discounted service to HOVs.

Designing for Vehicle Eligibility

In New Jersey, on the dual-dual facility, agencies identified increased safety related to heavy vehicle collisions as an objective and sought to achieve this by separating heavy-duty vehicles from light-duty passenger vehicles. The facility was designed in such a manner as to effectively manage the different vehicle types. The I-15 Express lanes as well as the two facilities in Houston were designed as HOV lanes to be accessed according to vehicle occupancy. Each of these three projects uses concrete barriers to separate eligible express vehicles from other vehicles.

Separating Trucks

The New Jersey Turnpike is the only operating managed lane facility that was designed specifically for the purpose of separating vehicle types. The other facilities typically do not allow commercial trucks onto the facilities. The inside lanes of the dual-dual roadway on the

New Jersey Turnpike are reserved for automobiles only while the outer lanes accommodate all vehicles types. These lanes are separated from the outer lanes by concrete barriers. Exhibit 15 is a picture of the signing on the turnpike. Each part of the roadway has its own entrance and exit ramps. Between Interchanges 11 and 14, the left-most lane of the outer roadway is designated as a HOV lane between the hours of 6 a.m. and 9 a.m. in the northbound direction and between 4 p.m. and 7 p.m. in the southbound direction. The HOV lanes are reserved for cars and vans carrying three or more persons and to all buses and motorcycles. These lanes act as general-purpose lanes at times other than the peak and are open to all traffic.

Exhibit 15. Signing on New Jersey Turnpike.

The dual-dual portion of the New Jersey Turnpike clearly demonstrates the operational and safety benefits of separating vehicle modes. Having the entrance to a HOV or passenger-car exclusive facility located in the center of a corridor without a dedicated ramp requires vehicles to weave across each of the general purpose lanes. The direct access to each barrel provided on the New Jersey Turnpike eliminates this weaving maneuver (which promotes a safer and more operationally efficient system). Maintaining similar geometric criteria for both barrels also provides greater flexibility in moving traffic between the barrels as needed for incidents and maintenance. Douglas' (*18*) finding that the dual-dual portion has lower crash rate, shown in Exhibit 16, supports separating trucks and passenger cars.

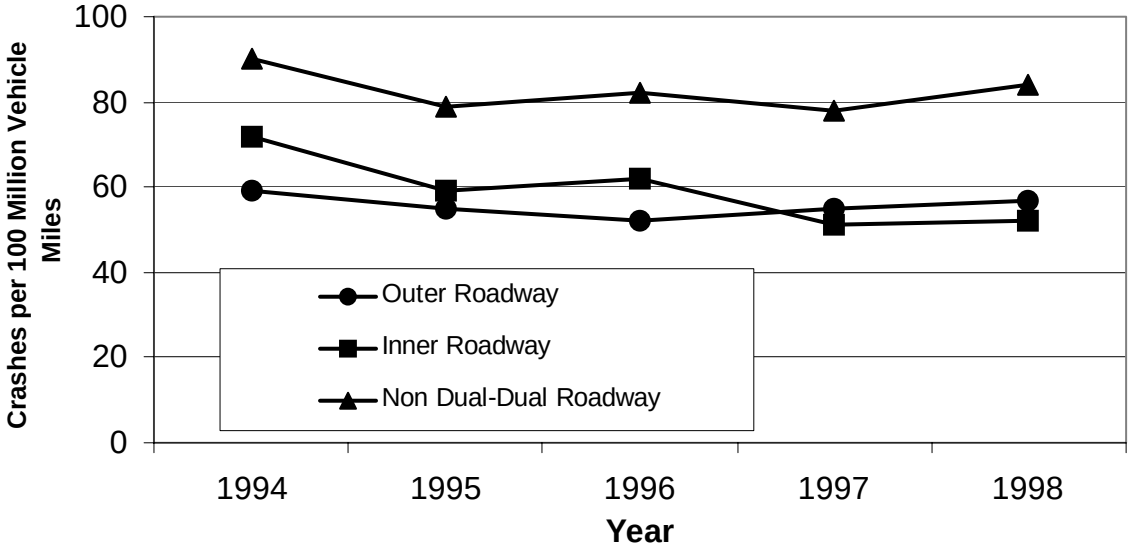

Exhibit 16. Crash Rates on New Jersey Turnpike (18).

Operations with Specialized Vehicle Eligibility

Operating a facility based on vehicle eligibility has been challenging from the perspective of allowing vehicles of varying occupancies access to a facilities. In many instances this has required separate lanes to allow for visual inspection of the vehicle to determine the number of occupants. When operations are based on vehicle eligibility, enforcement becomes critical in preserving the integrity and proper operation of the facility.

The I-15 Express lanes operate with consistent occupancy requirements as does the New Jersey Turnpike. SR 91 does not have occupancy requirements but now offers free travel to HOV 3+ at all times except in the PM peak when the toll is discounted 50 percent. However, the QuickRide program changes occupancy requirements based on time of day. HOV 3+ may travel on the facilities free of charge at any time. HOV2s are assessed the $ 2.00 when the QuickRide program is in effect at certain times of the day. The varying occupancy requirements have made signing on the facilities more complex. Exhibit 17 is an example of a dynamic message sign on the Katy Freeway. The signing must communicate several messages to the driver, such as eligibility requirements, occupancy requirements, times of eligibility, and that travelers must have an established QuickRide account and be equipped with a transponder.

Exhibit 17. Dynamic Message Sign.

Exhibit 18. Enforcement Zone.

In the case of the QuickRide program participants are issued a hangtag to indicate their participation in the program. To date, approximately 2,000 motorists have registered to participate in QuickRide; however, only about 10 percent of these motorists use the facility at any given time.

Enforcement

The QuickRide program is somewhat unique in that enforcement services are provided by the transit authority. Houston METRO, the transit authority, operates the program on the TxDOT facility because they are the operators of the HOV system. METRO provides enforcement with its own police department. Enforcement is conducted by METRO police as vehicles enter the facility (Exhibit 18). Enforcement in the QuickRide program is very complex. Enforcement officers must verify occupancy, confirm that the vehicle has a transponder, and look for the QuickRide hangtag. Additionally, technology is not currently used to assist in toll accounts verification because

the pilot project was developed using technology in place at the time. Plans are underway to upgrade the enforcement operation with additional technology. Transponder violations such as invalid reads or inactive or deficit accounts have resulted in violation rates that are higher than expected.

Enforcement on the I-15 Express lanes is provided by the California Highway Patrol (CHP) and supported with revenues generated from the project. SANDAG contracts with the CHP to provide this service which is usually performed on a voluntary over-time basis by off-duty officers. Enforcement officers are stationed at the entrance to the facility. Officers are also notified by a light if a solo driver's transponder does not register. FasTrak customers make up roughly 25 percent of the vehicles on the Express lanes; the rest are HOVs or transit. Occupancy violation rates on the facility are low at less than 5 percent. California law provides for a stiff penalty for violating occupancy requirements beginning at $ 341.00. The courts are very diligent about upholding these fines. Toll violations begin at a minimum of $ 20.00 for toll evasion.

The CHP also provides enforcement on the SR 91 Express lanes facility at the operators' expenses. The CHP visually inspects vehicles for occupancy and relies on photo enforcement for toll collection. Additionally, California state law also mandates that all vehicles be equipped with a FasTrak transponder that is properly mounted. Toll evasion fines for this violation begin at $ 100.00 for the first offense and increase to $ 500.00 for the third offense within a year. Three enforcement areas are located along the facility.

On May 19, 2003, OCTA instituted a new policy allowing HOV 3+ to travel for free at all times except for the eastbound PM peak; a discounted toll is assessed at this time. To aid in enforcement, carpoolers are directed to a specific lane as they pass through the tolling zone. Depending on the time, a toll may or may not be deducted from the motorist's account.

In New Jersey, the Turnpike rules and regulations are enforced by 214 state police patrols that are assigned exclusively to the Turnpike. These patrols are funded with toll revenues. In fact, the authority receives no state tax money and actually contributes $ 12 million annually to the state transportation fund.

The case studies indicate that enforcement is primarily facilitated by the presence of dedicated law enforcement officers, and secondarily by the design of the facility (presence of enforcement areas and no or few intermediate access points). Moreover, violation rates are lowest when enforcement officers have minimal tasks to perform (e.g., occupancy verification only versus occupancy coupled with tag verification) and are assisted by technology.

ACCESS CONTROL

Access control is used to limit entry to a facility based upon facility congestion levels or operational conditions, such as an accident or maintenance needs. In this case, access is not restricted by type of user. Facilities may limit access by having fewer entrance and exit ramps, using grade-separated ramps as opposed to at-grade access, or the facility may have actual barriers at ramp locations to control access.

Planning and Designing for Access Control

The New Jersey Turnpike is probably the best example of an operating facility that has successfully employed access management as a lane management strategy. Even back in the 1940's when the "superhighway" was under design, engineers established a standard of 70-75 MPH design speed, determined that the facility would be a controlled-access facility and that interchanges would be widely spaced. The New Jersey Turnpike serves long-distance trips. In contrast, the other case study projects serve more commuter-type trips. When the QuickRide HOV lanes and the I-15 HOV lanes were converted to HOT lanes, plans for access control were already in place since the lanes were separated from adjacent traffic as HOV lanes. The Northwest Freeway HOV lane was designed to encourage transit use since most of its access points are through transit centers or park-and-ride lots. The designers for the SR 91 Express lanes determined that the facility would operate better if there were no intermediate access points.

Since, the Express lanes on I-15 and SR 91 have no intermediate access points, they act as pipelines funneling traffic past congested general-purpose lanes. The QuickRide projects do offer intermediate access. However, each of these projects utilizes positive separation such as concrete barriers or pylons to separate the lanes from adjacent traffic. Positive separation tends to minimize the opportunity for intermediate access points.

Operations with Access Control

The gates of the New Jersey Turnpike were designed to allow for greater flexibility in managing the facility during major incidents. Each part of the roadway has its own entrance and exit ramps and there are periodic openings, equipped with gates, in each of the roadways to allow traffic to be diverted from one facility to the other as conditions may warrant. Traffic surveillance cameras and an integrated system of ITS applications relay information to the Turnpike Operations Center in New Brunswick. From there, the system controls changeable message signs, lane use signs, and hazard warning signs to alert motorist to congestion, incidents and adverse weather conditions, as shown in Exhibit 19.

Exhibit 19. New Jersey "Roadway Congested" Sign.

Volume on the turnpike varies greatly across the 148 miles. Traffic is typically lightest on the four-lane section between Exit 1 and Exit 4 with an average of 40,000 vehicles per day. The fourteen-lane section between Exit 11 and Exit 14 carries approximately 200,000 vehicles per day. The gates allow sections of the facility to be closed or opened to accommodate traffic as needed.

Caltrans also works cooperatively with SANDAG to deal with incidents that occur in the I-15 corridor. When an incident occurs on the Express lanes SOVs are not charged the toll. If an incident occurs on the mainlanes that delays traffic for more than an hour Caltrans has the authority to open the Express lanes to all traffic. When this occurs no tolls are charged to any motorists.

In the event of an incident or breakdown on the SR 91 Express lanes motorists are advised to try to reach one of the three enforcement zones or pull to the far left shoulder. Thirty-five cameras are located along the facility to monitor traffic. Customer service patrols generally patrol the lanes between 5:00am and 9:00pm Monday through Friday and at peak hours on the weekends. The CHP also has the authority to open the Express lanes to all traffic in the event of severe incident on the mainlanes.

Active Management and Life-Cycle Considerations

A primary difference between managed lanes and other more traditional forms of lane management is the notion of "active management." As conditions in a corridor change or the objectives of a community change, the operational strategy of a facility may need to change in order to continue to meet pre-defined objectives.

It is important to recognize and communicate the possibility of change as the project is developed. Each of the case study projects has evolved over time. The I-15 Express lanes and the QuickRide projects began as HOV lanes with varying occupancy requirements. Conditions in the corridor changed such that changes in operational strategies were implemented. The operator of a managed lanes project recognizes the life-cycle characteristics associated with the facility and expects that operations will inevitably be modified over time. The key to ensuring the success of the managed lane facility is the development of performance expectations and operating thresholds for the facility, and clearly communicating the active management premise to policy-makers and the public.

The Colorado Department of Transportation has developed a graphic that illustrates a life-cycle operation for a proposed managed lane facility on I-25. Exhibit 20 depicts at which stage various strategies will be enacted. In this scenario, SOVs are permitted access to the managed HOV lane, provided they pay the prevailing toll. Through the use of dynamic pricing, which varies the toll with the level of congestion on the managed HOV lane, the number of SOVs who use the facility is never allowed to exceed the critical operating threshold.

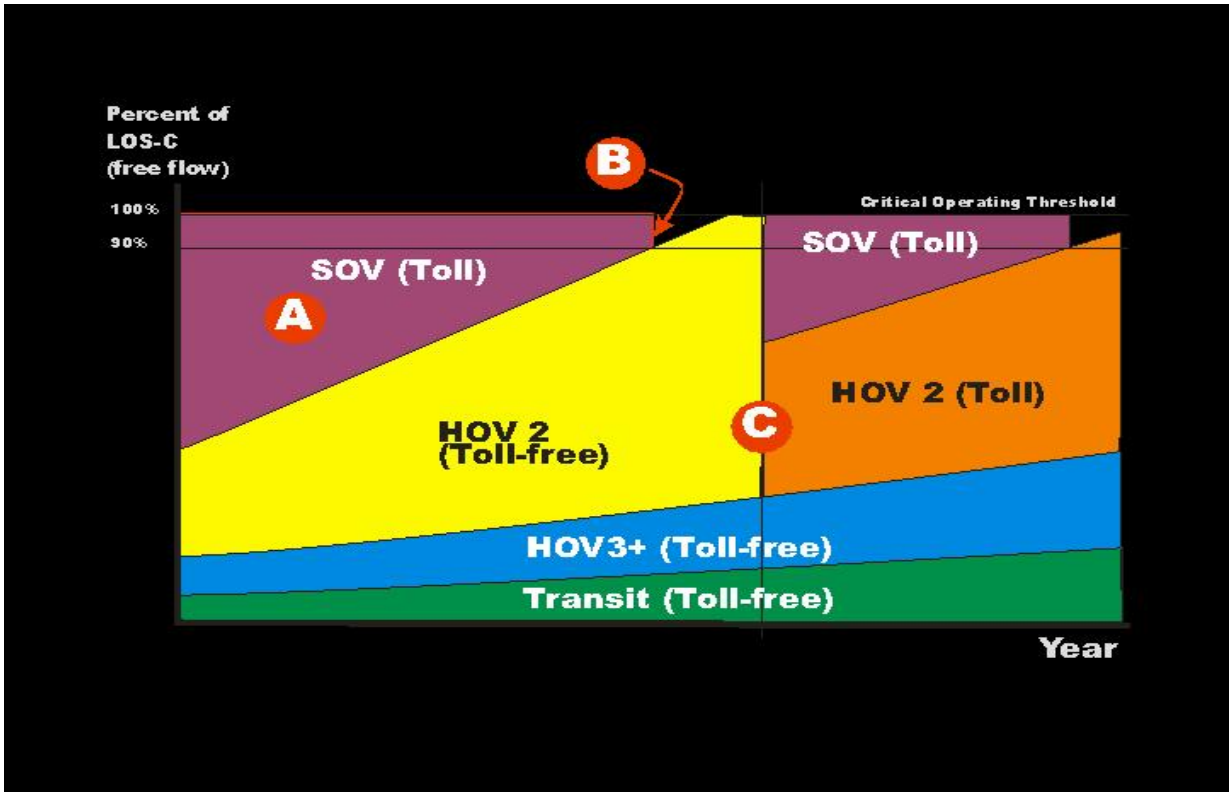

Exhibit 20. Life-Cycle of a Facility (10).

As depicted by point A on the figure, HOV traffic growth over time reduces the availability of capacity for toll-paying SOVs. At such a point where the prevailing toll charge would exceed a reasonable charge (point B), SOVs would no longer be permitted access to the managed HOV lane. When the growth in HOV traffic exceeds the critical operating threshold, authorities would once again change the occupancy policies for the facility. However, as shown by point C, the excess capacity is sold to both two-person carpools as well as single-occupant vehicles. In the managed HOV lane scenario, excess capacity is regulated to ensure a balance between maintaining free-flow conditions and avoiding the "empty lane syndrome." Therefore, the excess capacity is much more effectively utilized, further enhancing the overall effectiveness of the managed HOV facility.

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. The New Jersey turnpike has added HOV lanes in the past, is now offering discounted tolls to motorist not traveling in the peak, and is building more direct access to transit. The QuickRide program does not have the ability to easily alter operations in response to demand. As managed lanes projects are mainstreamed, planners and engineers are learning the advantages of including flexibility in the design of a facility. By including 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.

THRESHOLD VALUES

Inherent in the premise of active management is 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. In the case of the Colorado diagram, a "critical operating threshold" is established, which when exceeded triggers an action to modify the lane management strategies - whether that be price or occupancy or both - in order to maintain operating objectives.

At its inception, SR 91 used traffic and revenue studies to determine traffic volume threshold values that would allow conditions to remain free-flow at 50 MPH and that would generate enough revenue to provide a return on investment to the private company that financed, built and operated the facility. Now that the facility is owned by a public agency priorities may change and the thresholds may also change. OCTA is planning for improvements to the SR 91 mainlanes and this could impact the operation of the Express lanes. Additionally, OCTA has established a new toll policy that clearly defines the triggers of toll increases or decreases for the peak hours as defined in the toll adjustment goals. The goals are to:

- reduce the likelihood of congestion by diverting traffic to other hours with available capacity,
- maintain free flow travel speed in the 91 Express lanes,
- maintain travel time savings,
- accommodate projected growth in travel demand, and
- ensure that the toll road generates sufficient revenue to effectively operate the toll lanes and maintain a strong debt service position (11).

These triggers are based on the traffic volumes in the Express lanes. The traffic volumes are monitored on hourly, day of the week and direction over a 12 consecutive week period. If at any time during that period traffic volumes reach or exceed 3,128 vehicles per hour, per day, or per direction this occurrence is flagged. This volume was identified as that maximum amount of traffic that can be accommodated while maintaining and operating speed of 50 mph in the express lanes. If this happens six or more times during the 12-week period the second step in the toll adjustment policy is initiated. The second step in the process further analyzes the data to determine the amount of the toll rate increase. Exhibit 21 illustrates the toll rate setting parameters.

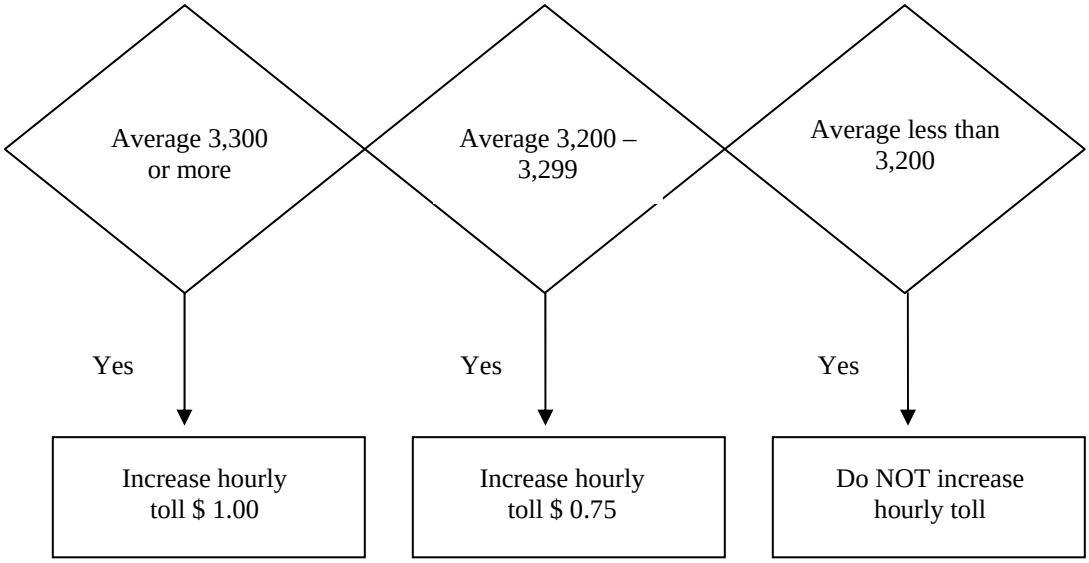

Exhibit 21. Parameters for Setting Toll Rates (11).

Any toll increase or decrease will stay in effect for six months at which time the process is repeated. Additionally, non-peak hour tolls will be adjusted annually for inflation. The Inflation Factor will take effect beginning July 1, 2004 and at the beginning of each fiscal year (July-June) thereafter. The Inflation Factor will be applied to non-peak hour tolls as well as peak hour tolls that were not adjusted using the process described above in the previous 12 months.

SANDAG established critical operating thresholds for the I-15 Express lanes by establishing parameters for operations that included specific level of service requirements so as to not adversely impact the HOVs on the facility. The capacity of the Express lanes is 1,525 vehicles per half hour and the toll is adjusted dynamically to ensure the capacity is not exceeded. The QuickRide program uses bus operating speeds for threshold values. The project partners there established the policy of maintaining bus operating speeds at 50mph.

HIERARCHY OF USER GROUPS

Determining a hierarchy of users may be an important goal for a managed lanes project. 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 HOV2s allowed on the facility. The I-15 Express lanes' parameters have been defined by state law. Level of service requirements must be maintained for HOVs on the facility. In addition, SANDAG dedicates all excess revenue generated by the Express lanes to fund transit service in the corridor.

Communities that have a goal of increasing person movement through the use of transit and HOVs will continue to provide preferential treatment to these groups either through price or by providing improved access. For example, as SANDAG considered pricing for the I-15 HOV lanes, data showed that transit users in the corridor were underserved. Therefore, SANDAG decided to dedicate revenues to providing transit service in the corridor. The Inland Breeze, as shown in Exhibit 22, is funded with revenues from the project. Direct connect ramps for the exclusive use of transit and HOV may provide a higher level of access to a managed lane facility. These treatments are being planned on the New Jersey Turnpike. With new managed lane facilities coming on line, operators will need to establish a hierarchy of users and design and manage the facility to maximize the convenience offered to these users.

MONITORING AND EVALUATION

Exhibit 22. Inland Breeze (12).

Under a premise 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 are defined and throughout the life-cycle of a project the measures are monitored and evaluated. I-15 did this when it established a performance measure of level of service (LOS) C and set that threshold at 1,525 vehicles per half hour. SR 91 Express lanes operators have raised tolls several times as a result of increased congestion on the facility and in effort to maintain free flow condition and return a profit. The new owners have established very clear objectives and set forth a policy that premises those objectives and the monitoring and evaluation of the facility.

Monitoring technology used successfully today include vehicle sensors, automatic vehicle identification, license plate recognition, and user information systems. Each of these components has been demonstrated in the case studies to be integral in ensuring smooth operation of a facility. 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 adjusted.

Likewise, more comprehensive, historical data must be collected and analyzed to determine if adjustments to the overall operating strategies should be made. Population, employment and land use changes will occur in the corridor over time. As a result, conditions on the facility will also change. These data will be necessary to make an accurate assessment of conditions on the facility. The conversion of the HOV lanes to HOT lanes in the case studies relied on operations data and the experience of staff with roadway conditions to make those operational changes. The New Jersey turnpike recently implemented variable pricing in

an attempt to shift traffic out of the peak periods because data indicated these were the most congested times.

The I-15 Express lanes and the QuickRide project each identified specific performance measures at the outset of the project. This has aided in conducting an objective analysis of the project and whether or not it is achieving the objectives set forth.

Public Education and Outreach

Public education and outreach has been proven critical to the success of managed lanes projects. The outreach has taken many forms. SANDAG, CPTC, and Houston METRO all conducted surveys and focus groups to conduct market research prior to implementation. This information was used to develop materials to educate and inform travelers of the projects. The SR 91 Express lanes benefited and implementation was aided by a political champion that advocated on behalf of the project. Additionally, political champions have supported enabling legislation for the projects in California.

PRE-PROJECT EDUCATION

The SR 91 Express lanes offered many new innovations that were unfamiliar to the public. Since the beginning of project planning, CPTC conducted extensive traveler surveys and focus groups regarding the pricing concept and traveler reaction to dynamic pricing. In fact, the information gathered throughout this process impacted the way the company conducted operations. Additionally, the project was championed by several prominent political leaders.

Once the commitment was made to pursue congestion pricing, the project sponsors involved the media. This project has been highlighted and spotlighted around the world because of its innovation. This was the first effort of road pricing in the United States; it was the first fully automated toll road; and it was the first demonstration of using pricing to affect travel behavior. These reasons naturally drew media attention to the project. The project sponsors took a proactive role in educating the media and public to the project objectives and possibilities. They issued press releases, formed a speakers' bureau and made several public presentations as well as using direct mail, radio and television to alert the public to the imminent opening of the facility.

I-15 in San Diego relied on extensive public outreach prior to changing the operations of the HOV lanes. As early as 1991, then San Diego MTDB member, Jan Goldsmith, had suggested pricing as a way to utilize the excess capacity on the HOV lanes. Caltrans and SANDAG presented the public with pricing as a way of raising revenue to pay for transit improvements in the corridor while providing a transportation choice for travelers. The public was assured that excess revenue would benefit transit and HOV in the corridor. Focus groups, surveys and interviews all helped in developing programmatic strategies for the facility.

Prior to implementation of the QuickRide program a number of focus groups were held to ascertain public sentiment regarding the value pricing concept. The results of these focus groups were used to develop a marketing strategy and public information plan.

PROJECT-SPECIFIC MARKETING

The Express lanes on SR 91 and I-15 are well marketed. Recently, OCTA has made great efforts to publicize the fact the SR 91 Express lanes are now owned by a public entity. The operators also have an extensive incentive program for FasTrak patrons. The operators have teamed with local vendors to offer discounted services to FasTrak account holders. Yearly surveys have been conducted of users of the facility. Other surveys of non-users are conducted occasionally.

The SR 91 project has had to overcome controversy surrounding the franchise agreement with private owners at the same time as traffic volumes in the area continue to grow. Still, the project is favored by the public as providing a choice in travel options. OCTA has made the transition to public ownership seamless to the customer. Current FasTrak accounts were not affected by the transfer of ownership.

SANDAG markets the I-15 Express lanes and the FasTrak program. Support for the I-15 project has been enhanced because revenues generated by the project are used to support transit and HOV operations in the corridor. This objective was supported by the public and the public sees the tangible results of the project.

ON-GOING PUBLIC INFORMATION

The OCTA maintains a website for the SR 91 Express lanes that allows for on-line account applications and account maintenance. There is also a customer service center and an 800 number for customers' convenience.

Additionally, an advisory committee has been formed that includes representatives from Caltrans, Riverside County Transportation Commission, Orange County Transportation Authority, and San Bernardino Associated Governments and the general public. The group will decide if a new operational strategy is needed, what excess revenues should be used for, if preferential treatment will continue or be enhanced for HOV, and any plans for expansion of the current facility. Each of these questions will be answered relative to the objectives of the project set by the community.

The New Jersey Turnpike keeps the public informed via a website, as shown in Exhibit 23, which provides information about the turnpike as well as a link to sign-up for the electronic toll collection program, E-ZPass. The website offers toll rate calculators, real-time traffic information, traffic advisories and information about turnpike construction. On the E-ZPass website customers may apply for an account on-line or manage their account.

On-going surveys in the I-15 corridor indicate that the project is supported by the public. As part of the project study for the facility expansion, additional stakeholder interviews, focus groups and surveys have been conducted and indicate continued support of the program and

enthusiasm about extending the project. Additionally, the project is supported through a website that provides information and offers on-line application, a customer service center and an 800 number to call for more information.

Exhibit 23. New Jersey Turnpike Web Site (13).

Chapter Five. Recommended Practices and Lessons Learned

In this chapter the study team has documented several key areas in which lessons have been learned from the case study projects. Challenges and opportunities that were encountered in the case studies are also identified.

CLEAR OBJECTIVES AND VISION

Managed lanes projects must have clear objectives and a vision of how to achieve the objectives in order to measure success. Seemingly all transportation agencies have a goal of reducing congestion for the entire population. This contributes to an improved quality of life. An agency may achieve this objective through different means. A successful managed lanes project has clearly defined objectives and the mechanism for achieving the objectives. For example, the New Jersey Turnpike established a vision of a controlled access facility at its inception. The SR 91 Express lanes sought to provide congestion relief to a severely congested corridor by adding additional capacity. An objective for QuickRide and the I-15 Express lanes was to better utilize the HOV lanes and pricing was a way to achieve this goal.

ACTION AND OPPORTUNITY

Most of the currently operating managed lanes projects have been the result of agencies taking advantage of opportunities, whether they are a funding source or the availability of right-of-way or underutilized capacity. The SR 91 Express lanes took advantage of new legislation that allowed for tolling and private contributions. This allowed Caltrans and the local agencies to capitalize on an opportunity that had not been available before.

Likewise, other agencies such as SANDAG and Houston METRO have been proactive in identifying weakness in various operating strategies and altering those strategies to maximize the efficiency of the system based on clearly defined performance measures.

DESIGN

The currently operating projects in Houston and San Diego were implemented on existing facilities. Both facilities were designed as barrier-separated HOV lanes, which limited the ability to alter operating strategies as conditions in the corridor change. Both of these facilities have adapted to the conditions and the projects are successful. The SR 91 and I-15 Express lanes are facilities that do not offer intermediate access and thus serve long-distance trips. The New Jersey Turnpike was designed to serve even longer trips and as such ramp spacing distances are very long. The Katy Freeway and the Northwest Freeway both have limited at-grade access. However, as more managed lane projects are proposed and developed and current ones are expanded, the design of the facility is key to accommodating a flexible operating strategy.

For instance, the proposed expansions on the I-15 Express lanes and the Katy Freeway are each considering multiple access points. This presents challenges for design, user information, and enforcement but also allows for a more robust management strategy. Consideration can now be made for distance-based tolling and point of access tolling in addition to time of day pricing, which allows the operating agency to more effectively manage the facility.

Additionally, the New Jersey Turnpike has been designed for effective management by using controlled access gates that allow for sections to be opened or closed as conditions warrant. Moreover, each access point in the dual-dual section of the roadway has independent ramps with long spacing.

AGENCY COOPERATION

Managed lanes projects are often large undertakings that cross jurisdictional boundaries, making agency cooperation crucial. Institutional roles and responsibilities should be identified early in the planning process and documented with project agreements that define each agency's role in project implementation. The agreements should also provide flexibility for unforeseen circumstances.

Similarly, the public must be assured that public agencies are protecting the interest of the public. The privatization of the SR 91 Express lanes and the non-compete clause created public mistrust because the public did not feel that Caltrans was diligently protecting the public's best interest. The legal battles waged by various parties exacerbated the problem. Clearly defined policies and expectations of each agency from the project outset may minimize any misconceptions between the parties.

The QuickRide program requires the cooperation of the state department of transportation and the transit authority. This program had the advantage of existing institutional arrangements that stemmed from the operation of the HOV system. Projects may benefit by utilizing existing agreements that work well and adapting those to meet the needs of the managed facility.

An important result of agency cooperation is seamlessness to the customer. In managed lane projects where pricing is employed agency cooperation has allowed for a superior level of service to be provided to the motorists. Interagency agreements and interoperability standards and requirements on California toll facilities greatly enhance the ease of travel for motorists.

PUBLIC EDUCATION AND OUTREACH

Managed lanes is a new and complex concept to most travelers. Public understanding and acceptance of a project is critical not only to individual projects but also to any expansion into a system. CPTC conducted extensive public opinion research prior to constructing the SR 91 Express lanes and the research indicated that the public was accepting of the pricing concept. Yet, the public did not have an understanding of the private development agreement between CPTC and the state. The result was confusion and mistrust by the public. In this case, the public was asked to accept a new concept, i.e. pricing and to accept the notion of a private developer providing what is traditionally a public service.

The I-15 Express lanes outreach clearly identified the project objectives to the public and demonstrated how SANDAG would achieve the objectives. Additionally, successes of the project are promoted. This enables travelers in the corridor to readily see project benefits.

Both of the California projects had the benefit of strong political figures to act as champions. Local officials as well as state officials recognized managed lanes as an opportunity to maximize efficiency of the transportation system that otherwise may not have occurred. Success of future projects will depend on a broader understanding of the benefits of a multi-modal system wide approach.

On the contrary, political opposition and lack of public understanding may kill a worthwhile project. The public, as well as key officials, must understand the circumstances in which managed lanes may provide a workable solution to problems of congestion or other lane management needs.

Barriers to Implementation

Many obstacles had to be overcome in implementing the currently operating managed lane projects. New and unfamiliar agreements had to be forged amongst various agencies and, in the case of SR 91, with a private company. Each of the challenges were addressed and allowed the projects to move forward.

CORRIDOR CHARACTERISTICS

A thorough understanding of corridor characteristics is imperative to managed lane success. In order for pricing to be feasible it must offer a service superior to the adjacent general-purpose lanes. This means there must be serious congestion on a facility without viable alternate routes. The public must understand the operational characteristics of this situation and the public may need to be educated on transportation funding and shortfalls. The equity of pricing may also need to be addressed.

The project sponsors on the SR 91 express lanes relied on extensive traveler surveys and public attitude surveys to assess the conditions that existed in the corridor prior to project implementation.

DESIGN ISSUES

Design elements including access treatments impact project feasibility. The currently operating pricing projects are very limited access facilities that primarily serve through trips and act as express lanes. This makes designing for enforcement and tolling areas easier. As more and more management strategies are analyzed and multiple access points are considered the design implications become much more complex.

Positive separation is used each in of the operating managed lanes projects. This is important because of the different operating characteristics that may occur on adjacent general-

purpose lanes. As more projects are developed lane separation techniques must be carefully considered in the design phase of project development.

ENFORCEMENT

Enforcement is paramount to protecting the integrity of a managed lane facility. Enforcement on facilities that use both pricing and vehicle eligibility has two compliance tasks: toll account verification and vehicle eligibility verification (usually based on occupancy). Technology is available to address account verification but preferential vehicle verification is usually performed by visual inspection.

The state of California has passed laws that provide for stiff penalties and fines for violating the rules of managed lanes in the state (Exhibit 24). The I-15 Express lanes have a violation rate of less than five percent. The laws provide fines for both HOV lane violations as well as non-payment of tolls. Enabling legislation is an important factor in the enforcement of a facility.

Exhibit 24. HOV Violation Sign.

As more complex projects are developed planning and designing for enforcement must be incorporated when considering different operating strategies. Specific performance measures and acceptable violation rates should be identified. Conversely, if a facility is not stringently enforced high violation rates should be expected.

Outlook for Future Implementation

The "first generation" managed lanes projects reviewed for this study are characterized by straightforward pricing applications, consistent vehicle eligibility requirements, and limited ingress and egress points. Next generation projects moving toward implementation are envisioned to operate with more complex pricing schemes, potential variations in eligibility by time periods, and multiple access points. Two of the "second generation" projects are described below, along with the emerging issues involved with implementation of more complex managed lane facilities.

I-15 MANAGED LANES, SAN DIEGO

The managed lane concept has been included in the regional transportation plan that was recently adopted. The plan calls for studying managed lanes on several facilities in the area. Currently, the project partners are working together to expand the I-15 HOT lanes currently in operation to a more robust managed lanes facility.

The ultimate design of the facility will add two additional express lanes to the current eight-mile facility. It will extend these lanes for another 12 miles. The proposed cross section includes a moveable barrier in the median to allow for three lanes to travel in the peak direction (see Exhibit 25). The facility will be barrier separated from the mainlanes but will include multiple intermediate access points including direct access for transit and HOVs. A significant component of the managed lanes plan is a Bus Rapid Transit System (BRTS) that will allow express buses direct access to the facility from park-and-ride lots within the corridor.

Consultants are still evaluating various operational strategies, including dynamic pricing, distance-based pricing, dynamic distance-based pricing, pricing according to access point, and numerous other scenarios. When implemented, this facility will truly be managed relative to very specific project objectives. Flexibility is being built into the planning and programming of the facility to allow for operations to be adjusted to meet the changing needs of the traveling public in the corridor.

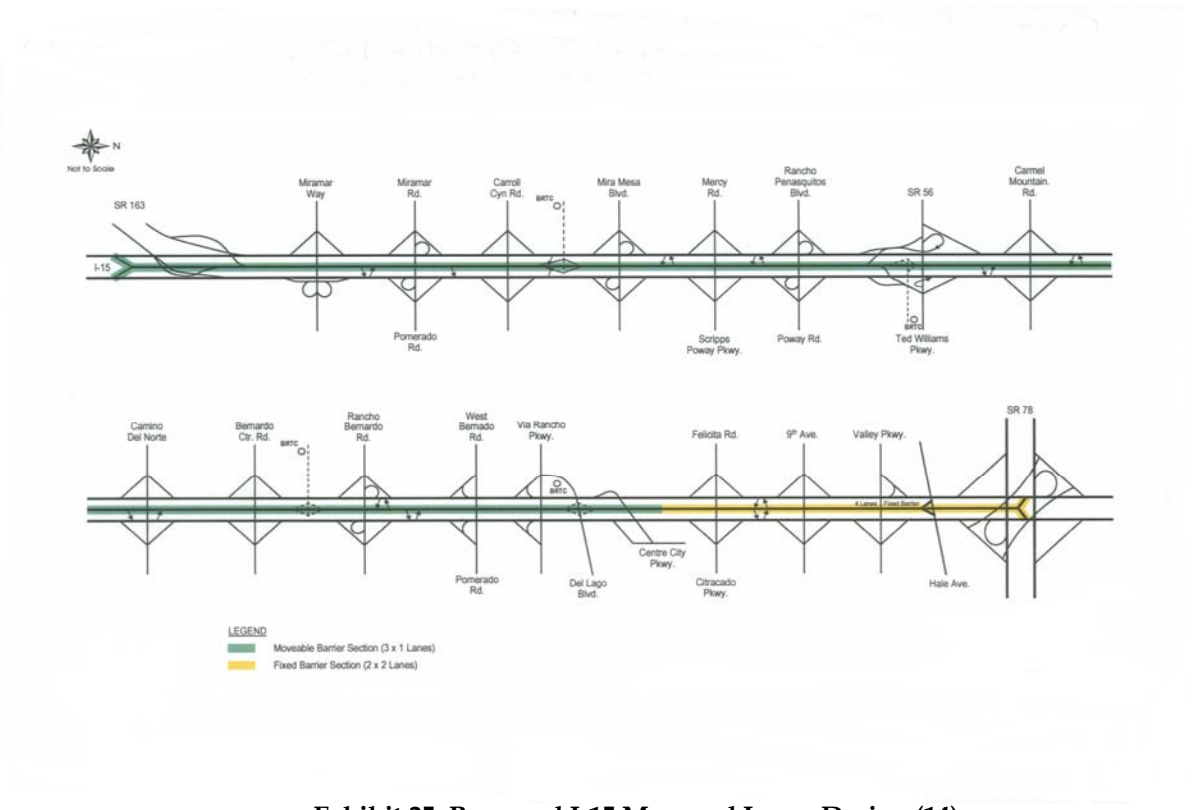

Exhibit 25. Proposed I-15 Managed Lanes Design (14).

I-10, KATY FREEWAY, HOUSTON

Like I-15 in San Diego there are plans to expand the Katy Freeway to a multiple-lane managed facility. The facility will be reconstructed and expanded to include four special use lanes. The proposed cross section is shown in Exhibit 26. The exact details of how the lanes will operate have not been finalized, but pricing and occupancy will both be used to manage demand and ensure that the facility operates at free flow conditions. The project is being undertaken cooperatively by Houston METRO, TxDOT, FHWA, and the Harris County Toll Road Authority (HCTRA). HCTRA is

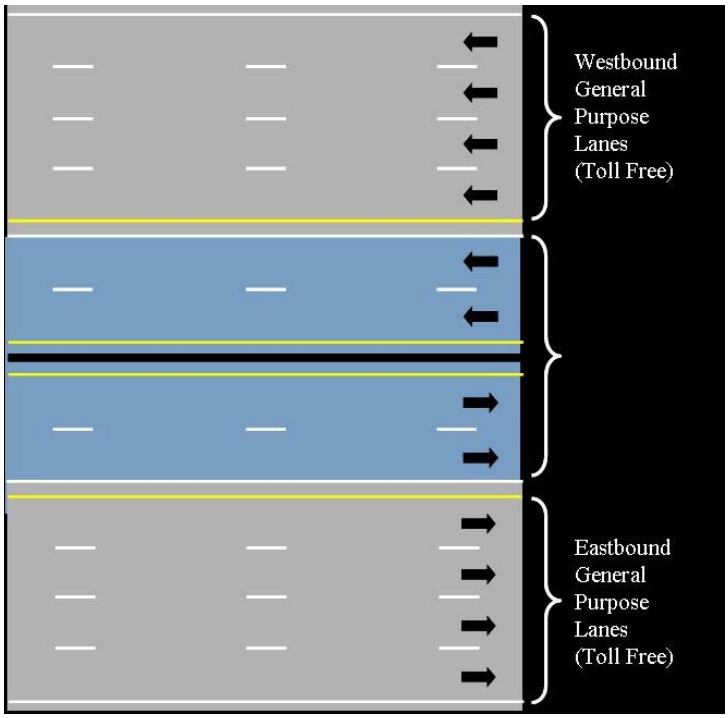

Exhibit 26. Proposed Cross-section for Katy Freeway (15).

contributing to the financing of the project and will operate the special use lanes. Travel on the lanes will require a toll but buses and HOVs will be given preferential treatment by way of free or discounted travel, direct connections, and other support facilities.

Emerging Issues and Knowledge Gaps

REVENUE GENERATION

Funding shortfalls in transportation are forcing more agencies to look at pricing and tolling as a mechanism to raise revenue. Clearly, the SR 91 Express lanes were developed as a result of funding issues. More and more politicians are viewing lane management with pricing as a viable alternative to expensive capacity expansion projects. Pricing on managed lanes is also a means to get projects implemented more quickly, as was also the case with the SR 91 Express lanes.

Moreover, more and more elected officials are heralding pricing as a way to finance additional capacity. Legislation is being proposed that would use variable tolls in an effort to manage demand and the tolls would finance the capital costs of the added capacity. The issue arises when payments on the facility are complete. If the variable tolls are removed when the facility is paid for, the ability to use price to manage demand is also removed. If such legislation is enacted, research will need to assess the ramifications of such a policy.

Communities must also reconcile revenue generation potential with the ultimate desires of the community and objectives for a particular project. If increasing person movement on a facility is the objective and HOV preference is given by way of reduced tolls, then the revenue generation potential will be diminished. Exhibit 27 illustrates the difference in costs versus revenue between a for-profit project, SR 91 Express lanes and a project with HOV priority, I-15 Express lanes (16).

Another important issue affecting revenue generation is ownership of the project. Private involvement in a public works project may require additional public education. The private enterprise should be fairly compensated for its investment in a public project; however, the public may only be willing to tolerate a certain amount of profit-making on a public good. Future project agreements will need to assess the public's willingness to accept private investment and the trade-offs that may be required. Additionally, these agreements may be structured to provide maximum caps on profits ensuring the public that investors are not price-gouging.

Nevertheless, the potential for revenue generation in a managed lanes project may provide an opportunity to public agencies that previously was not available. Pricing may provide the necessary means to cover capital and/or operating costs. It may also allow projects to be implemented sooner than would have otherwise been possible. Careful analysis and community consensus will be needed to balance revenue generation with other project objectives.

Exhibit 27. Costs vs. Revenue for HOV Priority and For-Profit Facilities (17).

	I-15 Conversion from HOV to HOT	SR 91 Express Lanes
Number of tolled lanes	2	4
Total Daily Traffic	22,400 (2003)	33,000 (1999)
• Tolled – full price	5,600 (2003)	29,000 (1999)
• Tolled – discount	-----	4000 (1999)
• Exempt	16,800 (2003)	------
Operating Expenses	$ 1 million/year	$ 10 million/year
Bus Service Expense	$ 1 million/year	------
Revenue	$ 2 million/year	$ 30 million/year

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 the cooperation between local agencies, state agencies, transit agencies, regional transportation authorities and private developers.

Political support of a project is a necessary component of project implementation. This support will also hasten changes in legislation that would support managed lane projects.

A synthesis of issues from agency perspectives will allow agencies to learn from previous agreements. Preparation of document templates used for operating projects will be useful in drafting legal and functional agreements between and among participating entities that address fiscal, technical and liability risks and responsibilities.

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.

Traffic and revenue studies are conducted to satisfy investment requirements and bond indentures. However, these studies are often conducted after basic project parameters are defined. The need exists for a more comprehensive tool to address the impacts of managed lanes design, access and operational strategies on factors such as demand management, revenue generation, and air quality conformity. Development of these tools and techniques will allow agencies to incorporate managed lanes into the long-range planning process. Not only will this produce a more meaningful and useful long-range plan it will also enable planning personnel to analyze the connectivity of the managed lanes facility with other types of systems such as HOV lanes, arterial streets, toll roads and free roads.

ENFORCEMENT

Stringent enforcement protects the integrity of the facility. The advancement of electronic toll collection technology has aided the use of pricing as a management tool; however, occupancy enforcement technology has not made as many significant advances. Moreover, when multiple operating strategies are employed on a facility, enforcement becomes increasingly complex.

Automated technologies are being explored and these new tools will aid in enforcing a facility. Technologies such as infrared occupancy detection, remote toll reading, and license plate capture are being tested and used in some instances but more evaluation is needed before there is widespread use. Furthermore, legislation is needed in several states to make automated enforcement legal.

A need exists for a synthesis of the current state-of-the-practice for determining vehicle occupancy. This information would allow for an assessment of the applicability of these systems to managed lanes that vary eligibility or cost to use the lane throughout the day based on conditions in the corridor. It is also important to test the public's acceptance of such technology and the ability of such technology to be admitted as evidence in court.

Because automated technology is not sufficiently reliable or legal at this time, enforcement, especially for occupancy, is performed visually by law enforcement personnel. For this reason, ongoing training and education of personnel charged with enforcing a managed lanes facility

and education within the court system on the effects of effective enforcement and the repercussions associated with non-enforcement, are both critical, on-going needs.

PERFORMANCE MEASURES

Many agencies establish operating thresholds for HOV lanes. Currently there is no uniform standard for managed lanes operations and to a certain extent the thresholds will be based on the objectives of the project as well as design elements such as cross section, location of access points, and bottlenecks. However, a need exists to apply standards to managed lanes much like standards are applied to freeway operations. A review of existing measures of effectiveness can identify which are applicable to managed lanes. New measures can be developed as projects evolve.

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 distance-based charging, charging based on a 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. The use of concrete barriers has enhanced safety and aided enforcement on HOV lanes and HOT lanes as well as the dual-dual roadway portion of the New Jersey Turnpike. However, this has also been a limitation in altering operating strategies. The determination of access points is also impacted by the flexibility of the facility design. Decisions on lane separation technique and ingress and egress from the facility will need to be explored in the planning phase of the project.

OPERATIONAL FLEXIBILITY

The managed lanes projects coming on line now are part of a "next generation" of projects that are much more complex in their operations. Not only are the operating strategies themselves more complex, the operators are proposing to vary the operating strategy depending on conditions in the corridor. This is true in both the short-term operations but also over time.

It is important that operators of these facilities have the authority to alter operations over time. This may require policy objectives that are codified by law to prevent changing political climates from impacting operational flexibility. Additionally, potential conflicts between federal and state agencies should be identified and remedies put forth at the inception of the project that will ensure flexibility over time.

DRIVER INFORMATION AND SIGNING

Currently operating managed lanes facilities employ a number of techniques to provide drivers with information. Dynamic message signs alert drivers to conditions on the roadway as well as current toll rates, enabling the driver to make an informed decision. Websites now contain published toll schedules and toll rate calculators to allow the driver to map his preferred route. Variable speed limits are also being used to communicate roadway conditions to drivers. Variable speed limits have been used successful to warn motorists of weather conditions and have shown promise in their usefulness in improving traffic flow. More research and testing is needed in the United States for the applicability of variable speed limits to operate in response to congestion.

Many lane management strategies are used in tandem with one another. This results in the need to deliver an array of information to the driver. Information must be conveyed in a manner that is easy for the driver to read and understand, and with enough advance notification for the driver to make a decision, and safely maneuver to the desired location. The SR 91 Express lanes are the simplest plan operating. A changeable message sign indicates the current toll prior to the entrance to the facility. A driver may then use that information to choose whether or not to enter the lanes. The scenario is more complicated on the I-15 Express lanes where the tolls may change as often as every six minutes. The QuickRide program has a set toll rate but the occupancy requirements change relative to the time of day.

Research is needed to determine the most effective way for communicating information to the motorists while maintaining safe operations on the roadway. The projects currently being planned involve multiple agencies, a greater number of access points and a more varied group of users. Information that has to be communicated may include:

- Ingress and egress locations,
- Occupancy requirements,
- Operating hours,
- Toll amounts, and
- Operating agencies.

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 identified ways to incorporate managed lanes into regional strategic planning network (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 SANDAG and 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. For instance, land use planning can identify areas suitable for park-and-ride lots which may serve bus rapid transit customers as well as carpoolers. Additionally, if discounts are offered as a demand management strategy and enhanced service is provided to potential bus riders and carpoolers, more options are available to the traveling public and the demand may be spread across modes. Agencies will have to weigh pricing strategies and discount policies against the objectives for the project. For instance, a transit fare structure should be considered in setting toll rates, including carpool discounts, if transit ridership is critical to mobility in the corridor.

To facilitate multimodal operations, simple understandable measures need to be used for the purpose of comparing strategies. In addition, an effort to promote public understanding of the alternatives' benefits and costs is important.

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 applications as the software and/or hardware can be developed. In applications of technology demonstrated to date, it appears that managed lane design will not be significantly influenced by emerging technologies. With the development of standards for dedicated short range communications (DSRC), specifically related to the 5.9 GHz band, the implications for integration of 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.

EQUITY

The projects in operation today have made great strides in addressing the equity issue and overcoming the perceived "Lexus lane" syndrome. The I-15 Express lanes fund an entirely new bus service with revenues generated from the Express lanes. SANDAG promotes this service as a benefit of the lanes. Users and non-users both believe the lanes offer a fair alternative to the commuting public. Likewise, public opinion gathered from other operating projects indicates that motorists of varied income levels take advantage of the managed lanes.

Facilities such as the expansion of the I-15 Express lanes that include a bus rapid transit component may achieve even greater strides in addressing the equity issue. Benefits to transit users, HOVs, SOVs that buy-in, and the adjacent general-purpose traffic should be quantified and this information should be disseminated to the public.

Even with the above noted public acceptance, a need exists for documentation and quantitative assessment of the equity concerns. The implication of pricing should be compared to alternative strategies. A framework should be developed that allows for the comprehensive and comparative analysis and measurement of equity issues. Mitigation efforts should be identified and included as part of the public education strategy.

PUBLIC ACCEPTANCE AND MARKETING

In order for the public, planners, engineers and politicians to embrace pricing, concise information and consensus on project objectives is necessary. A comprehensive list of real and perceived issues should be developed.

Because managed lanes are a new concept, it is important to identify messages that resonate with the public. But before the public can be involved it is imperative that planners, engineers, and politicians have an understanding and consensus on the purpose of a proposed project. Developing a list of issues, both real and perceived, can help the marketing professional at the local level. Focus groups comprised of agency professionals can delve into specific issues and marketing techniques to determine which messages are most effective. This will allow the marketing professional to develop clear and consistent messages tailored to specific needs. These messages can then be taken to the public in ways that will allow the public to visualize how a managed lane facility might operate.

Chapter Six. Conclusions

The managed lane concept seeks to address the issue of growing congestion in a proactive manner. Agencies are using a variety of management techniques to manage demand. This document has provided information from operating projects around the country in an effort to increase awareness and understanding of the managed lane concept.

The case studies researched for this report are using pricing, vehicle eligibility and access control to manage demand. Each of these operating strategies presented unique opportunities and challenges for the project sponsors. This research provides a synthesis of the operating projects and identifies issues agencies faced during project development and implementation. This research serves as a foundation to assist agencies that are considering implementation of lane management strategies, and project planners may build on this information as more complex projects are developed.

The study has highlighted successful practices in operation today. However, there are still many emerging issues and research needs. These issues should be explored so that specific tools, techniques and strategies can be developed that will insure successful implementation of future managed lane projects.

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