ATLANTA REGIONAL MANAGED LANE SYSTEM PLAN

EMERGING ISSUES: BARRIER VERSUS BUFFER SEPARATED MANAGED LANES

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ADVANTAGES AND DISADVANTAGES OF BARRIER VERSUS BUFFER SEPARATED MANAGED LANES WHITE PAPER

Introduction

The purpose of this white paper is to explore the advantages and disadvantages associated with the separation of managed lanes from the general purpose lanes by means of a barrier or buffer system. A number of factors contribute to the selection of a buffer or barrier system including issues of design specifications, costs, access, safety, congestion pricing operations, enforcement and public perception.

The advantages and disadvantages of barrier and buffer separated managed lanes facilities are fully elaborated on in the sections below. Each corridor within Atlanta should decide for itself, based on its current and projected needs, operational guidelines and ultimate goals, which system, or combination thereof, works best for their area. Appendix A summarizes the results of this paper in a matrix.

Nationwide Precedent

In the United States, both barrier and buffer managed lanes systems have been designed, constructed and utilized by travelers for several decades. Atlanta itself currently has a system of buffer separated High Occupancy Vehicles (HOV) lanes along four major corridors. The vast majority of managed lanes systems in the United States today utilize a simple buffer or painted separation system to visually isolate the lanes from the general purpose lanes.

In several areas, a series of barrier separated managed lanes have been constructed. These systems are almost always implemented in conditions where High Occupancy Toll (HOT) lanes are utilized to further manage traffic flow through pricing. Barrier separated managed toll lanes systems can be found on I-25 in San Diego, a portion of I-394 in Minneapolis and along the I-10 Katy Freeway in Houston, to name just a few locations. A portion of the HOT I-394 corridor in Minneapolis utilizes a buffer separated tolling system, the first such in the nation, in effect since May 2005. Non-HOT barrier separated systems also exist in the United States.

Design and Cost

Buffer systems are generally easier to design and less expensive to construct. Typically, they require less right-of-way purchase and can be more easily retrofitted into current highway design systems with only a few basic modifications. As several of metropolitan Atlanta's highways already utilize buffer separated systems, the integration of more lane miles under this alternative would have the benefits of being familiar to the public and more seamless to integrate at the junction points of existing and new managed lanes facilities.

Several variations on barrier separated system design exist. Some barrier systems physically isolate themselves within a separate highway of lanes using concrete barriers. Another method is the erection of a series of pylon barriers along a narrow strip of space to physically isolate the two lanes without utilizing as much space or cost as a concrete system. A further design alternative involves separating managed lanes by grade, often elevating them above the general purpose lanes. This option is by far the most expensive and requires additional planning and construction time to ensure the system provides adequate access and safety measures.

In concrete or grade barrier separated systems, extra space is often required to build a shoulder within the isolated system to allow for the removal of incapacitated automobiles, the passage of emergency vehicles and the removal of accidents from the general flow. As a result, in comparison to buffer separated systems, barrier separated managed lanes generally require the addition of more right-of-way, the construction of acceleration and deceleration lanes and are often more difficult to retrofit into a current highway scheme. Lanes will often need to be shifted outward more than in a buffer separated system, especially in corridors where the median is already utilized by general purpose lanes. This arrangement often requires the purchase of additional right-of-way, the construction of new interchanges and the design and erection of new ingress/egress points along the corridor. New design schemes and exceptions are often necessary to accommodate existing infrastructure and land use adjacent to the highway in heavily urbanized locations.

Access

Both barrier and buffer systems vary in their ability to provide access for travelers. Buffers can be designed with continual access or with painted ingress and egress locations. Buffers with continual access can have the undesirable consequence of reducing capacity in the managed lanes due to friction between the quick moving managed lane and the slower moving general purpose lanes. Motorists often drive slower in the managed lanes than necessary out of concern for a slower-moving vehicle entering quickly into the system. This problem is somewhat alleviated when painted access-control lines are provided, however the continued near proximity between the quick and slow moving lanes continues to provide concern for travelers as there is no physical means to prevent a motorist from merging into the managed lanes facility unexpectedly.

The problem of speed differential turbidity is generally alleviated in barrier separated managed lanes systems, where travelers are isolated by a physical barrier preventing access in most locations from the general purpose lanes. Where access does occur,

there are generally acceleration and deceleration lanes to help maintain a constant flow within the managed lanes system.

The frequent access afforded to buffer systems can help encourage carpooling in those systems, but generally is found to decrease the operational effectiveness of the managed lanes system. Most managed lanes facilities in the United States are designed as inside systems, with the lanes placed in the median. Travelers generally are forced to move through all the general purpose lanes to ingress and egress the managed lanes facilities to the arterial roadways. This design limits the distance carpools are able to travel within the lanes, reducing their usefulness. This problem can be mitigated through the design and construction of managed lanes-specific entrance and exit ramps. Additionally, in situations where exits are placed on the left-hand side of the highway, accommodations must be made for general purpose lane travelers to merge through the managed lanes facility to reach the exit.

In contrast, barrier managed lanes system access is more limited and better controlled. Barrier managed lanes trips are targeted more strongly to individuals making longer excursions with foresight into where they will be entering and where they will be exiting the system. In barrier separated systems, access is best provided by direct ramps and transit centers, keeping the system in less direct interaction with the general purpose lanes, and minimizing multi-lane merging for ingress and egress.

A final point relates to facility hours of operation. Buffer systems are generally constructed on both directions of a highway and are able to be utilized 24 hours per day, as operationally deemed fit. Barrier systems, on the other hand, are typically designed to be reversible and utilized by a direction concurrent with rush hour traffic. Regional traffic patterns and the demand for managed lanes in either direction during any particular time of the day should be considered before selecting a preferred system alternative.

Safety

Studies are inconsistent on the issue of safety differences between buffer managed lanes systems as compared to a barrier alternative. The buffer managed lanes system is either found less safe, due to the potential accidents caused by concurrent speed variations, or equally safe as barrier systems. Accident hot spots along managed lanes corridors are generally a result of congestion and not specifically the design or operation of the facility itself. Mitigation of congestion on the general purpose lanes would help to reduce the accident rate for the managed lanes facilities as well. Special care should be taken in selecting ingress and egress points in both the barrier and buffer separated systems, as these are the locations where most accidents occur.

A benefit for barrier separated systems is that accidents in the general purpose lanes do not generally affect operations or safety within their isolated system. Buffer systems, on the other hand, are directly impacted by accidents in the general purpose lanes, often reducing flow to a rate similar to the directly affected lanes. This congestion is in part due to traffic flow reduction induced by the speed variation concerns between concurrent lanes, and partially due to congestion from high violation rates during extreme congestion caused by a roadway incident.

Congestion Pricing Operations and Concerns

The implementation and enforcement of congestion pricing alternatives (including express toll lanes and HOT facilities) on buffer separated managed lanes is considered more difficult than on barrier separated systems due to the lack of physical separation between the managed and general purpose lanes. A primary concern is that travelers, even those with electronic toll collection transponders, may weave out of the managed lanes before passing an automated toll collection point and then swerve back into the lane immediately after to continue unimpeded without having to pay a toll. As a result, enforcement needs to be focused at the toll collection points along the corridor. Moreover, without the physical separation maintaining a clear and guaranteed express experience, single occupancy vehicles are less likely to see the benefits in paying into a tolled system, and unused capacity can go unutilized. This concern can be alleviated by implementing overhead signage that accurately shows the speeds managed lanes travelers are currently experiencing. For these reasons, a 2001 study by the Texas Transportation Institute entitled *An Evaluation of Dallas Area HOV Lanes, Year 2001* discouraged implementing congestion pricing on managed lanes along several buffer HOV corridors in Dallas.

HOT and express facilities are better able to operate on barrier separated facilities. These facilities make the avoidance of tolls more difficult and are able to better guarantee travelers will receive a congestion-free trip through a combination of limited ingress and egress locations and, if desired, variable toll rates.

Despite these factors, the I-394 MNPass HOT facility is considered to be a model of how buffer separated facilities can operate effectively and efficiently through the implementation of the latest technologies and enforcement techniques. This case study is further examined in the following section.

Enforcement

Buffer separated managed lanes facilities are harder to enforce and are easier for single occupancy vehicles to abuse. The ease with which travelers can ingress and egress the buffer separated managed lanes system make it more difficult for law enforcement officials to closely monitor and enforce regulations. Moreover, this phenomenon reduces the incentive to carpool and leads to additional congestion on the general purpose lanes of the highway as a result.

New technology, however, has made it less difficult to detect and fine buffer separated managed lanes violators. The I-394 MNPass HOT corridor in Minneapolis utilizes a series of flashing lights to indicate when a driver with a transponder enters the system. This system allows other drivers to see that the HOV/HOT lane is being legally utilized, helping to maintain traveler confidence. Additionally, law enforcement officials are outfitted with special transponder detection technologies that they can utilize to catch violators. Finally, the fine for illegal usage of the managed lanes system is very high, over $140 for a first time offense, helping to further deter offenders. The MNPass 2006 Annual Report indicates that as a result of the implementation of these new policies and technologies, violations of the HOT/HOV system are down more than 15 percent compared to pre-HOT conditions, to less than 10 percent of vehicles in violation.

Alternatively, barrier separated systems are more difficult to ingress and egress and are therefore found to have high levels of compliance. Travelers wishing to cheat the system have to willingly commit to riding a substantially longer distance illegally than in a buffer separated system. In a barrier separated managed lanes system, law enforcement officials are more capable of singling out violators within the enclosed system, especially when the latest transponder detection technologies are utilized. As a result, public confidence in the functionality of barrier separated systems remains generally high.

Public Perception

A 2004 Georgia State Road and Tollway Authority study, *High Occupancy Toll Lanes And Truck Only Toll Facilities: Potential for Implementation in the Atlanta Region,* attempted to evaluate traveler outlook on different managed lanes aspects. The study found various public opinion supported advantages and disadvantages between the utilization of a buffer and a barrier separated managed lanes system. Many of the design preferences varied from individual to individual as a matter of personal taste, emotion and perceived functionality.

Analysis of public opinion on concrete barriers, pylons, pavement markings (the buffer system currently in place in metropolitan Atlanta's HOV lanes), and grade separation was conducted to contrast various managed lanes design specifications. The perceived pros and cons of these technologies are listed in Table 1 below.

Table 1: Public Perception of Different Barrier and Buffer Schemes

System Separation Alternative	Perceived Pros	Perceived Cons
Pavement Markings (Buffer-separated)	▪ Inexpensive ▪ Familiarity to Atlanta residents ▪ Faster implementation possible ▪ Easy to remove if managed lanes system is unsuccessful ▪ Can vacate lane if necessary	▪ Easier to cheat this system ▪ Drivers can cut in and out of managed lanes
Concrete Barrier	▪ Reversible lanes concept is possible with this arrangement ▪ Feeling of safety when physically separated from the slower moving traffic in the general purpose lanes	▪ Some respondents feel this arrangement would exasperate their claustrophobia ▪ Fear of hitting the concrete barrier and damaging their vehicles induces some travelers to drive more slowly ▪ Trapped within the concrete barrier system in the event of an emergency

System Separation Alternative	Perceived Pros	Perceived Cons
Pylons	▪ Relatively inexpensive ▪ Provides a clear demarcation between lanes ▪ Travelers can drive over a pylon in an extreme emergency if necessary ▪ Easy to remove if managed lanes system is unsuccessful	▪ Frequent maintenance would be required for destroyed pylons
Grade Separation	▪ Perceived as efficient, especially for long trips ▪ The time and investment necessary elicited the response that this type of facility would best be suited as a HOT or toll system ▪ Feeling of safety when separated from slower moving traffic in the general purpose lanes	▪ Some respondents feel this arrangement would exasperate their claustrophobia and/or acrophobia ▪ Trapped within the system without a means to vacate in the event of an emergency ▪ Long construction times ▪ General disbelief that such a complex and expensive system would ever be implemented

Appendix A: Matrix of Advantages and Disadvantages of Barrier versus Buffer Separated Managed Lanes Facilities

System Separation Alternative	Design and Cost		Access		Safety	
	Advantages	Disadvantages	Advantages	Disadvantages	Advantages	Disadvantages
Buffer Separated	▪ Easier to design ▪ Less expensive to construct ▪ Typically require less right-of-way ▪ More easily retrofitted into existing systems ▪ Current alternative in use for Atlanta's HOV system	▪ If managed facilities are placed on the outside (right side) of the highway, or there is a left-hand exit, accommodations must be made for general traffic to pass through the managed lanes	▪ Can allow for continuous access when desirable ▪ Can allow for limited access through painted markings ▪ Frequent access encourages carpooling ▪ Typically capable of operations 24 hours per day in both directions	▪ Concurrent speed variation between managed and general lanes decreases managed lanes efficiency ▪ If placed on the outside of the freeway accommodations must be made for general purpose traffic to traverse the lane	▪ Capable of leaving managed lanes in an emergency	▪ Risk of accidents due to concurrent lane speed variations ▪ When general purpose lanes become congested, slow moving vehicles may weave into managed facility
Barrier Separated	▪ Several design alternatives including pylons, grade separation and concrete barriers ▪ Physical isolation from general purpose lanes improves efficiency	▪ More expensive ▪ Typically requires more right-of-way ▪ More environmental and social impacts ▪ Possible fly-overs and extra ramps required	▪ Isolates travelers away from slower moving traffic ▪ More constant flow generally achieved ▪ Reversible lanes access concept is possible with this alternative	▪ Limited access can be inconvenient for some trips ▪ Typically operational only in the direction concurrent with rush hour traffic	▪ Controlled ingress and egress ▪ Managed lanes separated from incidents in the general purpose lanes ▪ Concurrent speed variations not an issue	▪ Can be more difficult to vacate managed lanes in an emergency ▪ Harder for emergency vehicles to access incidents at certain locations in the managed facilities

System Separation Alternative	Tolling/ Congestion Pricing Operations		Enforcement		Public perception	
	Advantages	Disadvantages	Advantages	Disadvantages	Advantages	Disadvantages
Buffer Separated	▪ Provides more ingress and egress locations that encourage short trips and system utilization	▪ Lack of physical separation of lanes makes it more difficult to manage and enforce tolling ▪ Drivers are able to weave in and out of lanes prior to electronic toll booths, avoiding payment	▪ No special lane or shoulder needed for enforcement	▪ Enforcement needs to be concentrated at tolling locations to watch for toll-avoidance weaving	▪ Familiar to Atlantans ▪ Ease of ingress/ egress ▪ Efficiency for short trips ▪ Less expensive and still provides benefit	▪ Provides less clear benefits to public because the system seems easier to compromise ▪ Some people are unsure of the benefits of concurrent managed lanes
Barrier Separated	▪ Limited ingress and egress locations ▪ Toll collection avoidance more difficult as you are funneled into specific lanes ▪ Public more willing to pay tolls for utilization of separate facility	▪ Limited exit points may limit utilization by some share of travelers	▪ Vehicles are in a separated location and easier to monitor	▪ Separate lane or nook for enforcement is often necessary	▪ Some travelers feel safer inside a separate access system ▪ Respondents generally consider this arrangement to be efficient for longer trips	▪ Some travelers feel trapped within a separate system ▪ Complexity and cost of the system