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# Using moveable barrier in the new urban environment

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**Abstract**
The challenges faced by urban traffic planners are becoming increasingly difficult as populations and travel demands constantly rise in cities around the world. Lack of funding and right-of-way make new road construction a daunting and expensive task in the urban environment, and many agencies are now focused on reducing congestion through a managed lanes approach. One proven way to increase road capacity without new construction is to identify existing tidal flow traffic patterns where the road can be reconfigured throughout the day to give the maximum number of lanes to peak traffic at all times. This type of traffic pattern is commonly found on ring roads, bridges, and commuter highways and arterials. In many cities, capacity redistribution involves the use of plastic delineation and overhead lights to channel drivers into a new lane configuration, but these methods cause driver confusion and lead to head-on accidents with injuries and fatalities. When there is no positive barrier between opposing lanes of traffic, motorists in the corridor are always at risk. Moveable barrier is a system that quickly reconfigures the road in live traffic to mitigate congestion, while providing positive barrier protection between opposing lanes of traffic. The system allows agencies to create managed lanes on busy highways and arterials in either a contraflow or moveable median configuration. For urban construction work, moveable barrier maximizes traffic throughput while accelerating the construction process by providing more work space during off-peak traffic hours. Moveable barrier systems have proven success on urban arterials for both managed lanes and construction applications. When considered in the planning stages of new road construction, moveable barrier provides additional important options for future flexibility as the number of road users constantly increases.

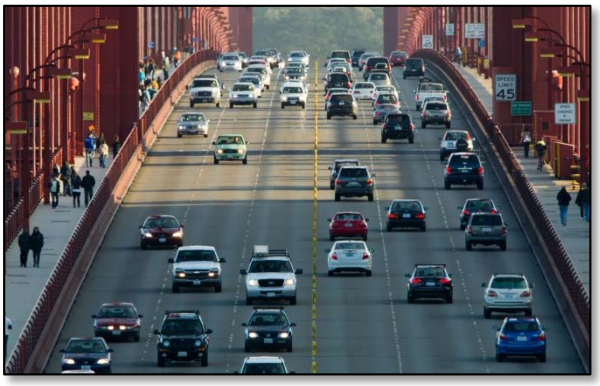
**Keywords**: Moveable barrier, managed lanes, capacity redistribution

## Managed Lanes Strategies in Urban Environments

Modern urban managed lane systems include a number of different strategies, and the definition of a managed lanes facility may vary from one government or agency to the next. In the US, the FHWA defines a managed lanes facility as “highway facilities or a set of lanes where operational strategies are proactively implemented and managed in response to changing conditions."(*1*) Managed lanes applications typically fall into one of three categories: capacity redistribution, vehicle eligibility, and pricing.(*2*) Some managed lanes facilities incorporate multiple strategies for a greater degree of operational control.

Capacity Redistribution: Some managed lanes facilities will employ a flexible or variable median to give more lanes to the peak traffic direction based on daily tidal traffic flow. Often times the agency goal is only to reclaim unused capacity or to balance traffic flow, and the additional lanes are unrestricted general purpose lanes. This strategy is common on bridges where traffic flows into the city in the morning and out of the city in the evening, with excess capacity available on the non-peak traffic side. The roadway reconfiguration is typically accomplished through overhead lighting gantries and painted lane buffers, and/or by manually shifting plastic delineation back and forth as a lane separator. While effective at increasing lane capacity, these systems are prone to severe crossover accidents.(*3*)


*Lane shift using overhead lights and paint buffers*




*Lane shift using plastic delineation*

Vehicle Eligibility: Another popular managed lanes strategy is to allow certain vehicles to make use of the managed lanes while restricting others. The most common example of this is the High Occupancy Vehicle (HOV) lane. The HOV lane imposes a minimum number of vehicle occupants (usually two or three) for access to the managed lanes during specific times of certain days of the week, essentially providing travel time advantages to high occupancy vehicles. This strategy encourages ridesharing and van pools, reducing the number of vehicles on the roadway and provides benefits to all users. Bus Rapid Transit (BRT) systems also benefit from vehicle eligibility strategies. BRT systems that use the HOV lanes or dedicated Bus Only Lanes can offer faster, more reliable transit times for users, building confidence in the system and increasing ridership. Motorcycles and low emission vehicles are also commonly allowed to use restricted lanes.

*Concurrent flow HOV lanes*

*Bus Rapid Transit (BRT) lanes*

Pricing: This strategy implements fixed or variable tolling costs associated with the use of the managed lanes. These programs generate revenue while allowing single passenger vehicles to use the express lanes. Tolling is often combined with vehicle eligibility restrictions to create HOT (High Occupancy/Toll) lanes, so that non-eligible vehicles may use the HOV lanes for a fee. Pricing often varies during the day to manage lane speed and throughput. Revenue generated by pricing lanes can be a great benefit to the facility.


*Variable pricing in the I-15 Express Lanes*

**Capacity Redistribution with Moveable Barrier**

Moveable barrier is a two-part system. The first part consists of one-meter sections of highly reinforced concrete that are pinned together at each end to form a continuous barrier wall. The barriers have a T-top, which acts as a lifting surface for the transfer machine. The second part of the system is a Barrier Transfer Machine (BTM), which lifts the barrier and passes it through a conveyor system, transferring the barrier from 8 to 24 feet (2.4 m to 7.3 m) in one pass at speeds up to 16km/h (1km can be reconfigured in four minutes). When necessary, the ends of the barrier are protected with a water-filled crash cushion that can articulate through the transfer machine for seamless operation. Systems such as the Road Zipper, manufactured by Lindsay Transportation Solutions, have been used worldwide for over 30 years and are well proven.

There are two main types of Managed Lane facilities that can be created with moveable barrier: moveable medians and contraflow lanes. The moveable median is most commonly applied to bridges and in other highway applications with few center structures. Viaducts or elevated structures also fit this model. The moveable median is perhaps the simplest way of optimizing highway capacity. In this case, there is no fixed barrier and the moveable barrier is the only barrier on the roadway. The barrier is moved back and forth multiple times per day to reconfigure lanes based on the needs of peak traffic.

*Moveable medians are the only barrier on the roadway*

There are cases where a single moveable median barrier is not practical. This may be because the two directions of the highway are on different elevations or structures, because there is a substantial existing median barrier, or because there are many center structures such as bridge piers and significant signposts, any of which would inhibit the movement of a moveable median system. In these cases, two moveable walls are used, one on each side of the roadway, in order to take or borrow a lane from the off-peak side of the road and allow traffic from the peak side of the road to utilize that lane, thus gaining additional capacity. This system provides the same optimization and efficiency as a moveable median but requires two separate walls to achieve the same results because of the geometric challenges.

*Contraflow lanes run on both sides of I-30 in Dallas, TX*

**Managed Lanes for Bus Rapid Transit: Victoria Road, Sydney AUSTRALIA**

Bus Rapid Transit (BRT) is becoming an increasingly popular concept for urban areas. Agencies can deliver fast, reliable, cost-effective transportation services by creating BRT corridors to move people in, out, and around urban centers. BRT corridors typically provide dedicated bus lanes and bus right-of-way, along with additional features that add to reliability and convenience including prohibiting turns for traffic across the lanes and alternative fare collection options. Moveable barrier can be used to create flexible BRT corridors that can be returned to traffic during non-commute periods to maximize the full use of the roadway.

BRT Case Study: Victoria Road

Victoria Road in Sydney, Australia, is a six-lane arterial. Cars were allowed to park in the outside lane to access businesses, bringing the useful number of lanes down to two in each direction. This created difficulties for the Bus Transit system, and bus travel times were long and unreliable. The Regional Transit Authority required a solution that improved the BRT system without taking additional lanes from motorists, all while keeping a solid center median to discourage pedestrians from crossing the street except at approved locations. The solution was to install a moveable median barrier that could reconfigure the roadway to add a lane to the peak morning direction, giving the peak direction four lanes rather than three. The outside lane was then converted to a Bus Only lane between 5:30 and 9:45 am. Vehicles were not allowed to park in the outside lane during this time. After the peak traffic period, the extra lane would be restored to traffic and the road would be returned to a 3/3 configuration. The agency goal of saving 18 minutes on each bus trip during the morning peak was realized on the first day of system operation, increasing bus schedule reliability and reducing transit times without any negative impact on passenger vehicle traffic.


*Sydney: Moveable barrier quickly reconfigures the roadway*


*Sydney: BRT travel time and reliability goals were met on Day One*

**Moveable Barrier and Urban Construction**

In a construction work zone, there must be a balance between the number of lanes that are available for motorists and the space requirements of the contractor. Implementing a flexible divider between vehicle traffic and the construction work zone is traditionally accomplished by using plastic cones, barrels, and flexible delineators that offer no positive protection. Until moveable barrier, road delineation that could be reconfigured quickly enough to respond to the needs of peak traffic conditions would by definition lack the crashworthy physical attributes of positive protection. In addition, work zone traffic control that does not adhere to specific regional guidelines can cause driver confusion which leads to higher accident and intrusion rates.

*Work zone signage and delineation can create confusion and allow intrusions*

<u>Construction Case Study: 3500 South, Salt Lake City, UT</u>

3500 South is a busy arterial in Salt Lake City, Utah. The first phase of the reconstruction called for two traffic lanes to be open for traffic in each direction, and plastic barrels were used to separate directional traffic and to delineate the work zone. The work zone area was confined and restricted, and it lacked positive barrier separation, which created dangerous conditions as confused motorists occasionally turned into the work zone. For the second phase of the project, it was decided that a moveable barrier system would be used to create a larger work zone, while minimizing the impact on traffic and limiting left-hand turns. It was determined that moveable barrier could keep two lanes open to traffic in the peak direction by using a total of only three lanes. This would give the contractor an extra lane to expand the work zone, keeping workers safe and accelerating construction. The barrier was moved multiple times daily to create a 1/2, 2/1 traffic pattern. The project was completed seven months early and saved one full construction season. The savings from early completion were estimated at US $1.3 to $1.4 million, with an estimated $1 million in crash cost reductions. The total benefits were estimated at $2.4 million, with a benefit to cost ratio between 4:1 and 10:1.(*4*)

*Moveable barrier protects workers and motorists while accelerating the construction process*

**Moveable Barrier and ITS: Reconfiguring the Road Using Real-Time Data**

Automated decisions regarding when to change lane patterns can decrease congestion to a greater degree than reconfiguring the road based solely on a structured time schedule. Data collection systems gather cellphone data that can be used to analyze vehicle counts in a work zone. Microwave radar systems can count and analyze data in real time over a predetermined section of roadway and transmit the collected data to a central control system. Once this data is analyzed against historical patterns or site-specific algorithms, changes can be made to the road in real time. Now, instead of changing a moveable barrier lane configuration based on assumed peak commute times, the real-time lane configuration changes can respond to any external factors, including the daily ebb and flow of traffic, special events and road incidents. This technology was used recently in the UK on two trial road works projects, the M25 Dartford Widening and the M27 Crawler Lane project. Named DRUM (Dynamic Roadspace Utilisation Manager), the system collects live traffic count data from portable radar sensors and compares the data with historical traffic counts. The system then assesses the optimal times for lane closures based on current traffic conditions rather than relying on a rigid lane closure timetable. With the ability to adjust traffic lanes based on immediate traffic data, it was estimated that these projects saved 6 months and 3 months respectively while maintaining positive protection between workers and motorists(*5*). These types of systems are likely to be used on larger road works in major urban areas, but that is where the congestion is greatest and the cost benefit justifies the initial expense of implementing the system. A system is currently scheduled for deployment on a project in Asia where the lane reconfiguration schedule will be determined by real time traffic counts.

*Solar powered microwave radar detectors gather real-time traffic data for DRUM*

Another use of real-time traffic data is to make public policy decisions based on directionality. Many overcrowded urban areas are finding it beneficial to reconfigure the road based on keeping vehicles out, rather than bringing more in. A city center choked in traffic can benefit from reducing the number of lanes in to the downtown as a motivator for workers to leave the center and work in the outskirts or suburbs. This “traffic deterrent” policy is working well in cities around the world where it is understood that building more and more lanes may not be the best answer to a major congestion problem.

**Moveable Barrier and ITS: Planning for Future Flexibility**

In most cases, moveable barrier and ITS systems are implemented on existing roadways that have achieved a level of commuter traffic exceeding the design capacity of the road, and managing lanes and traffic flow is critical to keeping the corridor functional. Greater benefits from ITS can be realized, however, when agencies plan a managed lanes facility with ITS tools and concepts into the initial construction of the roadway. One reason for this is that the greatest challenge in reconfiguring an existing roadway into a managed lanes facility is often the permanent center median barrier. This inflexible divider bifurcates the roadway and narrows the possibilities into a "left side, right side" mentality. Roads that are designed without any permanent concrete barriers are ultimately flexible and reconfigurable. Moveable medians can adjust traffic flow quickly and safely, and the options increase exponentially with two or more moveable walls. Vehicles can be separated by direction, passenger count, vehicle type, speed, payment and even autonomous capability to move more people safely through a heavily travelled corridor.

*Permanent barriers create an inflexible cattle chute.*

*Moveable barriers allow flexibility for reconfiguration.*

<u>Future Flexibility Case Study: I-15, San Diego, CA</u>

The I-15 Express Lanes encompass a 20-mile, state of the art managed lanes facility. The concept for the corridor was to build in future flexibility to make the freeway functional for many years to come. The Express Lanes began in 1988 as an eight-mile facility with two reversible center lanes for High Occupancy Vehicles. These lanes were separated from the general purpose lanes with concrete barrier. Between 1996 and 2006, average daily traffic through the corridor increased 100%, and HOV usage increased 45%. The current facility, built in three stages at a total cost of over US$1 billion, has four barrier separated center lanes, with a moveable median barrier managing the lanes in a 1/3, 2/2, or 3/1 configuration. The center lanes are now HOT lanes, allowing single passenger vehicles to use the facility for a fee. The pricing structure is designed to maximize free-flow travel, and the cost fluctuates in real time based on location, miles traveled, and congestion hotspots, with total revenue estimated between US$7 million and US$9 million per year. Direct access ramps allow buses from a new BRT system to bypass freeway ramps and travel directly into and out of the Express Lanes. The success of the I-15 Express Lanes serves as a model for other agencies to design managed lanes systems from the ground up to create the Dynamic Highways of the future.

*Direct access ramps for Express Lanes users and BRT*

*Four barrier separated center lanes with a moveable median*

**Conclusion**

As the costs of congestion reach record levels around the world, highway agencies and concessionaires must develop innovative approaches to reach their mobility, safety and economic goals. Creating managed lanes is a viable option in many instances. When properly designed, constructed and operated, these facilities can mitigate congestion while generating additional revenue and improving quality of life for road users and surrounding communities. ITS solutions provide additional benefits by optimizing the roadway in real time based on live traffic data.

Safety cannot be sacrificed to reach managed lanes goals, and agencies must review appropriate safety options for each facility. Static barrier separated lanes and cattle chutes with wide shoulders offer the safety of positive protection, but they do not provide the flexibility required by an ITS enhanced managed lanes facility. Moveable barrier systems allow agencies to reconfigure the roadway in real time, and moveable barriers are a reusable asset that can be redeployed to a different facility if traffic patterns change. Moveable barrier can be a critical, flexible element for increasing free traffic flow and reducing constriction points when designing BRT lanes. Whenever possible, moveable barrier should be considered during the planning stages of new road construction to build in future flexibility, which provides unlimited options for road reconfiguration.

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