Managed Lanes Strategy Paper

Chicago Metropolitan Agency for Planning
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Introduction: What Are Managed Lanes And Why Might They Be Important?

The purpose of this report is to explore the effectiveness of managed lane strategies in achieving travel congestion reduction and other related benefits, such as reduced travel delay and hours of travel, greater use of transit and rideshare participation, improved safety, improved air quality, improved quality of life, and enhanced economic activity.

"Managed lanes" are defined as a limited number of lanes set aside within an expressway cross section <u>or</u> lanes comprising a separate expressway facility where multiple operational strategies are utilized and actively adjusted as needed for the purpose of achieving pre-defined performance objectives. The operation and utilization of managed lanes, typically situated within expressway rights-of-way, are controlled in order to optimize travel flow and reduce congestion. To move toward uncongested operations, managing a lane typically involves reducing excessive traffic volumes, reducing conflicts between vehicles, reducing the number of incidents, and better managing those incidents that occur.

Managed lanes can maintain the capacity of a highway facility under a wider variety of future scenarios than unmanaged facilities. While many people believe that good central planning can produce a network of uncongested highway facilities through enlightened engineering and construction, the truth is that a dynamic region will have growth and change that simply can't be foreseen. Congestion will occur on our highway system even when prior planning took into account all likely future conditions. We are limited in our response to changes by the financial constraints we have to live with, so we cannot respond immediately to changes with new construction projects. Thus, highway facilities need to be sufficiently resilient to function in a variety of future scenarios. The ability to manage the use and operations of a facility enhances this resiliency, and assures that the facility can operate closer to its optimum usage over the life of the facility.

Managed lanes require substantial investment over and above a basic facility. This investment includes the cost of an enhanced facility, technology, and personnel. A larger, better-funded cadre of transportation operations personnel would be required. In addition, new trained enforcement personnel would be required to implement rules governing managed lanes.

The following summarizes the most commonly applied managed lane strategies.

<u>Dedicated Lanes</u>. Express lanes and reversible lanes separate vehicles by trip destination and by vehicle type. Express lane facilities typically serve passenger cars only and provide point-to-point service with a much lower frequency of access and egress points. Conflicts and weaving are minimized in express lanes, optimizing capacity. Structural barriers are the primary means of assuring optimum system performance.

<u>Congestion pricing</u> allocates capacity through a traveler's willingness to pay. Prices are usually set so that speeds do not approach congested levels. Variable toll lanes and dynamic toll lanes are a form of congestion pricing applied to managed lane concepts.

<u>Vehicle Preferences</u>. Lanes can be managed by restricting or encouraging certain vehicle characteristics. For example, lanes can be restricted to trucks only, buses only, long-length vehicles (trucks and buses), passenger vehicles only, or high-occupancy

vehicles (HOV's). HOV's are passenger vehicles with multiple occupants, including commuter vans and buses.

High-occupancy toll lanes (HOT lanes) further enhance congestion pricing and managed lane concepts by allowing high occupancy vehicles (HOV's) to utilize assigned lanes to maximize person throughput.

Supporting Technologies and Strategies
Managed lane strategies depend heavily on the successful application of several operations strategies and technologies. These strategies and technologies may include:

- Traffic Operations Centers
- Variable Message Signage (VMS)
- Overhead Lane Usage Signal Systems
- Closed Circuit TV (CCTV) Monitoring
- Electronic Toll Collection
- Variable Speed Limits / Speed Management
- Direct and Priority Access Ramps
- Lane Separation Systems: Fixed and Movable Barriers
- Enforcement – Police and Video Assisted

Each of these will be discussed in more detail below.

Overview of Existing Conditions

The seven-county CMAP region and 16-County Gary-Chicago-Milwaukee (GCM) Corridor face increasing traffic congestion with an estimated cost of $11 billion annually (US Department of Transportation, 2006). This cost includes the direct costs of delay, lost productivity, wasted fuel, environmental impacts, crashes and injuries, higher freight handling costs, and extra time budgeted for travel time variation.

Peak period travel times in the Chicago region often approach 150% (1 1/2 times) of free-flow travel times. In 2005, the Texas Transportation Institute estimated metropolitan Chicago's annual delay per peak hour traveler at 46 hours per year. Calculated over a number of weeks and workdays, this figure translates to 11+ minutes of delay per day for each traveler. The recently devised FHWA *Urban Congestion Report* also indicates significant congestion in the Chicago region as compared to 19 other regions, as shown in **Table 1.**

Table 1
Urban Congestion Report Comparison, August-October 2007

Measure	Chicago	**Chicago Rank (of 20)**	National Composite	Explanation of Measurement
Congested Hours	13.04	**Worst**	6.12	Hours per day when 20% of the system is congested
Travel Time Index	1.49	**Worst**	1.348	Ratio of peak-period travel time to free-flow travel time
Planning Time Index	2.07	**2nd Worst**	1.755	Factor showing extra time to set aside for on-time arrivals because of travel time variation

Source: FHWA, Urban Congestion Report, August-October 2007

Recent growth in automobile travel compounds this existing problem. Within the Chicago region, daily vehicle miles traveled (VMT) on the limited-access expressway system more than doubled between 1985 and 2005, growing by 136%. During the same period, additional lane miles on the expressway system grew much more slowly at 36%. Recently, expressway VMT has declined, though the legacy of a congested expressway system remains.

Traffic congestion affects not only the traveling public, but also commercial vehicle operations. The Chicago Metropolitan Area contains six of the FHWA's list of twenty-five most delayed interchanges, ranked in terms of goods movement delay. These six interchanges alone inflict an estimated $556,164,000 in costs associated with delay on the movement of goods through and within the region. For a summary of highway interchange bottlenecks in the region, please refer to **Table 2**.

Table 2: Truck Highway Interchange Bottlenecks in Northeastern Illinois

Bottleneck Location	Top 25 Rankings					
	All Trucks (Table A.1)			Large Trucks Long Distance > 500 mi (Table A.2)		
	National Rank	# in Class	Annual Hrs of Delay	National Rank	# in Class	Annual Hrs of Delay
I 90/94 @ I290 Circle Interchange	4	25	1,544,900	3	25	286,400
I 94 @ I 90 Skyway	6	25	1,512,900	4	25	281,700
I 80 @ I 94 Split B. Ford/Kingery Int	12	25	1,343,600	7	25	250,400
Pulaski Rd @ I 55	14	25	1,300,400	10	25	240,500
I 290 @ I 355	17	25	1,246,200	11	25	231,800
I 55 @ I 294	NA	NA	NA	22	25	185,400
% of # in Class	**20%**		**6,948,000**	**24%**		**1,476,200**

Source: FHWA Highway Interchange Bottlenecks National Study, 2005

http://www.fhwa.dot.gov/policy/otps/bottlenecks/chap5.htm

Managed lane facilities are currently used in a number of locations in the region to reduce congestion, including:

Dan Ryan Express Lanes

The Dan Ryan Expressway express lanes extend from 26th Street to 67th Street in both directions. Local lanes provide access to all exits starting at 31st Street, while express lanes provide more limited access and egress to high-demand destinations in both directions (US Cellular Field, University of Chicago, Chicago Skyway). The express lanes are limited to passenger vehicles.

Figure 1. Dan Ryan Expressway, SB Local and Express Lanes at 31st Street

Source: IDOT

Kennedy Reversible Lanes

The Kennedy Expressway features a barrier-separated two-lane express corridor running a distance of 7 miles from Ohio Street (north of the Chicago Loop) northwesterly to the Edens Expressway. Access and egress points are limited to the termini and one midpoint location. The reversible lanes are limited to passenger vehicles.

Figures 2 and 3: Kennedy Expressway Reversible Lanes

Sample Kennedy Expressway Reversible Lane Conversion Schedule (Subject to Change)

Conversion	Day	Time
Inbound to Outbound	Monday through Friday	Between 11:30 am & 1:00 pm
Outbound to Inbound	Sunday through Friday	Between 11:30 pm & 1:00 am
Inbound to Outbound	Saturday	Between 1:00 pm & 3:00 pm
Outbound to Inbound	Saturday	Between 3:00 pm & 5:00 pm
Inbound to Outbound	Saturday	Between 8:30 pm & 9:30 pm
Outbound to Inbound	Sunday	Between 12:01 am & 1:00 am
Inbound to Outbound	Sunday & Holidays	Between 2:30 pm & 4:30 pm

Sources: (2) Knight AE; (3) IDOT

Other Existing Managed Lanes Resources

Several other metropolitan Chicago resources are worth mentioning:

- The Illinois Tollway's I-Pass transponder system separates slow-speed cash transactions from automated high-speed toll transactions using open-road tolling. The system also facilitated a limited congestion pricing system applied to trucks.
- Substantial technological resources, including incident detection and management using traffic management centers.
- The expressway system typically limits trucks to the two right lanes. Trucks are prohibited on Lake Shore Drive. While there may not be a need for additional truck restrictions, compliance is good, indicating an understanding among the public of the benefits of vehicle preferences in managing traffic, even among those not preferred.

Dedicating Managed Lanes

The managed lanes most familiar to motorists are dedicated to managed lane operation through a structural barrier, as in the case of the reversible lanes on the Kennedy Expressway and the express lanes on the Dan Ryan Expressway. Since these facilities are separated by barriers, separate shoulders are required for safety. In these cases, the managed lanes facility is very expensive, requiring both additional concrete construction and right-of-way. Sometimes, lower-cost alternatives are required by economic and engineering considerations. These low-capital options include separating managed lanes with a pavement buffer with appropriate markings and closely spaced, flexible plastic pylons.

In some cases of lane management strategies, e.g. left-lane truck prohibitions, no separation of lanes has been implemented. Typically, lane separation is required when the managed lane operates at a different speed than any unmanaged lanes. If managed lanes operate at substantially different speeds than regular lanes, lane changes to and from the managed lanes should be controlled with lane separations to reduce the safety hazard of vehicle conflicts at different speeds. Thus, a greater benefit for a managed lane facility in the form of higher managed lane speeds will require a more substantial investment.

How many lanes should be dedicated to a managed lane facility? Frequently, initial managed lane proposals are for a single lane in each direction, as in the initial proposal for a high-occupancy lane in the Eisenhower Expressway right-of-way. However, a single-lane facility has disadvantages in case of incidents, even the most minor of which may close the facility. An advantage of multiple-lane facilities is that in normal operations, having a two-lane facility will allow vehicles to pass each other, preventing blockages by slow-moving vehicles. Thus, if passenger vehicles are to be accommodated, a managed lane facility should be at least two lanes in each direction (if applicable). If a single lane is to be added to an existing facility to create a managed lane facility, facility planners should consider reallocating a general-purpose lane to the managed lane facility to maximize safety and traffic flow.

Taking the concept of managed lanes to a higher level, an entire freeway can be managed, particularly through the price mechanism. Managing an entire freeway has an advantage over managing a subset of lanes because it requires less right-of-way and requires less money for construction and enforcement. Safety is dramatically improved on a managed freeway because the speed differential inherent in most managed lane scenarios is eliminated – all lanes travel at the higher, uncongested speed. In addition, the clearing price for a managed freeway is lower than for individual lanes. However, such a facility reduces the choice of prices for travelers.

Congestion Pricing

Much like a business allocates its inventory to customers based on their willingness to pay, congestion pricing allocates scarce highway capacity through a traveler's willingness to pay. Congestion pricing is a form of road pricing, a broader concept that includes conventional tolling and charges for vehicle miles traveled. Congestion pricing, like other road pricing, will raise revenues, but will do so as part of a strategy to address highway congestion.

We have not succeeded in attaining our goals for regional mobility and accessibility by managing only the supply of transportation. Demand management is necessary. Likewise, travel demand management is not likely to succeed if it operates only by trying to attract people to alternate modes of transportation. Congestion pricing allows system operators to manage demand like any business – by varying prices to find a "clearing price" where supply equals demand.

Congestion prices can be charged for a variety of travel activities:

- *Area Charges.* Typically, an area charge is applied to all vehicles traveling within a congestion charge area. For such a system, monitoring is required not only on the periphery of the zone, but in the interior of the congestion charge area. An area charge is expected to reduce the total volume of traffic within the congestion charge area and the immediate surrounding area. An area charge has been implemented in London.
- *Cordon Charges.* Under a cordon charge system, a cordon line is established, typically around the central area of a city. Vehicles are charged to pass through the cordon line regardless of the functional class of the roadway. Cordon charges reduce traffic in and around the cordoned area. Though substantially simpler to administer than an area charge, a cordon charge may not be quite as effective. A cordon charge has been established in Stockholm.
- *Parking Congestion Fees.* Instead of charging road use directly, parking fees can be managed to reduce congestion. Such a system has been proposed for the City of Chicago.
- *Highway Congestion Fees.* Highway congestion fees are congestion charges applied to managed lane concepts. Fees are established as a tool to manage demand on the facility. Typically, highway congestion fees are established to manage demand to attain an established *performance standard*. For example, highway congestion fees on State Route 91 in California are set so that facility demand does not exceed 1,700 vehicles per hour per lane, eliminating recurring congestion on the roadway. Highway congestion fees have been established in southern California, Texas, and in Minnesota, among other locations.

Managed lanes applications of congestion fees allow system operators to keep a facility from reaching a state of oversaturated flow. Hourly highway volumes serviced are maximized at approximately 45-50 miles per hour; spot volumes may be higher than 2000 vehicles per hour per lane. However, when volumes are maximized, a slight disruption of traffic flow causes a “breakdown” leading to lower speeds and lower volumes comprising oversaturated flow. Maximized volumes at 45-50 miles per hour are not sustainable with current technologies. Thus, by maintaining slightly lower volumes and higher speeds with congestion pricing, system operators of SR 91 in California keep managed lanes volumes and speeds substantially higher than on unmanaged lanes.

Congestion fees are set in a variety of ways:

- Static, flat fees can be established to reduce congestion. For example, London’s £8 congestion charge applies regardless of the congestion level and is not regularly adjusted to reflect travel conditions. Flat fees are not well-suited to performance-based pricing.
- Variable fees are set to vary by time of day, reflecting average demand. Such fees are typically reviewed quarterly and reset to meet highway performance standards. Variable fees enable stable travel mode choices, since the fees are known in advance.
- Dynamic prices employ real-time data to vary prices throughout the day as needed to meet highway performance standards. Dynamic prices permit lower average prices than variable prices, but the prices may not be known to users until they are en-route. Therefore, dynamic prices are more likely to affect route choice than mode choice.

A key component of congestion pricing success is the availability of travel options. However, such options do not need to be feasible for all travelers for congestion pricing to be successful. A successful congestion pricing program will encourage users to make different route choices (e.g, a bypass route), mode choices (transit), and destination choices (local instead of distant shopping). The accummulation of different choices in response to price will yield a positive price response.

Congestion pricing can be set differently for various vehicle classes. However, congestion pricing is best limited to passenger vehicles, since passenger travel is best able to divert to other modes. While pricing experiments in other areas focusing on passenger vehicles has demonstrated a strong response to price, a modest pricing experiment limited to trucks showed that truck routing and timing decisions were not very responsive to price.

Vehicle Preferences

System operators may restrict or encourage certain vehicles. Operators may restrict lanes to trucks only, buses only, long-length vehicles (trucks and buses), passenger vehicles only, or high-occupancy vehicles (HOV's). When applied to priced lanes, several operators have established high-occupancy toll lanes, to allow high occupancy vehicles (HOV's) to utilize assigned lanes to maximize person throughput.

Preferences can be established based on policy, economic, or operational bases. For example, in keeping with a region-wide “green transportation heirarchy” system of preferences (favoring walking and bicycling, transit, freight, and high-occupancy passenger vehicles and single-occupancy passenger vehicles, in that order), a managed lane preference may be established for transit and freight. Likewise, a truck-only managed lane may be established to keep trucks off of arterial streets. In such cases, performance and planning measures for providing these managed lanes is with reference only to the service for those vehicle classes, not to improve passenger vehicle service.

When crafting a managed lanes policy solution through vehicle preferences, it is important to assure that the regulation has the desired affect. For example, high-occupancy vehicle lanes may draw family travel, rather than commuters sharing a ride. Thus, one solution adopted by SR 91 express lanes in California is to only give preferences to registered carpools and vanpools. Such narrow focus allows the policies to differentiate between high-priority policy goals of encouraging carpooling and low priority goals like getting families to the beach.

Vehicle preferences on managed lanes are often best implemented as part of systems. For example, a high-occupancy lane preference can be accompanied by queue by-pass facilities for ramp meters at on-ramps and/or by adjacent park and ride facilities. Truck facilities can be routed between inter-modal freight terminals with dedicated entrances and exits. Congestion pricing on managed lanes can be introduced with new high-speed bus service.

Typically, vehicle preferences alone are not sufficient to attain performance standards on facilities for passenger vehicles. Thus, in order to assure the managed lane achieves performance standards, HOV lanes are now usually implemented with a toll option – as a high-occupancy toll (HOT) lane.

Managing Managed Lanes

Supporting Technologies and Strategies: Managed lanes require management, which in turn requires the application of advanced technologies and strategies to optimize system operations. Some strategies and technologies have been applied widely, including in northeastern Illinois. Some of the strategies discussed for managed lanes are experimental.

Management of a managed lane facility is usually coordinated through a traffic operations center, which is the nexus of a transportation communications system linking highway data (sensors indicating volumes and speeds, audio-video feeds, and traffic control device status data) with control features (dispatch of emergency and incident personnel, ramp meter controls, and traveler information provided through expressway variable message signs, broadcast and Web-based information services). A key control strategy for traffic management centers is the detection and quick removal of incidents. Future advancements, through an *integrated corridor management system,* could integrate freeway and arterials with arterial variable message signs, traffic signal control, and access controls. Integration would facilitate a system-wide response to serious incidents, while likewise facilitating alternative routes through signal and access controls.

A second control strategy employed by traffic operations centers to manage lanes is to smooth the flow of vehicles to prevent incidents and optimize travel speeds. To smooth traffic flow, traffic operations centers can control ramp meters, close access points, and could, with appropriate authority, establish speed and lane control regulations. For example, *speed management* establishes speed limits or speed guidance in real time to ramp down speeds slowly as traffic approaches slower speeds ahead. Such a system prevents crashes, maximizes throughput, and reduces shock-wave effects of stop-and-go traffic resulting from incidents and bottlenecks.

For dynamic pricing applications, highway information explained above is used to establish the price at which the established performance measure (e.g., maximum hourly volumes and minimum speeds) is maintained and sustainable. The established price is then transmitted to toll notices on the highway, the corridor, and through information services, allowing travelers to make route and mode choices in real time.

Establishing Performance Standards Two meaningful and highly interrelated sets of performance measures can be used by system operators to assess and maintain managed lane effectiveness:

- Traffic Speed and Volume levels can be used to measure performance, in some cases on a real time basis. However, these are often derivative measures of in-pavement loop detectors that measure lane occupancy rates. Other detection strategies include microwave, infrared, and video sensors that each have strengths and weaknesses.

- Travel Time is perhaps the truest measure of value to drivers, but can also be the most difficult to measure. One process uses existing corridor speed/volume sensors to calculate travel time. Also, travel times can be collected from transponder-equipped vehicles by matching transponder identification numbers at two points. However, these processes result in a lag time between the measurement and its dissemination to drivers based on the time that it takes a transponder-equipped vehicle to travel the distance. Adjustments are feasible to account for upstream and downstream volume, time of day, and other stochastic processes.

Access to managed lane facilities is guided by optimizing system performance. Caltrans seeks to maintain traffic conditions on the San Diego's I-15 Express Lanes at an LOS of level "C" which is generally a Volume to Capacity ratio of .66 to .80. Volume over Capacity or V/C as seen in **Figures 4 and 5** can be broken down into a flow rate, or throughput, usually in vehicles per hour per lane (VPHPL).

Figure 4

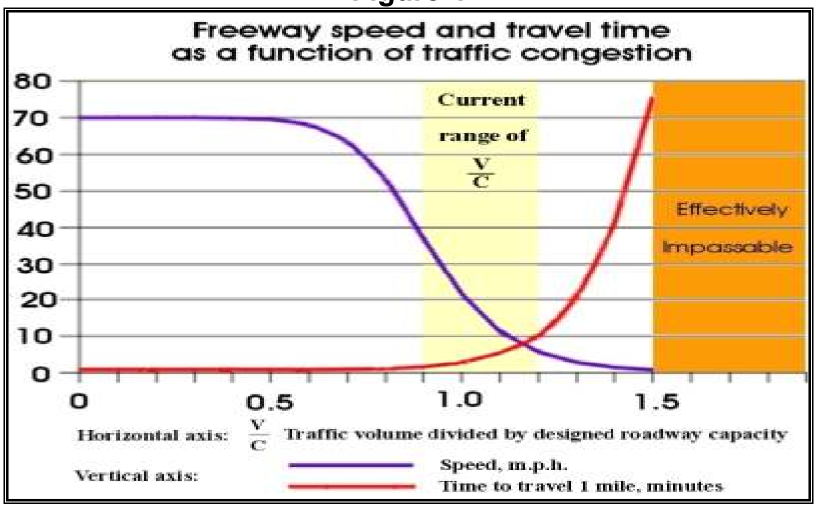
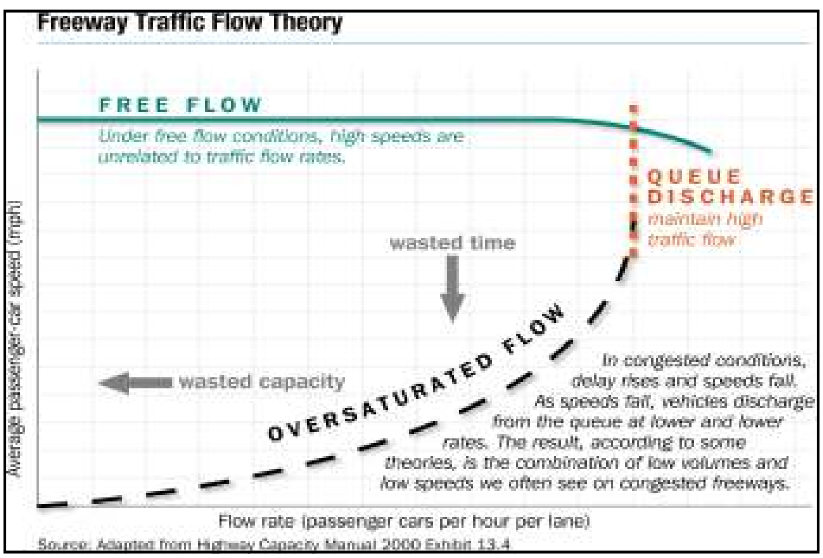


Figure 5



Source: (4) US DOT, Model Validation and Reasonableness Checking Manual; (5) US DOT, Highway Capacity Manual, 2000 Edition

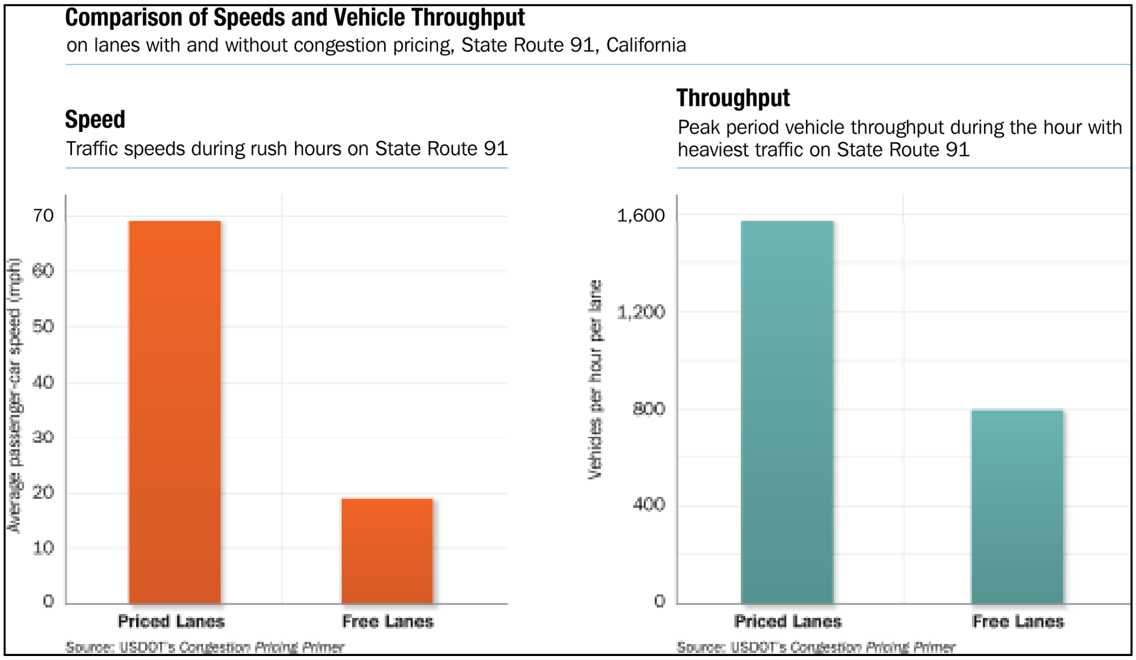
Most expressway systems are built for a maximum capacity of 2000-2200 VPHPL. This measure generally occurs at a travel speed no more than 10 mph lower than free-flow speed. Beyond the maximum capacity, systems break down resulting in lower travel speeds and lower volumes. 1700 VPHPL is a standard flow threshold cited by several managed lane system operators. **Figures 6 and 7** chart the positive effects on vehicle speed and throughput of congestion pricing strategy as applied along California's State Route 91. Several additional performance measures (Congestion Measures) are listed on a corridor data sheet for Denver's Wadsworth Boulevard **(Table 3).**

Table 3: Wadsworth Blvd: US 285 to I-70

Typical Weekday Characteristics (Arterial)	US-285 to I-70
Roadway Characteristics:	
Through Lanes	4-6
Free-Flow Speed (Posted Speed + 5 mph)	40.45
Average Daily Traffic (ADT) (2005)	51,800
Average Peak Hour Traffic Volume	4,275
Total Vehicle Capacity per hour	3,400/5,100
Peak Hour Volume/Capacity (V/C)	1.18
Arterial Capacity Factors:	
Total Signals (Signal per Mile)	17 (1.9 per mile)
Non-Signalized Access Points	421
Pedestrian Activity Level	Low/Medium
Average Daily Transit Ridership	1,150
# of Crashes per Year (2003)	975
Congestion Meausres:	
Hours per Day Congested	3.5
Total Daily Vehicle Delay	5,250 hours
Total Daily Person Delay	7,250 hours
Average Delay per Person	6.1 minutes
Peak Travel Time Factor (vs. Free-Flow)	2
% of Peak Travel Time in Delay	51%
Daily Cost of Delays	$140,000

Source: 2006 Congested Corridor Data Sheets, Congestion Mitigation

Figures 6 and 7



Source (6 & 7): US DOT, Congestion Pricing PrimerProgram, DRCOG

All of these measures require a high degree of accuracy. It follows that the existing field traffic sensor infrastructure may need to be updated to properly support lane management strategies, particularly dynamic pricing. In a general sense, existing infrastructure has been deployed for traffic management and monitoring purposes where the occasional failure of individual sensors does not drastically impact the overall effectiveness of the system. However, toll systems require high accuracy and reliabilities of greater than 99 percent to ensure accurate toll rates and to maintain public confidence. The tighter the frequency or greater the number of segments, the more important accuracy and reliability becomes.

Throughput Concept
Other measures of managed lane strategy performance include vehicle and person throughput, particularly for peak periods. HOV lane systems have had notable success in achieving high levels of person throughput relative to vehicle throughput. In 2007, the Seattle region's extensive HOV network moved 34% of all travelers on 19% of the vehicles traveling daily. By moving more people with fewer vehicles, these HOV lanes, like many other HOV lanes, have been able to maintain speed and travel time advantages over general-purpose lanes (Downs, 2004. p. 110).

Price-Performance Concept
The cost of implementing managed lane strategies depends on several factors: 1) whether they are to be deployed on existing and/or new lane miles, 2) the geographic extent of the facility, 3) the permanence and footprint of barrier structures, and 4) the amount of element infrastructure hardware deployed (for access control, electronic toll collection, speed management, and the level of transit and rideshare services and facilities provided).

Managed lane facility development will be expensive. However, through congestion pricing, revenue may be generated. Whether the congestion pricing generates sufficient revenues to cover facility development cost will depend on the extent of the congestion to be alleviated and the prospective volumes. Generally, new development of priced facilities in uncongested areas would not likely be self-sustaining; new development of priced facilities in congested facilities might be, but might need a cross-subsidy from existing toll facilities. Redevelopment of existing highways into high-performance, managed and priced facilities would likely be revenue-positive.

Transportation mode choice, safety, and security

Reduction in percentages of SOV trips between particular origins and destinations will depend on whether managed lane facilities encourage ridesharing or transit ridership through occupancy discounts (HOT) and through placement and seamless integration (e.g. direct ramp access) of adjacent park and ride facilities. On a positive note, the average number of HOVs using the I-15 Express Lanes in San Diego per weekday has grown by 50% - from 7,700 in 1998 to 11,500 in 2006.

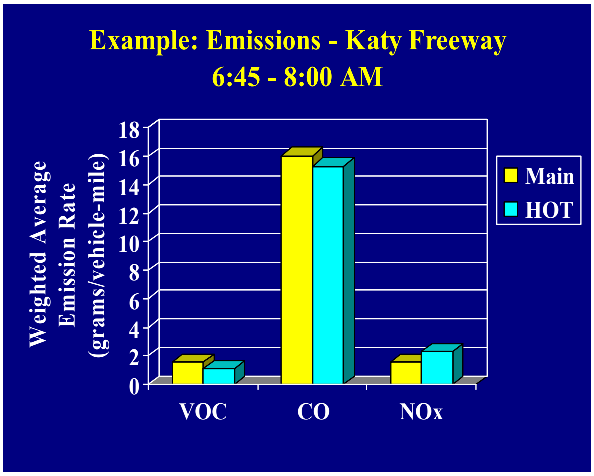
If transit services are provided along with managed lanes, increases in transit use may occur. The amount of increase in the number of households and jobs with transit access will depend on whether managed lane facilities connect a significant number of dense residential areas to job-rich economic corridors and centers. Free-flow travel lanes managed with congestion pricing combined with new transit and park and ride facilities may provide disadvantaged communities with improved access to jobs and economic opportunities. Congestion pricing may impart enhanced access by maximizing vehicle throughput across priced corridors.

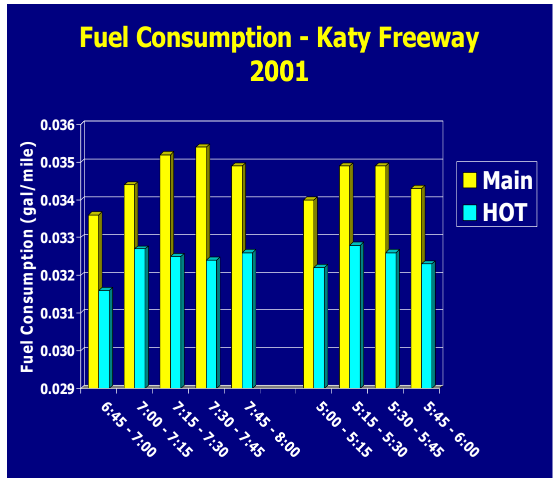
Separated lane segments, access barriers, ramp meters, variable message signs, and speed management treatments are all strategy elements that can be deployed to facilitate evacuation, response, and recovery activities in the event of a major incident. These same elements also play a positive role in reducing the likelihood and severity of vehicle-to-vehicle collisions that in turn reduce the occurrence of lengthy travel delays caused by incidents. Managed lane strategy element adaptations in the region include barrier gate installations and the widespread adoption of traffic signal interconnect systems.

Environmental Quality and Public Health

By enabling higher travel speeds and reducing idling caused by congested conditions, managed lanes can reduce fuel consumption. If rideshare and transit services and facilities develop in conjunction or as a result of management strategies, there is potential for even further reductions in fuel consumption. These strategies should consider the energy necessary to power automated systems for signage, toll collection, access control, and speed management. Lower emissions rates and fuel consumption are shown by the comparison between mainline and HOT lanes in the Houston area in **Figures 8 and 9.**

Figures 8 & 9
Emissions Rates and Fuel Consumption:
Comparison between Mainline and HOT lanes on Katy Freeway (I-10), Houston





Source (8 &9): Texas Transportation Institute

By reducing travel delay along major thoroughfares, managed lane strategies also reduce emission levels of volatile organic compounds (VOC)s and carbon monoxide. This in turn improves air quality, with positive impacts on public and environmental health as well as stormwater quality. Managed lane strategy elements also reduce the likelihood and severity of crashes, in turn reducing the likelihood of injury and fatalities.

Equity and Impacts on Low-Income Groups

While managed lane strategies focus primarily on improving the throughput of automobiles on selected segments of the regional transportation network, it is anticipated that a major benefit of such strategies is improved accessibility to employment by disadvantaged communities. Additionally, there may be air quality benefits imparted through reduction of delay and associated vehicle idling; traditionally, low-income communities have suffered disproportionately high rates of asthma that some attribute to proximity to congested highway facilities.

Congestion pricing applications may be perceived as having an adverse affect on low-income people's ability to access expressway facilities. They may also force higher volumes of and/or heavy vehicle traffic onto densely settled arterial corridors. Yet low income people have also recognized the benefits managed lanes offer to mainline expressway systems, in terms of improved flow and travel speed. According to SANDAG, 80% of low-income drivers (below $40,000 annual income) approve of the application of HOT lanes to congested corridors.

Conclusion

Managed lanes consist of a wide number and array of infrastructure improvements, technological improvements, and pricing strategies with the overall objective of improving travel flow. Where implemented, managed lanes have been shown to improve travel times and traffic flows, reduce the economic costs associated with congestion, reduce fuel consumption, and improve air quality though reductions in vehicular emissions. They can also achieve these benefits at lower cost than other transportation improvements.

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